MND 1014

Department of Energy
Washington, DC 20585

May 7, 2019

Mr. David Seely, Remedial Project Manager
Region 5 -SR-6J
U.S. Environmental Protection Agency
77 West Jackson Boulevard
Chicago, IL 60604

Mr. Brian Nickel, EPA Supervisor, DERR
Ohio Environmental Protection Agency
401 East Fifth Street
Dayton, OH 45402

Subject: Final *Sitewide Groundwater Monitoring Report, Mound, Ohio, Site for Calendar Year 2017*

Dear Mr. Seely and Mr. Nickel:

Enclosed is the Department of Energy Office of Legacy Management (DOE-LM) final *Sitewide Groundwater Monitoring Report, Mound, Ohio, Site for Calendar Year 2017* (LMS/MND/S18737). This report, dated May 2018, was transmitted to the U.S. Environmental Protection Agency (EPA) and Ohio EPA for review on June 4, 2018.

On August 16, 2018, the Ohio EPA provided a letter stating it had no comments on the 2017 report. On April 17, 2019, EPA provided an email stating it had no comments on the 2017 report. The enclosed will be posted to the DOE-LM public website and placed in the Comprehensive Environmental Response, Compensation and Liability Act Information Repository for the Mound, Ohio, Site.

Please contact me at (513) 648-3333 or Sue.Smiley@lm.doe.gov, if you have any questions. Please send any correspondence to my attention at:

U.S. Department of Energy
Office of Legacy Management
10995 Hamilton-Cleves Hwy.
Harrison, OH 45030

Sincerely,

SUSAN
SMILEY

Digitally signed by SUSAN SMILEY
DN: c=US, o=U.S. Government, ou=Department of Energy, cn=SUSAN SMILEY, 0.9.2342.19200300.100.1.1=89001000223787
Date: 2019.05.07 08:15:46 -04'00'

Susan Smiley
Mound Site Manager

Enclosure

cc w/enclosure:
G. Hooten, DOE-LM (e)
B. Zimmerman, DOE-LM (e)
B. Cato, Navarro (e)
M. Lutz, Navarro (e)
J. Massie, Navarro (e)
DOE Read File
File: MND 0400.02 (records)

Ohio
Ohio Environmental
Protection Agency

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Craig W. Butler, Director

August 16, 2018

Ms. Sue Smiley
Site Manager, Fernald Preserve
U.S. DOE, Office of Legacy
Management
10995 Hamilton-Cleves Highway
Harrison, Ohio 45030

Re: DOE Mound Facility, Miamisburg
Remediation Response
Project Records
Remedial Response
Montgomery County
557000864003

Subject: Sitewide Groundwater Monitoring Report for Calendar Year 2017 – Mound Ohio, Site

Dear Ms. Smiley:

Ohio EPA has completed our review of the "*Sitewide Groundwater Monitoring Report for Calendar Year 2017 – Mound Ohio, Site*". Ohio EPA has no comments or concerns with this report. Please feel free to contact me at (937) 285-6069 or Brian Nickel at (937) 285-6468, if you have any questions regarding this matter.

Sincerely,

Anthony T. Campbell
Site Coordinator
Division of Environmental Response and Revitalization
Remedial Response/Federal Facility Oversite Sections

ec: Melissa Lutz, Navarro, Mound Site Lead
Brian Nickel, Supervisor, DERR, SWDO
David Seely, Remedial Project Manager, U.S. Environmental Protection Agency
Katie Moore, Engineer/Geologist, DERR, SWDO

ATC/tsf

Southwest District Office • 401 East Fifth Street • Dayton, OH 45402-2911
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From: Seely, David
To: Brian.Nickel@epa.ohio.gov; Smiley, Sue
Cc: Hooten, Gwen; Zimmerman, Brian; Cato, Becky (CONTR); Lutz, Melissa (CONTR); Massie, Joyce (CONTR)
Subject: Re: Sitewide Groundwater Monitoring Report for Calendar Year 2017 - Mound, Ohio, Site
Date: Wednesday, April 17, 2019 3:00:54 PM

Sue,

This email is following up on the CORE Team outstanding document status awaiting an EPA response. EPA has reviewed the Sitewide Groundwater Monitoring Report for Calendar Year 2017 - Mound, Ohio, Site and has no comments on this report.

Please contact me if you have any questions.

-David Seely-
Remedial Project Manager
United States Environmental Protection Agency
(312) 886-7058

From: Perschelli, JoAnna (CONTR) <JoAnna.Perschelli@lm.doe.gov>
Sent: Monday, June 4, 2018 2:50 PM
To: Seely, David; Brian.Nickel@epa.ohio.gov
Cc: gwen.hooten@lm.doe.gov; Shafer, David S; Smiley, Sue; Zimmerman, Brian; Cato, Becky (CONTR); Lutz, Melissa (CONTR); Massie, Joyce (CONTR)
Subject: Sitewide Groundwater Monitoring Report for Calendar Year 2017 - Mound, Ohio, Site

The attached letter transmits the Mound Site Groundwater Monitoring Report for the Calendar Year 2017.

Submitted on behalf of Susan Smiley, Mound Site Manager, DOE-LM-22.

Jo Anna Perschelli
Administrative Assistant
Navarro
Contractor to the U.S. Department of Energy
Office of Legacy Management
Fernald Preserve
10995 Hamilton-Cleves Hwy.
Harrison, OH 45030
Phone: 513-648-3165

LMS/MND/S18737

MND 1014

Sitewide Groundwater Monitoring Report Mound, Ohio, Site

Calendar Year 2017

May 2018

U.S. DEPARTMENT OF ENERGY | Legacy Management

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Abbreviations

BVA	Buried Valley Aquifer
DCE	dichloroethene
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	feet
ft MSL	feet above mean sea level
MCL	maximum contaminant level
MK	Mann-Kendall
µg/L	micrograms per liter
MNA	monitored natural attenuation
nCi/L	nanocuries per liter
Ohio EPA	Ohio Environmental Protection Agency
OU	Operable Unit
PCE	tetrachloroethene (perchloroethene)
RAO	remedial action objective
RIN	report identification number
TCE	trichloroethene
VC	vinyl chloride
VOC	volatile organic compound
VSP	Visual Sample Plan

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1.0 Introduction

1.1 Purpose

This report was prepared in support of the selected remedies for Phase I and Parcels 6, 7, and 8 of the Mound, Ohio, Site as outlined in the *Operations and Maintenance Plan for the U.S. Department of Energy Mound, Ohio, Site* (Sitewide Operations and Maintenance Plan) (DOE 2015). It summarizes the data collected in 2017 and documents the progress of the monitored natural attenuation (MNA) remedies for both areas of the Mound site. All sampling and data analyses were performed in accordance with the Sitewide Operations and Maintenance Plan, unless noted otherwise.

This report includes data collected during the groundwater sampling performed in 2017. Data are presented in both time-series and map-view plots. Trend analysis was performed on selected wells using the nonparametric Mann-Kendall (MK) test. This type of long-term trend analysis can be used to confirm trends in contaminant concentrations over time. The time-series plots will also be used to evaluate changes in data over time and interpret the effectiveness of the MNA remedy.

This report also documents operational changes that occurred during the reporting period and identifies maintenance activities associated with the monitoring wells being sampled.

1.2 Project Description

The Mound site[1] is in Miamisburg, Ohio, approximately 10 miles southwest of Dayton. In 1995, the U.S. Department of Energy (DOE) Mound Plant, named after the Miamisburg Indian Mound adjacent to the site, comprised 120 buildings on 306 acres. The Great Miami River, west of the site, flows from northeast to southwest through Miamisburg and dominates the geography of the region surrounding the site. Figure 1 shows the locations of Phase I and Parcels 6, 7, and 8.

DOE remediated the Mound site to an "industrial use" standard consistent with the exposure assumptions provided in the *Mound 2000 Residual Risk Evaluation Methodology, Mound Plant* (DOE 1997) and endorsed by the U.S. Environmental Protection Agency (EPA) and Ohio Environmental Protection Agency (Ohio EPA). The remedies for groundwater at the site combine groundwater monitoring and institutional controls in the form of deed restrictions on future land and groundwater use. These combined remedies will prevent current and future exposure of workers, the public, and the environment to contaminated groundwater from the Mound site.

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[1] The Mound site has also been called the Mound Laboratory, Mound Laboratories, the Mound Plant (EPA ID OH6890008984), the USDOE Mound Plant, the Mound Facility, the USDOE Mound Facility, the Miamisburg Environmental Management Project (MEMP), and the Miamisburg Closure Project (MCP). Currently, LM uses Mound, Ohio, Site as the formal name of the site.

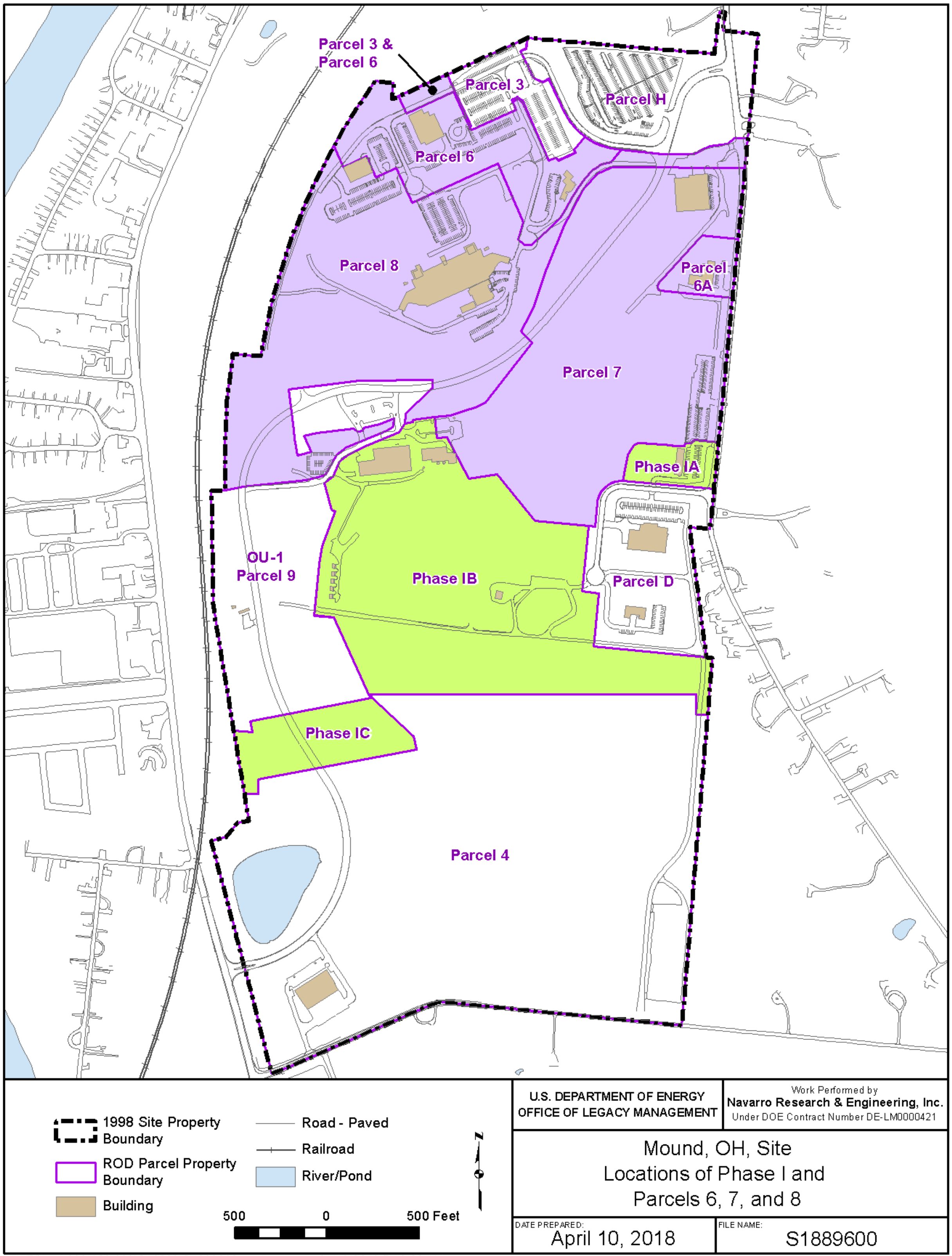

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Figure 1. Locations of Phase I and Parcels 6, 7, and 8

The long-term remedial action objective (RAO) for groundwater is to meet Safe Drinking Water Act maximum contaminant levels (MCLs) through MNA in the Phase I and Parcels 6, 7, and 8 areas. Until these goals are achieved, the near-term RAO is to prohibit the extraction and use of groundwater underlying the premises unless prior written approval is obtained from EPA, Ohio EPA, and the Ohio Department of Health.

1.2.1 Phase I

Phase I is an approximately 52-acre area made up of three distinct sections. It lies on the southern border of the former production area of the Mound site. This area contains monitoring wells that are screened in both the Buried Valley Aquifer (BVA) and the upgradient bedrock aquifer system. MNA is being used as the remedy for a small, discrete section of the bedrock groundwater system contaminated with trichloroethene (TCE) to ensure that concentrations of TCE within the bedrock groundwater are decreasing to levels below the Safe Drinking Water Act MCL and do not impact the downgradient BVA.

1.2.2 Parcels 6, 7, and 8

Parcels 6, 7, and 8 occupy approximately 101 acres of the northern portion of the Mound Plant site. The main production facilities were located within Parcels 6 and 8, an area called the Main Hill. A tributary valley runs between these two parcels and Parcel 7; it contains a narrow tongue of glacial deposits that is hydraulically connected with the BVA. Groundwater within the fractured bedrock beneath the Main Hill area, and in topographic highs within Parcel 7, flows along horizontal bedding planes and fractures and ultimately discharges to seeps or to the downgradient BVA.

Two monitoring wells on the western the edge of the BVA indicate volatile organic compound (VOC) impact, primarily TCE, which exceeds MCLs of the Safe Drinking Water Act. MNA is the remedy for the VOCs in groundwater associated with the Main Hill. Sampling is being performed to assess the contaminant concentrations and verify that the BVA offsite and downgradient of these wells is not being adversely impacted.

Five seeps are also associated with this area and are located along the Main Hill of the plant property. Two seeps are within the plant property boundary, and the remaining three are offsite to the north. Several seeps have elevated levels of tritium and VOCs. These seeps, as well as several downgradient wells, are being monitored to verify that source removal (buildings and soil) on the Main Hill will result in decreasing concentrations over time.

1.3 Geology and Hydrology

The aquifer system at the Mound site consists of two distinct hydrogeologic environments: groundwater flow through the Ordovician shale and limestone bedrock beneath the hills, and groundwater flow within the unconsolidated glacial deposits and alluvium associated with the BVA in the Great Miami River valley. A thin tributary valley, which is located along the southern edge of the Main Hill, divides the two main portions of the Mound site and contains a narrow tongue of glacial deposits that is hydraulically connected with the BVA.

The bedrock flow system is dominated by fracture flow and is not considered a highly productive aquifer. Groundwater flow in the bedrock typically mimics the topography, with groundwater discharging to the BVA or at seeps from the upper bedrock. The BVA is dominated by porous flow, with interbedded gravel deposits providing the major pathway for water movement. The unconsolidated deposits are Quaternary-age sediments that consist of both glacial and fluvial deposits. The BVA is a highly productive aquifer capable of yielding a significant quantity of water. It is designated a sole-source aquifer. Groundwater flow in the BVA flows south, following the downstream course of the Great Miami River. The general structure and flow characteristics for these two interconnected systems are depicted in Figure 2.

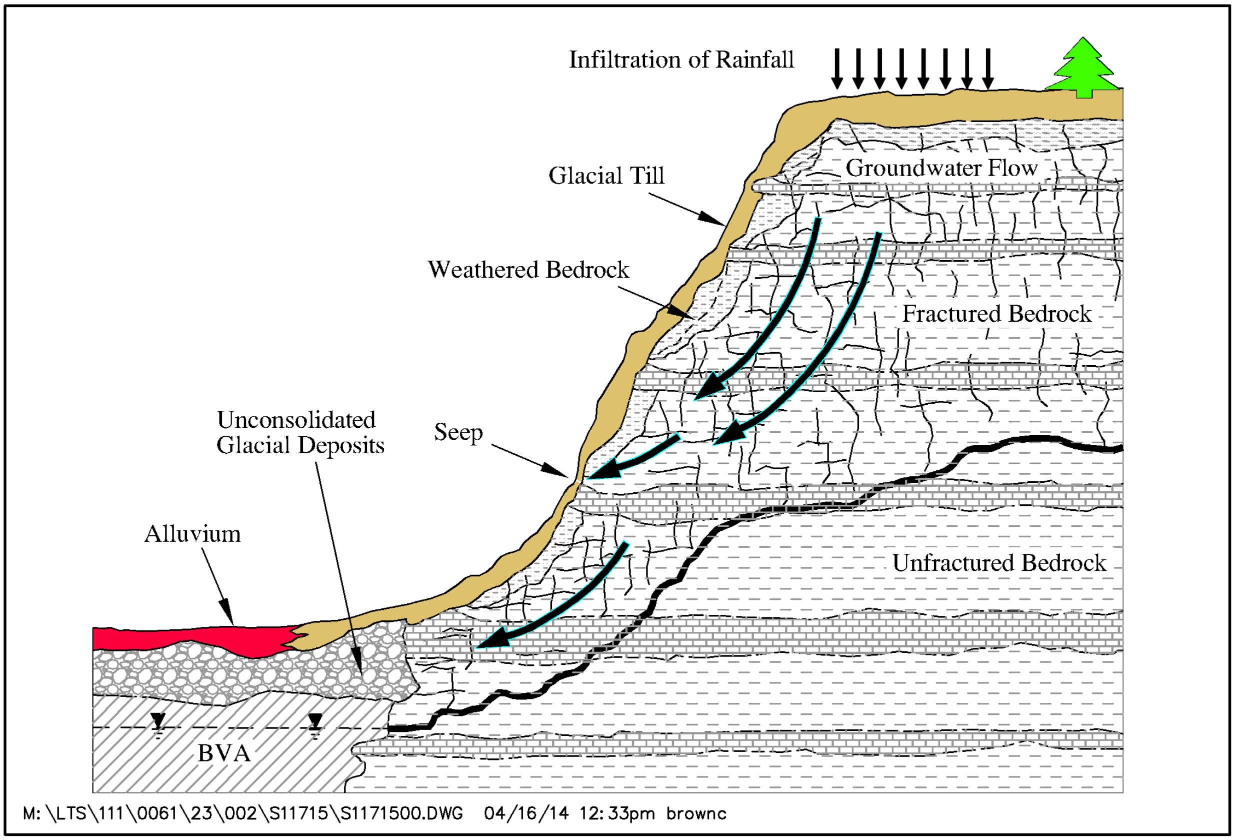

Figure 2. Generalized Cross Section Showing Flow from Bedrock to the BVA

For detailed descriptions of the geology, lithology, and groundwater flow regimes at the Mound site and specific hydrogeologic information for each area, refer to hydrogeologic investigation reports and work plans prepared for the site (DOE 1992, DOE 1994a, DOE 1994b, DOE 1995, and DOE 1999).

2.0 Monitoring Programs

2.1 Phase I

The Phase I groundwater monitoring program was established to verify that the BVA is not negatively affected by TCE-contaminated groundwater within the bedrock aquifer system. Groundwater in Phase I is monitored for TCE and its degradation products to verify that concentrations of TCE are decreasing by natural attenuation. The objective of this monitoring is to protect the BVA by verifying that the concentration of TCE near well 0411, well 0443, and seep 0617 is decreasing and confirm that TCE is not adversely affecting the BVA.

2.1.1 Monitored Natural Attenuation of TCE

Under the Phase I MNA monitoring program, samples are collected semiannually from selected wells and a seep (Figure 3) and analyzed as outlined in Table 1. Sampling was performed in the first and third quarters of 2017.

Table 1. Remedy (MNA) Monitoring for Phase I

Monitoring Location	Area	Parameters
Well 0411	Well 0411 area	TCE dichloroethene vinyl chloride
Well 0443		
Well 0353	Bedrock monitoring	
Well 0444		
Well 0445		
Seep 0617		
Well 0400	BVA monitoring	
Well 0402		
Well P033		

Note:
All locations are sampled semiannually.

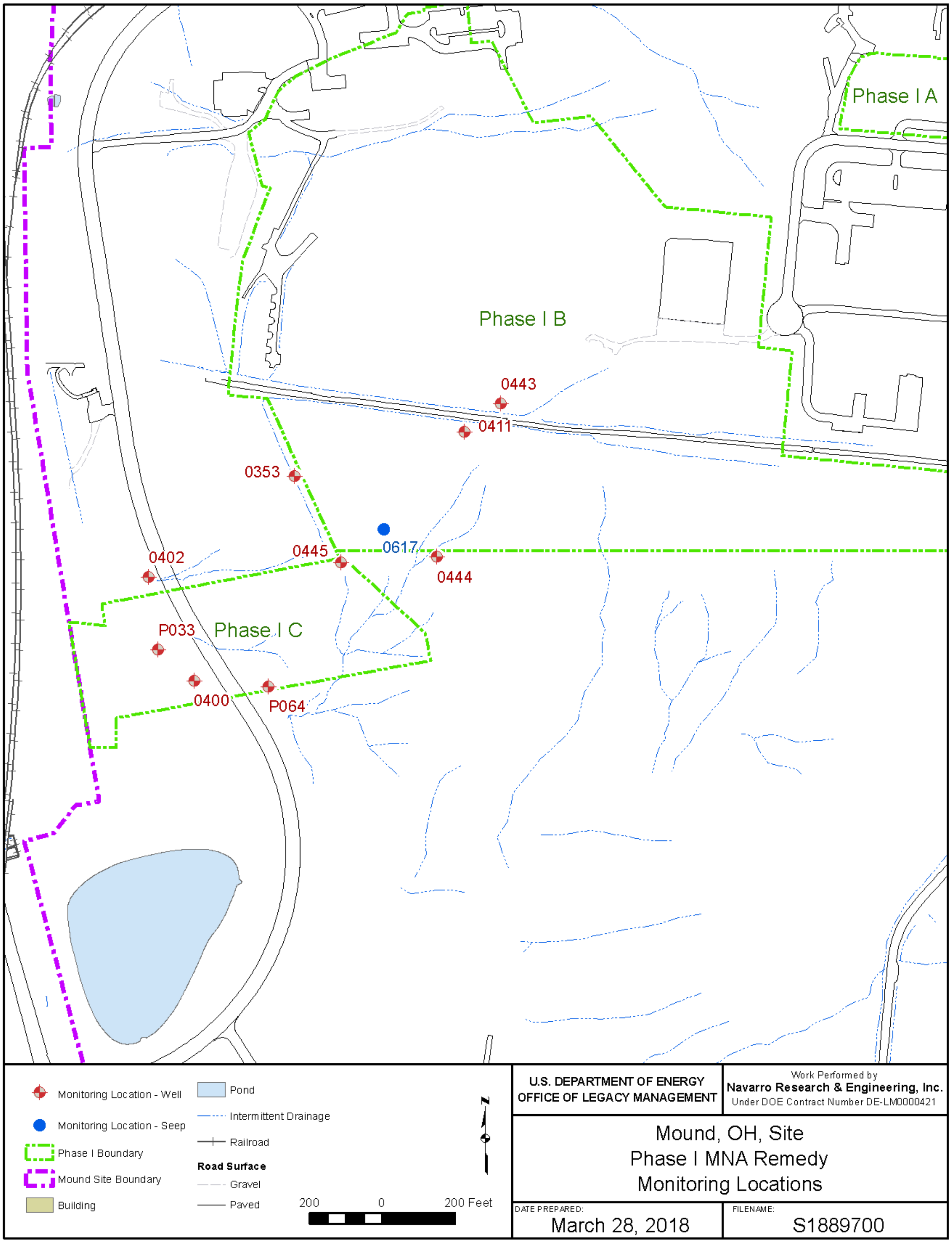

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Figure 3. Phase I MNA Remedy Monitoring Locations

2.1.2 Triggers

The contaminant data are evaluated against previous data collected at each location to determine if MNA is adequately addressing groundwater impact and to monitor the geochemical conditions in the aquifer. Trigger levels and response actions have been established for each contaminant as presented in the Sitewide Operations and Maintenance Plan (DOE 2015). The triggers are summarized in Table 2.

Table 2. Trigger Levels for Phase I MNA Remedy

Location	TCE (µg/L)	DCE (µg/L)	Vinyl Chloride (µg/L)
0353	5	70	2
0400	5	70	2
0402	5	70	2
0411	30	70	2
0443	18	70	2
0444	5	70	2
0445	5	70	2
P033	5	70	2
0617 (seep)	16	70	2

Abbreviations:
DCE = dichloroethene
µg/L = micrograms per liter

EPA and Ohio EPA must be notified if trigger levels are exceeded. After notification, the Core Team (EPA, Ohio EPA, and DOE) will determine an appropriate course of action.

2.2 Parcels 6, 7, and 8

Groundwater in the Parcels 6, 7, and 8 area is monitored for TCE and its degradation products to verify that the downgradient BVA is not affected and that concentrations are decreasing. In addition, groundwater discharging from seeps is monitored for tritium and TCE and its degradation products to verify that source removal has resulted in decreasing concentrations over time.

The sampling program focuses on the following areas:

- **Well 0315/0347 Area:** Wells at the edge of the BVA on the southwestern corner of Parcel 8 that have elevated concentrations of VOCs. The program consists of wells that have TCE concentrations greater than the MCL and downgradient wells to the west. Wells 0315 and 0347 (source wells) and other selected downgradient BVA wells are monitored for VOCs—namely, tetrachloroethene (also known as perchloroethene or PCE), dichloroethene (DCE) isomers, TCE, and vinyl chloride (VC).
- **Main Hill Seeps:** Seeps on the northern and southern sides of the Main Hill that have elevated concentrations of VOCs and tritium. The program consists of seeps and downgradient wells to the west. Water from seeps 0601, 0602, 0605, 0606, and 0607 is

collected and analyzed for VOCs and tritium. Select wells within the BVA that are downgradient of the bedrock groundwater discharge area of the Main Hill are also sampled to monitor VOCs and tritium.

2.2.1 Monitored Natural Attenuation of TCE and Tritium

Under the Parcels 6, 7, and 8 MNA monitoring program, samples are collected quarterly for VOCs and semiannually for tritium in selected wells and seeps (Figure 4). Table 3 provides a summary of the monitoring locations as specified in the Sitewide Operations and Maintenance Plan.

Table 3. Monitoring for Parcels 6, 7, and 8 Area

Monitoring Location	Area	VOC	Tritium
Well 0315	Source wells	X	
Well 0347		X	
Well 0118	Downgradient BVA monitoring	X	X
Well 0124		X	
Well 0126		X	
Well 0138		X	X
Well 0346		X	X
Well 0379		X	X
Well 0386		X	
Well 0387		X	
Well 0389		X	
Well 0392		X	
Seep 0601	Main Hill seeps	X	X
Seep 0602		X	X
Seep 0605		X	X
Seep 0606		X	X
Seep 0607		X	X

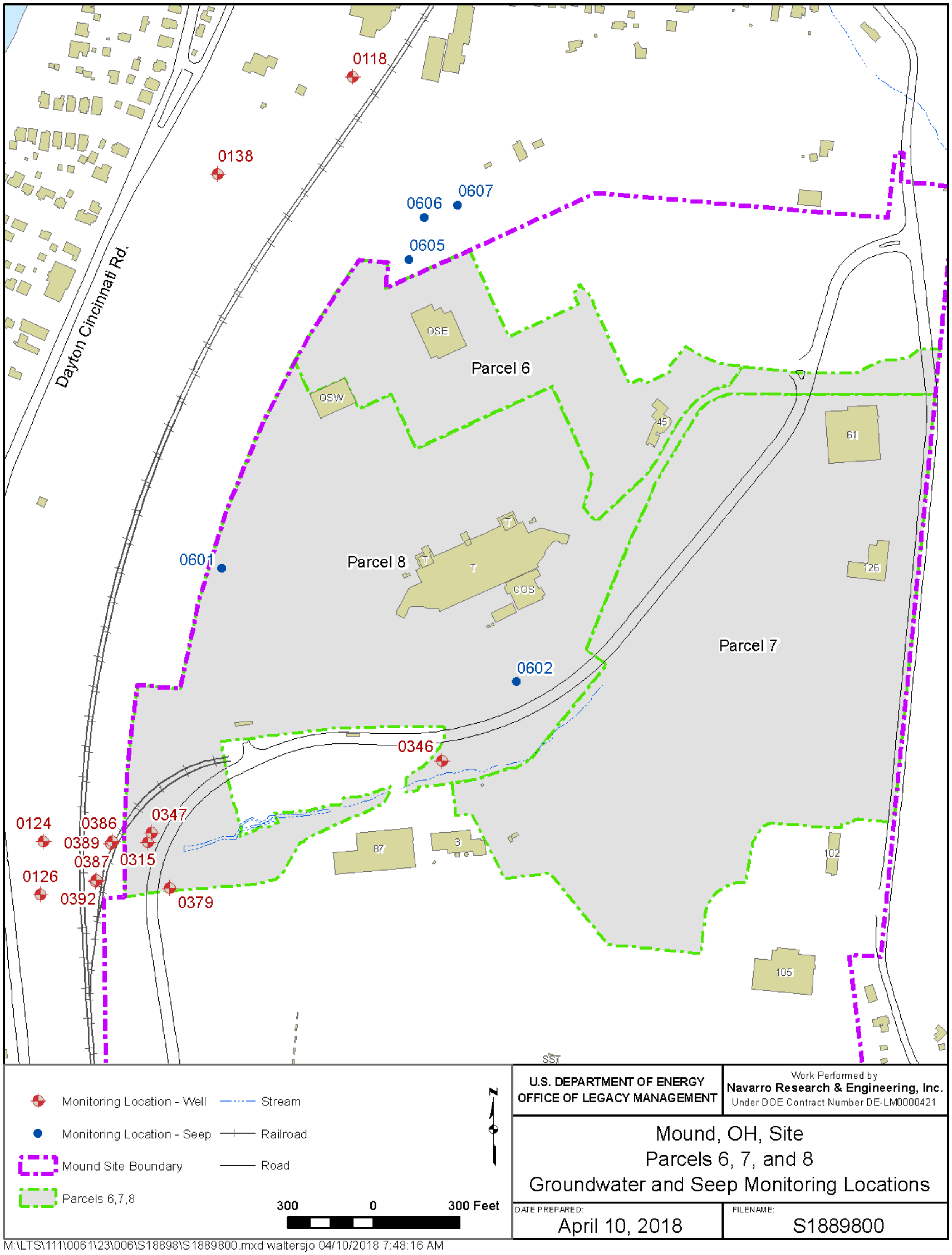

Figure 4. Parcels 6, 7, and 8 Remedy Monitoring Locations

2.2.2 Triggers

The contaminant data are evaluated against previous data collected at each location to determine if downward trends are occurring. Trigger levels and response actions have been established for each contaminant as presented in the Sitewide Operations and Maintenance Plan (DOE 2015). The triggers are summarized in Table 4.

Table 4. Trigger Levels for Parcels 6, 7, and 8 Monitoring Locations

Location	TCE (µg/L)	PCE (µg/L)	Tritium (nCi/L)
0315	30		
0347	30		
0124	5		
0126	5		
0386	5		
0387	5		
0389	5		
0392	5		
0601 (seep)		75	1500
0605 (seep)	150		

Abbreviations:
µg/L = micrograms per liter
nCi/L = nanocuries per liter

EPA and Ohio EPA must be notified if these trigger levels are exceeded. After notification, the Mound Core Team (EPA, Ohio EPA, and DOE) will determine an appropriate course of action.

2.3 Monitoring Network

The monitoring well and seep locations sampled under these programs were selected to provide data of sufficient quality to meet the objectives of the groundwater remedies for either Phase I or Parcels 6, 7, and 8. These wells were initially installed to support various site characterization activities and were designed and constructed to provide high-quality groundwater data. Appendix A contains construction information for each well used to support these remedies.

2.4 Deviations from the Sitewide Operations and Maintenance Plan

Sampling was performed as outlined in the Sitewide Operations and Maintenance Plan (DOE 2015), which compiles the sampling requirements outlined in previous plans for each area. Modifications to these monitoring programs (e.g., reduction in sampling frequency or discontinuation of monitoring locations) are also incorporated into the Sitewide Operations and Maintenance Plan.

There were no deviations from that outlined in the Sitewide Operations and Maintenance Plan. Sampling was performed as follows:

- All required locations in Phase I were sampled in 2017.
- All required locations in Parcels 6, 7, and 8 were sampled in 2017.
- Site-specific sampling methods for the Mound site were followed during these sampling events. These methods were developed by the Mound Groundwater Technical Team and approved by the Mound Core Team and are integrated into the Sitewide Operations and Maintenance Plan.

2.5 Trend Analysis Methodology

Groundwater data from select locations are evaluated for trends in contaminant concentrations over time. The computer program Visual Sample Plan (VSP, Version 7.10), developed by Battelle Memorial Institute, was used to perform trend analysis; the method used was the Mann-Kendall test. Summary reports for each monitoring location are contained in Appendix B.

The Mann-Kendall test is a nonparametric statistical procedure that is appropriate for analyzing trends in data over time. There is no requirement that the data be normally distributed or that the trend, if present, is linear. The Mann-Kendall test can be used if there are missing values and values below the detection limit. The assumption of independence requires that the time between samples be sufficiently large so that there is no correlation between measurements collected at different times. All locations were previously evaluated for seasonality as part of the annual review in 2014 (DOE 2015). Those results indicated there are no seasonal trends in contaminant data collected from any of the monitoring locations.

The Mann-Kendall procedure tests whether to reject the null hypothesis (H_0) and accept the alternative hypothesis (H_α), where:

- The null hypothesis (H_0) is that there is no monotonic trend in the series.
- The alternate hypothesis (H_α) is that a monotonic trend exists.

The initial assumption of the Mann-Kendall test is that the null H_0 hypothesis is true and that the data must be convincing beyond a reasonable doubt before H_0 is rejected and H_α is accepted. One of three alternative hypotheses is chosen:

1. A monotonic downward trend exists
2. Either a monotonic upward or monotonic downward trend exists
3. A monotonic upward trend exists

A summary of the Mann-Kendall statistical approach used for this report, as well as the specified error rates and data assumptions, is present in Appendix B. Data analysis reports for each well and parameter are also included in Appendix B.

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3.0 Phase I MNA Remedy

3.1 Monitoring Results

Monitoring results for 2017 (Table 5) continue to show low-level detections of TCE and *cis*-1,2-DCE, a TCE degradation product, in wells 0411 and 0443 and in seep 0617. All VOC concentrations were below the applicable trigger levels (Table 2). Concentrations of TCE at these locations continue to exceed the MCL of 5 micrograms per liter (µg/L). No detectable concentrations of *trans*-1,2-DCE or VC were reported at these three monitoring locations. None of the downgradient wells indicated impact attributable to VOCs originating from the Phase I area. Concentrations of *cis*-1,2-DCE were reported in BVA well 0400 during the first half of 2017 and are attributable to VOC impact in Operable Unit (OU)-1, which is immediately upgradient of these wells. No detectable concentrations of *trans*-1,2-DCE or VC were reported in the BVA or bedrock wells.

Table 5. Summary of VOC Monitoring Results in Phase I for 2017

Well ID	Location	Parameter	First Semiannual Event	Second Semiannual Event
Source Area Wells and Seep				
0411	0411 Area	TCE (µg/L)	**10.5**	**10.3**
		cis-1,2-DCE (µg/L)	1.2	1.3
0443	0411 Area	TCE (µg/L)	**5.8**	**6.0**
		cis-1,2-DCE (µg/L)	0.35 (J)	0.55 (J)
0617	Seep/ Bedrock	TCE (µg/L)	**8.2**	**8.2**
		cis-1,2-DCE (µg/L)	2.3	2.3
Other Wells				
0353	Bedrock	TCE (µg/L)	ND (<1)	ND (<1)
		cis-1,2-DCE (µg/L)	ND (<1)	ND (<1)
0444	Bedrock	TCE (µg/L)	ND (<1)	ND (<1)
		cis-1,2-DCE (µg/L)	ND (<1)	ND (<1)
0445	Bedrock	TCE (µg/L)	ND (<1)	ND (<1)
		cis-1,2-DCE (µg/L)	ND (<1)	ND (<1)
0400	BVA	TCE (µg/L)	ND (<1)	ND (<1)
		cis-1,2-DCE (µg/L)	0.59 (J)	ND (<1)
0402	BVA	TCE (µg/L)	ND (<1)	ND (<1)
		cis-1,2-DCE (µg/L)	ND (<1)	ND (<1)
P033	BVA	TCE (µg/L)	ND (<1)	ND (<1)
		cis-1,2-DCE (µg/L)	ND (<1)	ND (<1)

Note:
Values in **bold** exceed the MCL of 5 µg/L for TCE.

Abbreviations:
J = estimated value less than the reporting limit
ND = not detected above reporting limit

TCE concentrations in well 0411 (Figure 5) have decreased since monitoring began in 1999; however, since 2002, the concentrations of TCE in this well have ranged between 9 and 15 µg/L.

Concentrations of TCE in well 0443 and seep 0617 have varied since monitoring of these locations started in 2002. Concentrations of TCE in well 0443 have been consistently greater than the MCL since 2010. The time-concentration plots for well 0443 and seep 0617 indicate that concentrations vary and are lower than those in well 0411.

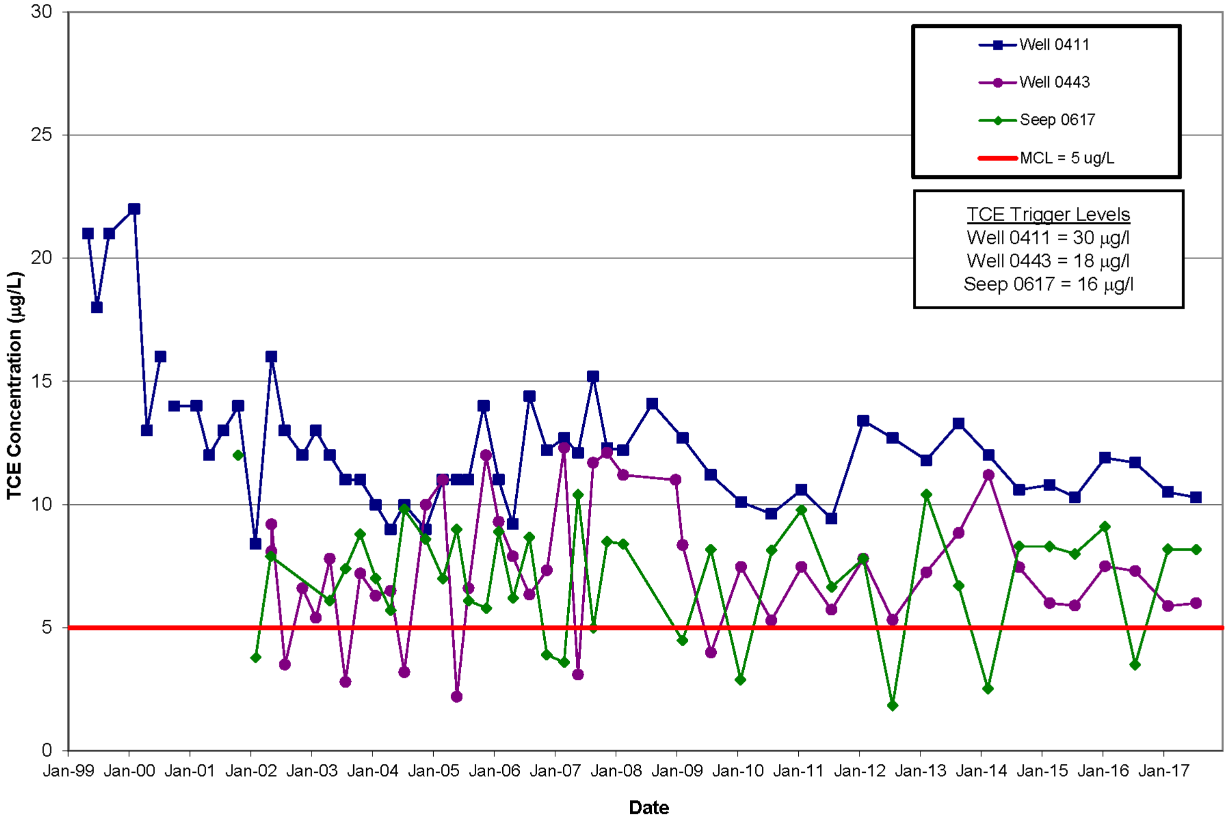

Figure 5. TCE Concentrations in Phase I, 1999–2017

The concentrations of *cis*-1,2-DCE in groundwater (Figure 6) have varied. Concentrations greater than the reporting limit of 1 µg/L have consistently been reported in well 0411 and seep 0617. Concentrations of *cis*-1,2-DCE in well 0411 are generally greater than those measured in seep 0617. Estimated detections lower than 1 µg/L have been reported in well 0443 since 2009. None of the locations had concentrations of *cis*-1,2-DCE that exceeded the MCL of 70 µg/L.

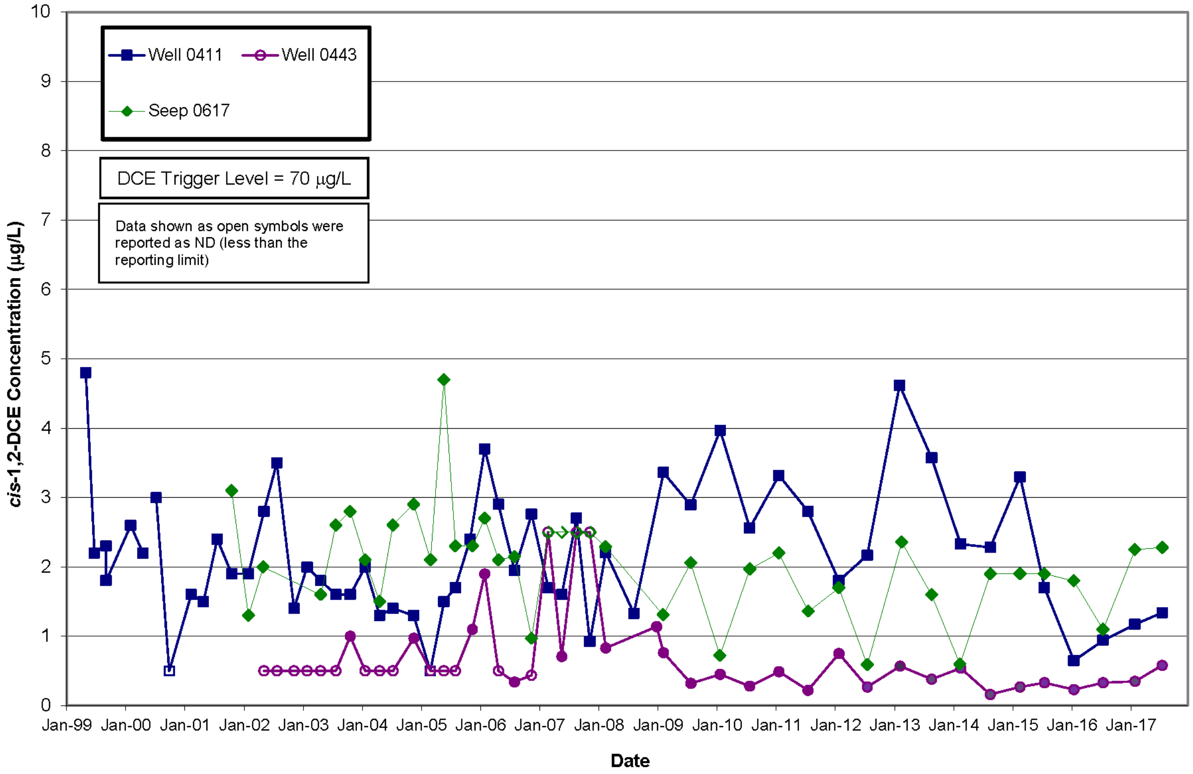

Figure 6. cis-*1,2-DCE Concentrations in Phase I, 1999–2017*

A new monitoring well, designated P064 (Figure 3), was installed in August 2017 and was sampled on November 8, 2017. The well is screened in the outwash and will be used to monitor the groundwater quality where bedrock groundwater originating from the well 0411/0443 and seep 0617 area discharges into the BVA. Monitoring results (Table 6) for the November 2017 sampling event show low levels of TCE and *cis*-1,2-DCE. These results are consistent with the results from the in situ groundwater sampling performed previously at this location.

Table 6. Summary of VOC Monitoring Results in Well P064, November 2017

Well ID	**Location**	**VOCs (µg/L)**			
		TCE	***cis*-1,2-DCE**	***trans*-1,2-DCE**	**VC**
P064	BVA	1.4	2.4	ND (<1.0)	ND (<1.0)
MCL		5	70	100	2

Abbreviations:
J = estimated value less than the reporting limit
ND = not detected

The distributions of TCE and DCE in groundwater (Figure 7) indicate that impact is localized in the bedrock groundwater near wells 0411 and 0443 and seep 0617. Wells screened in the bedrock and BVA do not have detectable concentrations of TCE or DCE, with the exception of wells 0400 and 0402. It has been determined that VOC impact in wells 0400 and 0402 is attributable to groundwater impact from OU-1, which is located immediately upgradient.

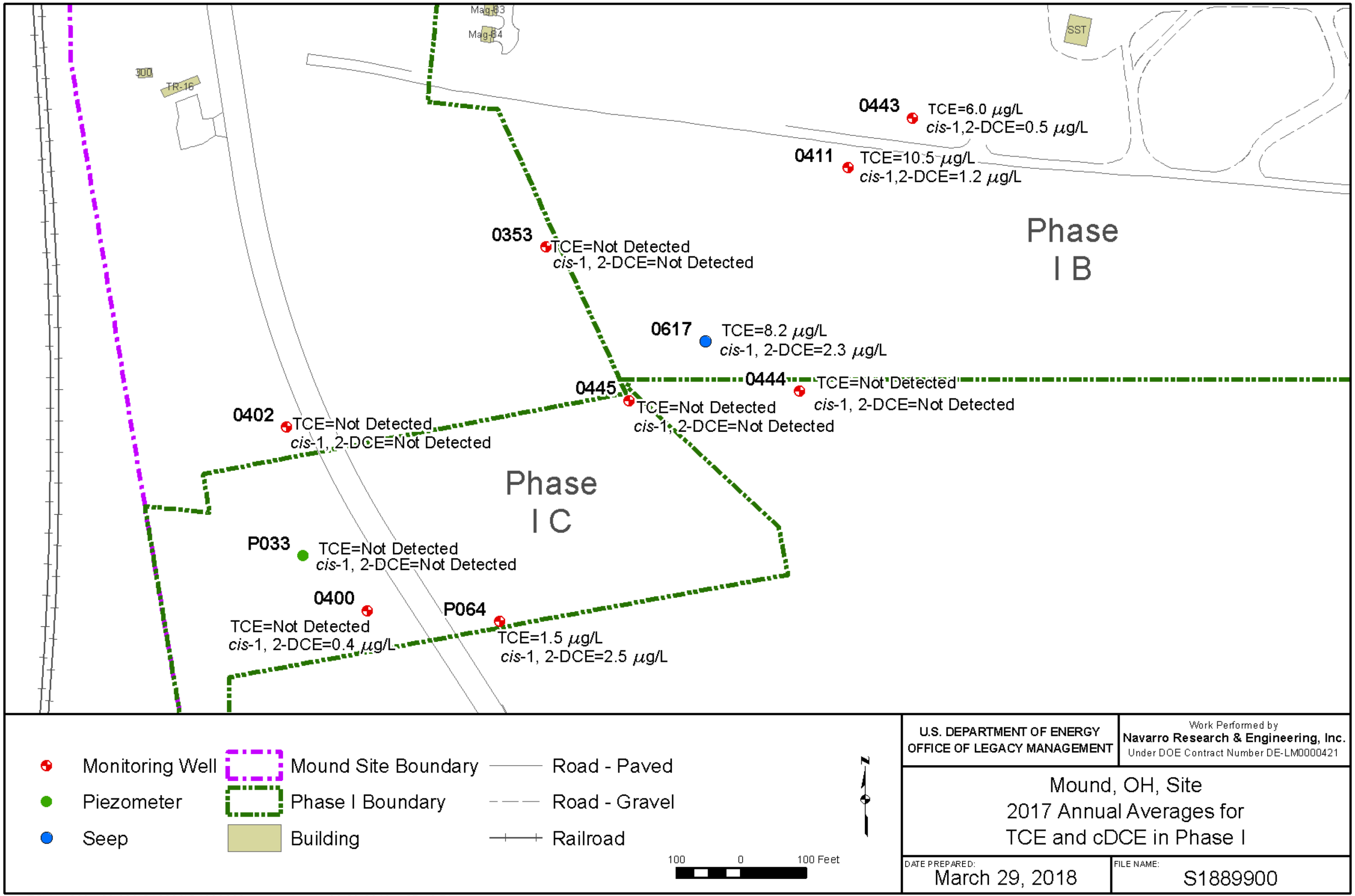

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Figure 7. 2017 Annual Averages for TCE and DCE in Phase I

3.2 Trend Analysis

Trend analysis for TCE data collected since 1999 indicates downward trends for TCE in well 0411 and for *cis*-1,2-DCE in well 0443 and seep 0617 (Table 7). Summary reports providing details for each statistical evaluation for each monitoring location are contained in Appendix B.

Table 7. Trend Analysis Results for TCE and DCE in Phase I for 1999–2017

Location	Analyte	Trend
0411	TCE	**Down**
0443		None
0617		None
0411	*cis*-1,2-DCE	None
0443		**Down**
0617		**Down**

Evaluation of the downward trend in TCE concentrations in well 0411 may indicate the time frame when concentrations may approach the MCL of 5 µg/L. The nonparametric slope calculated for the trend analysis suggests that the MCL may be reached by 2044, which is similar to the estimated time frame from previous annual reports. The nonparametric analysis typically represents the decrease of contaminant concentrations in groundwater over time and provides estimates of cleanup time frames.

3.3 Groundwater Elevations

A map of the average groundwater elevations measured in the Phase I area during 2017 (Figure 8) represents the two flow regimes present at the Mound site: bedrock and the unconsolidated materials of the BVA. The approximate location of contact of the BVA with the bedrock is indicated on this figure. Groundwater originating from the well 0411/0443 area flows southwest within the bedrock, following the bedrock topography. This groundwater enters the BVA along this contact. Flow within the BVA is generally to the south-southeast (parallel to the bedrock contact). Appendix C presents a summary of the groundwater elevations measured during 2017.

3.4 Data Evaluation

The TCE and *cis*-1,2-DCE results for the groundwater sampling continue to show that VOC impact is localized in the bedrock groundwater near wells 0411 and 0443 and downgradient seep 0617. Concentrations of TCE at these three monitoring locations continue to exceed the MCL of 5 µg/L. Low levels of *cis*-1,2-DCE continue to be present at all three locations. Data from well P064 indicate the concentrations of VOCs are low at the point where bedrock groundwater enters the BVA.

Table 8 summarizes the results from annual trend analyses performed in Phase I since 2007. Results show a continued downward trend in TCE concentrations in well 0411. Cleanup time estimates based on the slope of the downward trend suggest that the MCL of 5 µg/L for TCE may be reached by 2044 in well 0411. By 2014, downward trends for *cis*-1,2-DCE were calculated for both well 0443 and seep 0617.

Table 8. Summary of Trend Analysis Results for Phase I

Location	**Analyte**	**Year**										
		2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Well 0411	TCE	D	D	D	D	D	D	D	D	D	D	D
Well 0443		N	U	N	N	N	N	N	N	N	N	N
Seep 0617		N	N	N	N	N	N	N	N	N	N	N
Well 0411	cDCE	---	N	N	N	N	N	N	U	U	N	N
Well 0443		---	U	N	N	N	N	N	D	D	D	D
Seep 0617		---	N	N	N	N	D	D	D	D	D	D

Abbreviations:
D = downward trend
N = no trend (either upward or downward)
U = upward trend

3.5 Recommendations

On the basis of the data collected in 2017, no changes to the Phase I MNA monitoring program are warranted. On the basis of no upward trends in TCE concentrations and these concentrations remaining considerably below trigger levels, it is recommended monitoring frequency remain semiannual for 2018. Well P064 will be incorporated into the Phase I MNA remedy monitoring program starting in 2018, and sampling at wells 0400, 0402, and P033 will be discontinued. These changes to the monitoring program were approved by EPA and Ohio EPA during the August 17, 2017, Core Team meeting. Sampling will continue during the first and third quarters of the year in an effort to bracket possible seasonal variations.

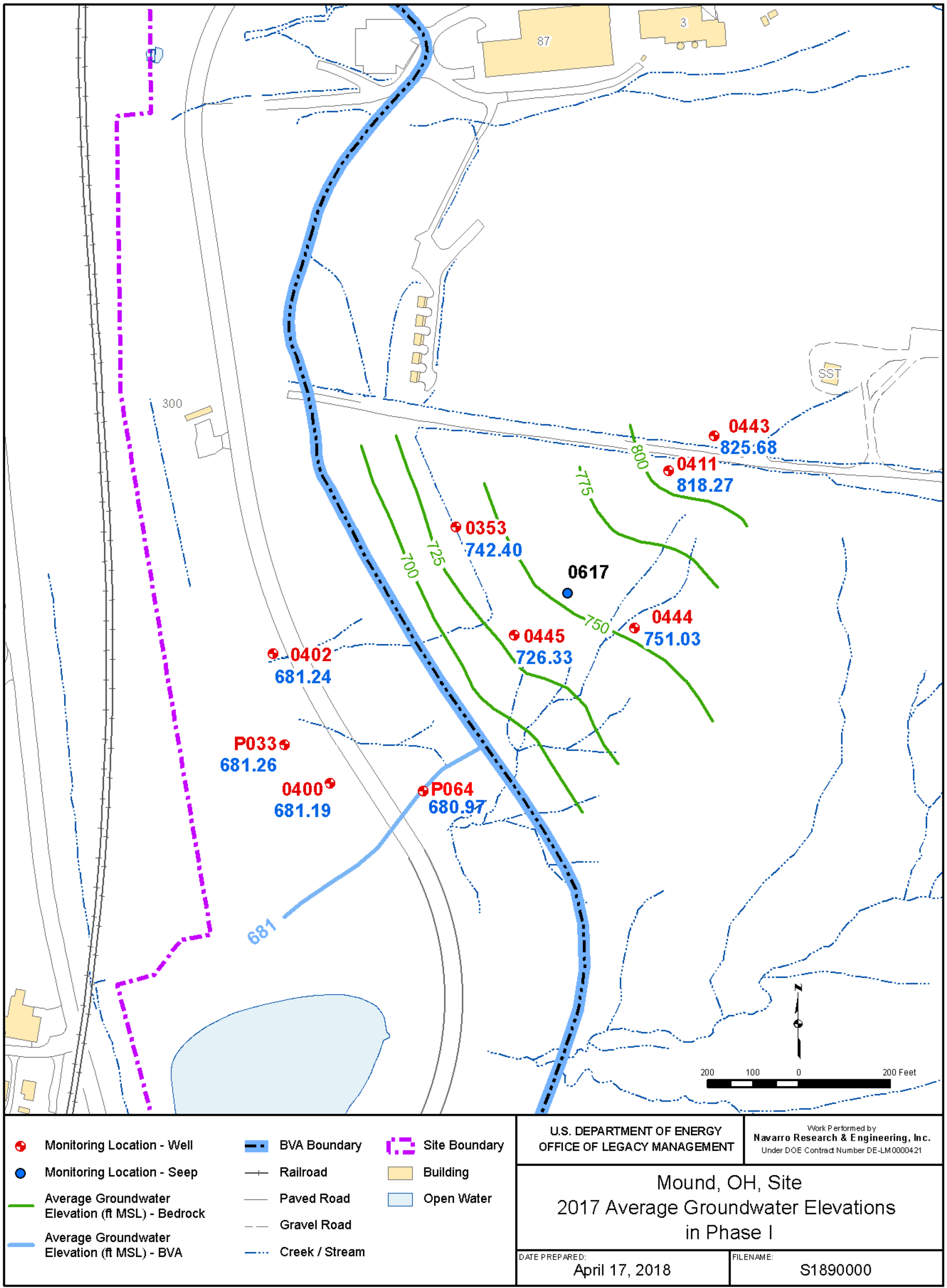

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Figure 8. 2017 Average Groundwater Elevations in Phase I

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4.0 Parcels 6, 7, and 8 MNA Remedy

4.1 Monitoring Results—VOCs

4.1.1 Seeps

Concentrations of TCE in Main Hill seeps 0601, 0602, and 0605 continued to exceed the MCL of 5 µg/L in 2017 (Table 9). No locations had concentrations that exceeded the trigger level of 150 µg/L (established for seep 0605) (Table 4). The highest concentrations of TCE continued to be measured in seeps 0602 and 0605. PCE concentrations continued to exceed the MCL of 5 µg/L in seep 0601; however, concentrations at this location did not exceed the trigger level of 75 µg/L. PCE was not reported in any of the remaining seeps. *cis*-1,2-DCE was reported in all of the seeps; seep 0602 had the highest concentrations. Estimated detections of *trans*-1,2-DCE (less than 1 µg/L) were reported in seep 0602. No VC was detected in the seeps.

Table 9. Summary of VOC Results in the Main Hill Seeps for 2017

Location	Area	VOC Concentrations				
		VOC	Q1	Q2	Q3	Q4
Seeps						
0601	Onsite	PCE (µg/L)	**8.7**	**11.5**	**10.8**	**13.5**
		TCE (µg/L)	**7.2**	3.6	**6.3**	3.7
		cis-1,2-DCE (µg/L)	0.64 (J)	0.65 (J)	0.81 (J)	1.0
		trans-1,2-DCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0602	Onsite	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	4.6	**13.6**	2.8	**12.5**
		cis-1,2-DCE (µg/L)	5.8	8.7	8.3	8.3
		trans-1,2-DCE (µg/L)	ND (<1)	0.32 (J)	ND (<1)	ND (<1)
0605	Offsite	PCE (µg/L)	ND (<1)	ND (<1)	ND (< 1)	ND (<1)
		TCE (µg/L)	**9.2**	**6.2**	**9.9**	4.3
		cis-1,2-DCE (µg/L)	2.7	1.9	1.7	0.95 (J)
		trans-1,2-DCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0606	Offsite	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	1.7	0.77 (J)	2.0	ND (<1)
		cis-1,2-DCE (µg/L)	0.50 (J)	ND (<1)	0.75 (J)	ND (<1)
		trans-1,2-DCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0607	Offsite	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	4.7	3.3	4.7	1.3
		cis-1,2-DCE (µg/L)	1.0	0.41 (J)	0.60 (J)	ND (<1)
		trans-1,2-DCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)

Notes:
PCE trigger level at seep 0601 = 75 µg/L.
TCE trigger level at the seeps = 150 µg/L.
Values in **bold** exceed the MCL.

Abbreviations:
J = estimated value that is less than the reporting limit
ND = not detected
Q = quarter

A graph of TCE concentrations measured in the seeps since the remediation of contaminated buildings and soil on the Main Hill (completed in mid-2006) (Figure 9) shows that the highest concentrations of TCE have been measured in seeps 0602 and 0605. After the completion of site improvements and the closure of the tritium capture pits on the Main Hill in 2011, VOC concentrations have been less variable and decreasing.

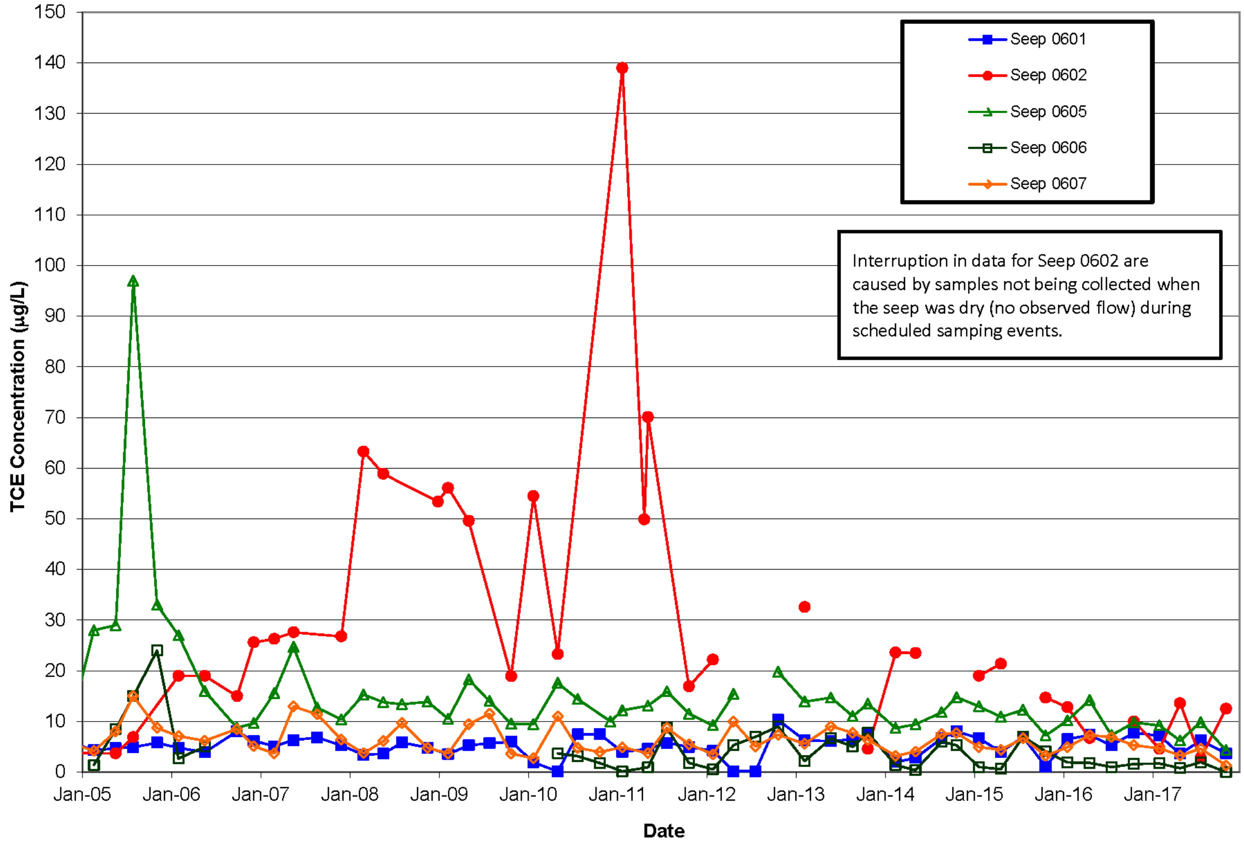

Figure 9. TCE Concentrations in Parcels 6, 7, and 8 Main Hill Seeps

Seep 0601 is the only location where detectable concentrations of PCE were reported. PCE concentrations in this seep (Figure 10) are similar to those measured before remediation on the Main Hill. Low concentrations of PCE (less than 1 µg/L) were reported in seep 0605.

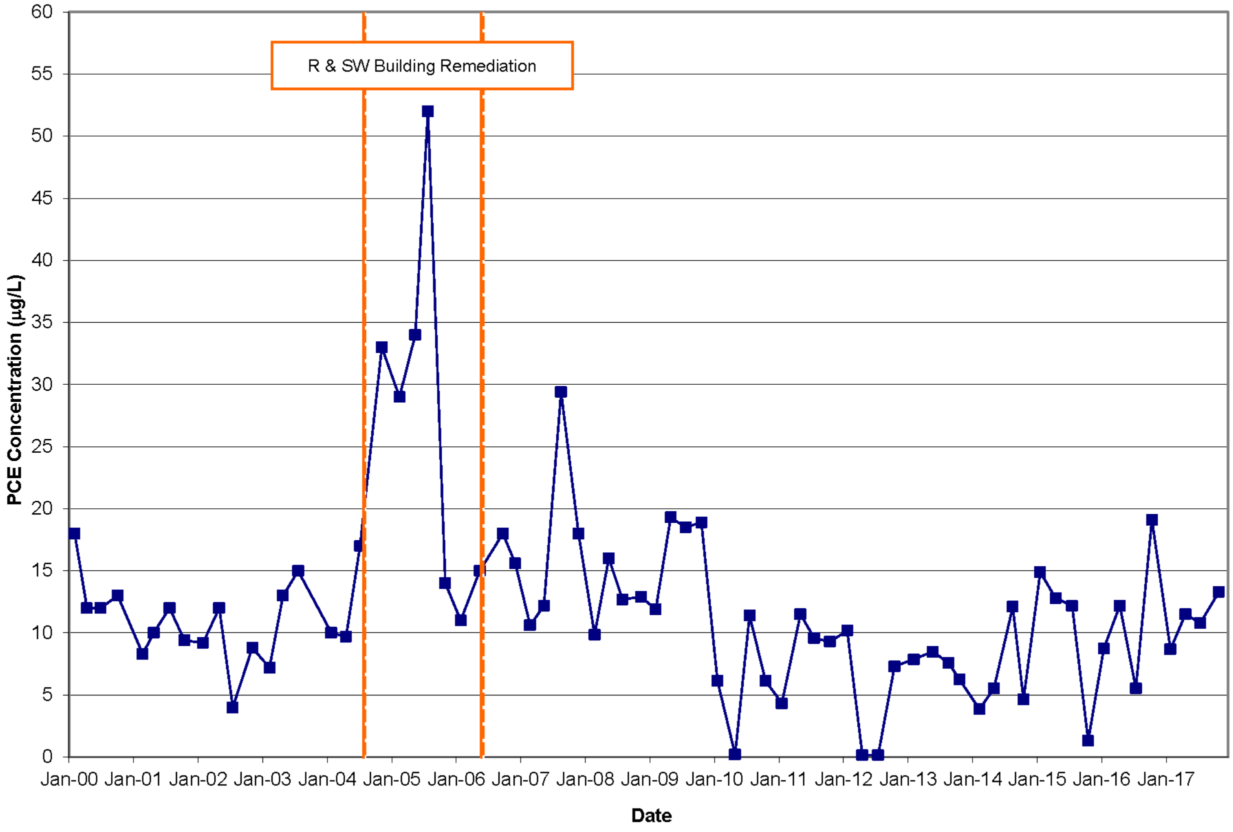

Figure 10. PCE Concentrations in Parcels 6, 7, and 8 Seep 0601

4.1.2 Groundwater

Monitoring results for 2017 (Table 10) continue to show TCE in wells 0315, 0347, 0379, and 0386; the highest concentrations are detected in wells 0315 and 0347 (source area wells), where concentrations also exceed the MCL. The concentrations of TCE reported in wells 0315 and 0347 were below the trigger level of 30 µg/L established for these source area wells (Table 4). Well 0386 is downgradient of wells 0315 and 0347 just outside the Mound site boundary (Figure 4). Well 0379 is onsite within the tributary valley, where wells 0315 and 0347 are also located. An estimated detection of TCE was reported in well 0389, and no detectable concentrations of TCE were measured in the other wells. All TCE concentrations were below applicable trigger levels.

Estimated detections of PCE less than 1 µg/L were reported in wells 0126 and 0379. These wells are located where the tributary valley enters the BVA. No trigger levels for PCE have been set for these locations. No detectable concentrations of *cis*-1,2-DCE, *trans*-1,2-DCE, or VC were reported in any of the wells monitored as part of this program.

Table 10. Summary of VOC Results in Parcels 6, 7, and 8 Groundwater for 2017

Location	Area	VOC Concentrations				
		VOC	Q1	Q2	Q3	Q4
Onsite Wells						
0315	Source Area	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	4.1	**7.0**	4.7	**6.4**
0347	Source Area	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	**20.4**	**18.0**	**18.0**	**25.7**
0346	Onsite	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0379	Onsite	PCE (µg/L)	0.33 (J)	0.45 (J)	0.35 (J)	0.60 (J)
		TCE (µg/L)	1.3	1.5	1.5	1.5
Downgradient Wells—Near						
0386	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	1.8	1.8	2.2	2.2
0387	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0389	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	0.72 (J)
0392	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
Downgradient Wells—Far						
0118	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0124	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0126	BVA	PCE (µg/L)	0.69 (J)	0.83 (J)	0.81 (J)	0.79 (J)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
0138	BVA	PCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)
		TCE (µg/L)	ND (<1)	ND (<1)	ND (<1)	ND (<1)

Notes:
TCE trigger level for wells 0315 and 0347 = 30 µg/L.
TCE trigger level for other wells = 5 µg/L.
Values in **bold** exceed the MCL.

Abbreviations:
J = estimated value that is less than the reporting limit
ND = not detected
Q = quarter

A graph of TCE concentrations measured in select wells shows that concentrations in wells 0315 and 0347 have consistently been greater than the MCL of 5 µg/L (Figure 11), although TCE concentrations in well 0315 have periodically been less than the MCL in the last 2 years. The concentrations of TCE in the downgradient wells have been less than the MCL since 2000. The pattern in TCE concentrations in wells 0315 and 0347 has been similar since 2012. The concentrations in well 0347 are always higher and have greater changes (increases and decreases). An overall decrease in TCE concentrations can be observed beginning at the same time. It is possible that surface water influences noted in previous reports (DOE 2014a; DOE 2014b) were less significant and more-recent data reflect concentrations of TCE in groundwater that are not influenced by external factors.

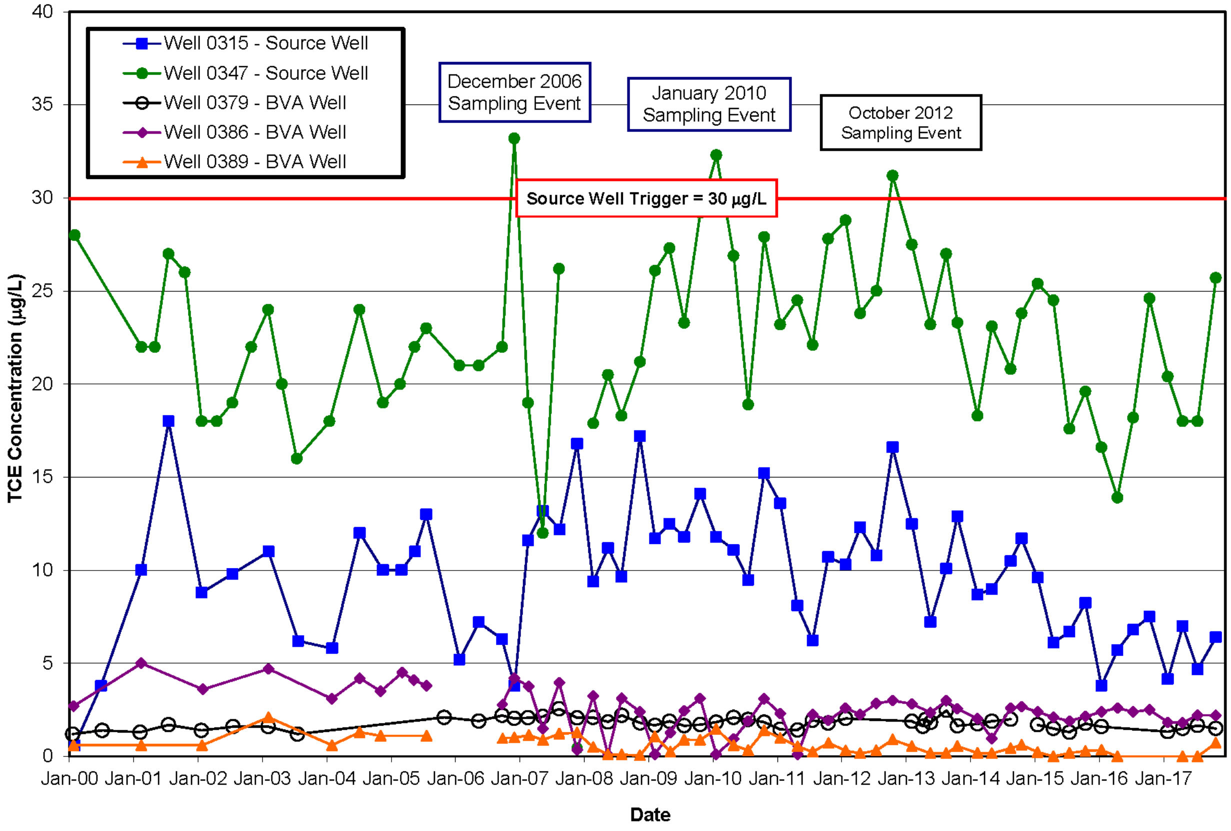

Figure 11. TCE Concentrations in Parcels 6, 7, and 8 Groundwater

4.1.3 Distribution of TCE

The distribution of TCE in groundwater (Figure 12) in the Main Hill area indicates that the highest area of impact is associated with wells 0315 and 0347. Concentrations of TCE are higher in the seeps than in the groundwater monitoring wells. Only BVA well 0386, a near downgradient well, had detectable TCE concentrations, which were below the MCL. Figure 12 depicts the 2017 annual averages of TCE in the monitoring network.

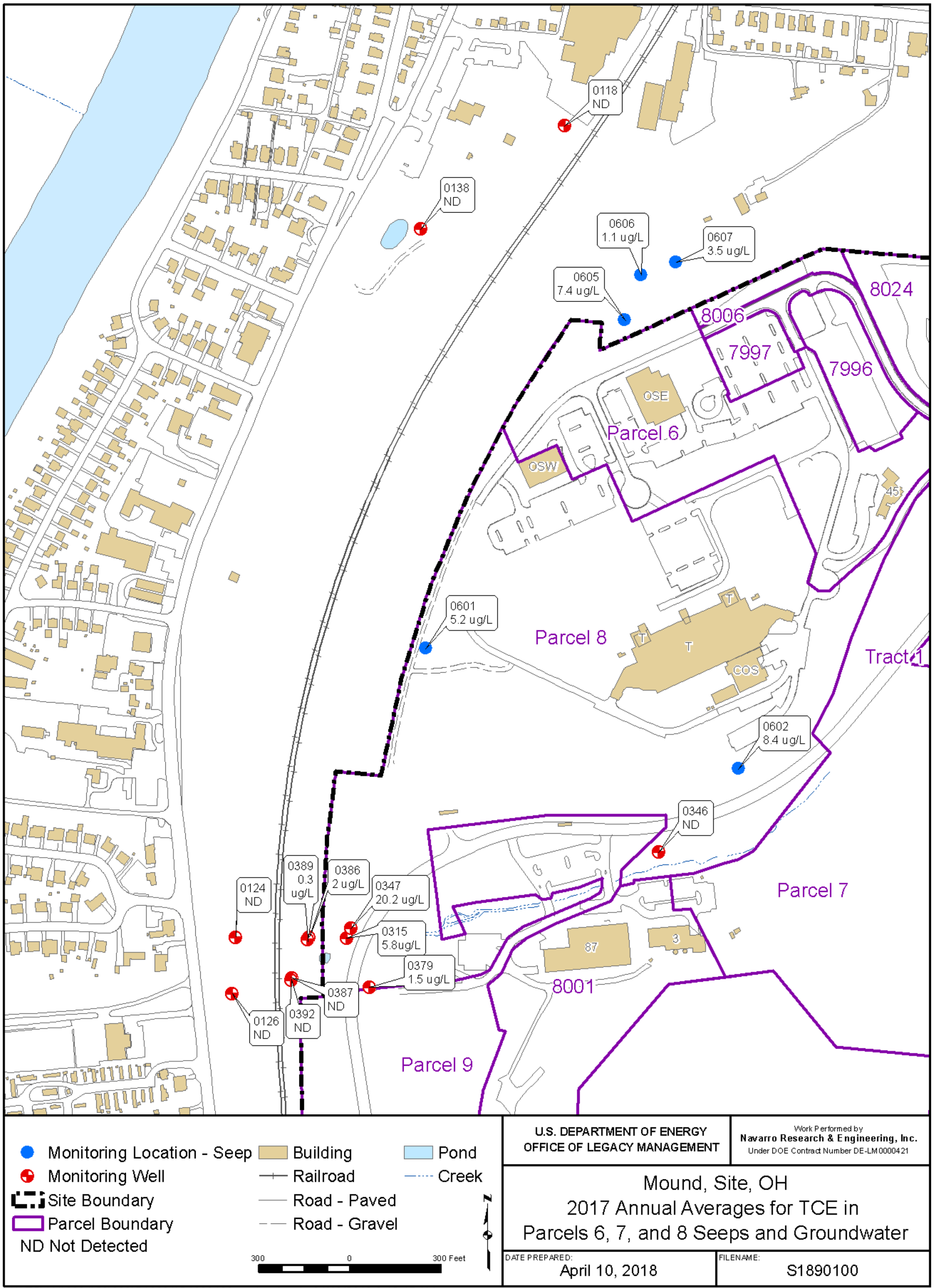

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Figure 12. 2017 Annual Averages for TCE in Parcels 6, 7, and 8 Seeps and Groundwater

4.2 Monitoring Results—Tritium

Tritium levels in the Main Hill seeps continued to be elevated in 2017 and were higher than those in the downgradient groundwater wells (Table 11). The highest tritium activity continued to be measured in seep 0601, which is onsite. No location exceeded the MCL of 20 nanocuries per liter (nCi/L) or the trigger level of 1500 nCi/L in 2017 (Table 4). The wells had tritium levels similar to background (0.77 nCi/L [DOE 1996]).

Table 11. Summary of Tritium Results in the Main Hill Area for 2017

Location	Tritium Activity (nCi/L)	
	Semiannual Period 1	Semiannual Period 2
Seeps		
0601	19.2	16.3
0602	4.1	3.2
0605	6.5	4.6
0606	3.0	2.8
0607	3.1	2.1
Downgradient Wells		
0118	ND (<0.35)	ND (<0.31)
0138	ND (<0.35)	0.86 (J)
0346	ND (<0.36)	ND (<0.31)
0347	1.3	1.4
0379	0.88 (J)	0.85 (J)

Note:
Tritium trigger level at the seeps = 1500 nCi/L.

Abbreviations:
J = estimated value that is less than the reporting limit
ND = not detected

Tritium levels in the seeps were highest during remediation activities on the Main Hill (2004−2006). Tritium data collected after building demolition and soil removal indicate decreasing levels in all of the seeps (Figure 13). The decrease in tritium levels in post-remediation data continues to support that the majority of the source was removed from the Main Hill area and that, with continued flushing, levels should continue to decline. Starting in 2009, the tritium levels in all seeps except seep 0601 were lower than the MCL of 20 nCi/L.

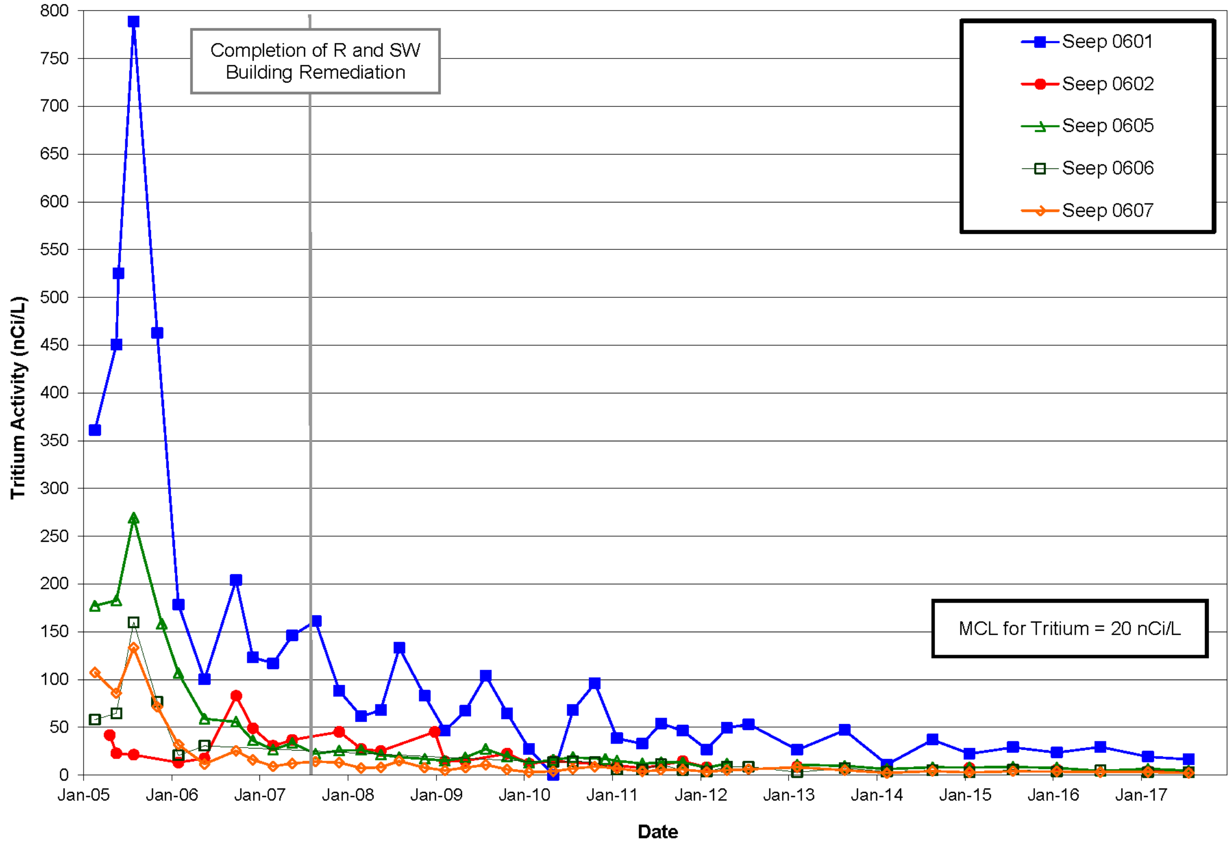


Figure 13. Tritium Activity in Parcels 6, 7, and 8 Main Hill Seeps

A graph of tritium levels in downgradient wells (Figure 14) illustrates that groundwater impact in the wells lagged behind impact expressed in the seeps. Groundwater impact increased near the end of remediation activities on the Main Hill, and impact in the seeps occurred as remediation activities were being performed and began to decrease as activities were completed. The tritium levels in the wells also responded quickly to remediation activities. Well 0347 has the highest levels of tritium. Tritium levels in wells 0138, 0346, and 0379 have leveled off and are similar to background. All tritium levels in the monitoring wells were below the MCL of 20 nCi/L.

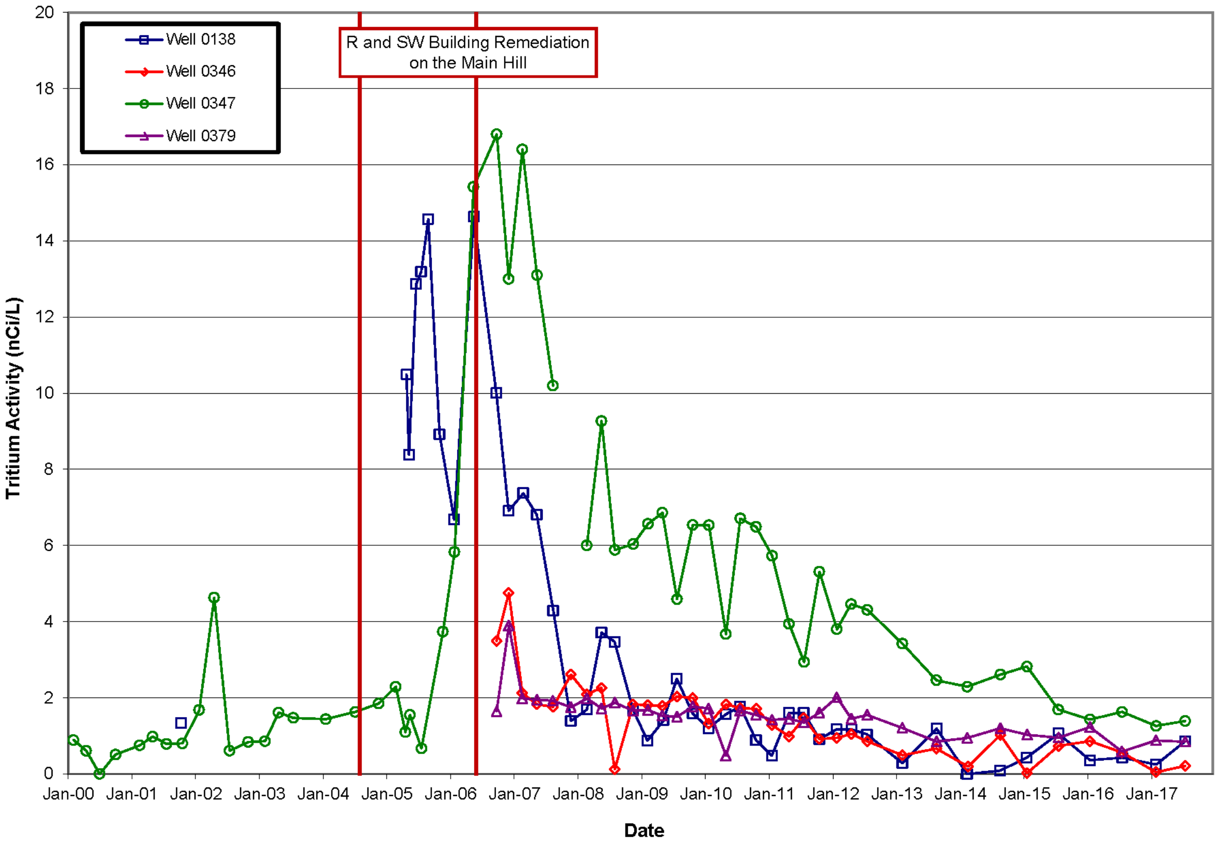


Figure 14. Tritium Activity in Parcels 6, 7, and 8 Wells 0138, 0346, 0347, and 0379

The distribution of tritium in groundwater (Figure 15) in the Main Hill area indicates that the greatest impact is still associated with the seeps, particularly seep 0601. Downgradient wells showed some elevated levels of tritium; however, levels are similar to background. Figure 15 depicts the 2017 annual averages of tritium in the monitoring network.

4.3 Trend Analysis

Trend analysis was performed on VOCs and tritium data using the nonparametric MK test. Trend analysis is reported for data collected since 2005. This period was selected to represent data collected since the completion of remediation activities on the Main Hill.

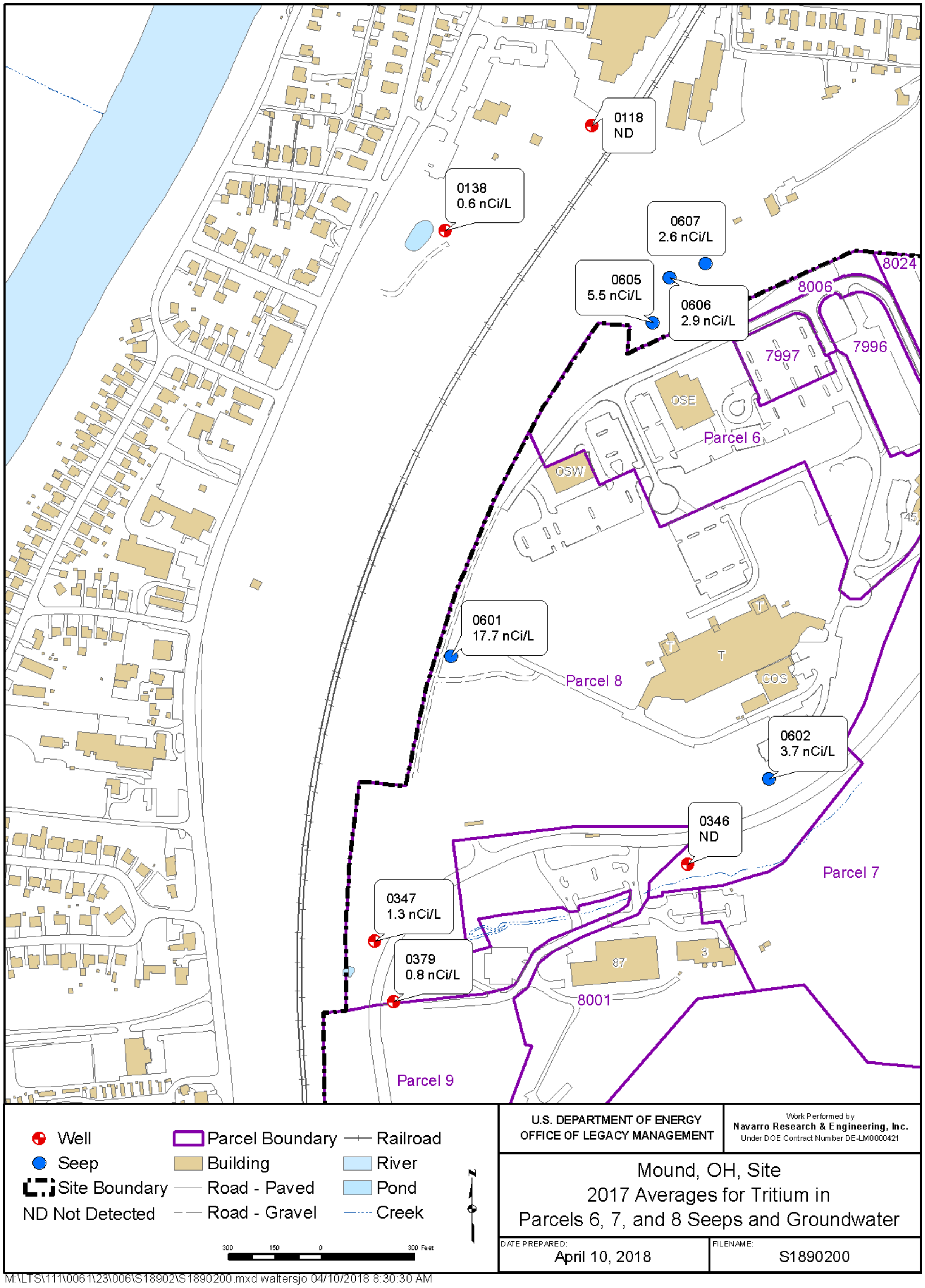


Figure 15. 2017 Annual Averages for Tritium in Parcels 6, 7, and 8 Seeps and Groundwater

4.3.1 VOCs

Trend analysis of TCE data collected since 2005 indicates downward trends for seeps 0602, 0605, 0606, and 0607 and wells 0315, 0386, and 0389 (Table 12). Trend analysis was not performed on data from the remainder of the wells because results consistently showed nondetects or sporadic estimated detections. Summary reports providing details for each statistical evaluation for each monitoring location are in Appendix B.

Table 12. Trend Analysis Results for VOCs in Parcels 6, 7, and 8 (2005–2017)

Location	Trend
TCE	
0601	None
0602	**Down**
0605	**Down**
0606	**Down**
0607	**Down**
0315	**Down**
0347	None
0386	**Down**
0389	**Down**
PCE	
0601	**Down**
***cis*-1,2-DCE**	
0602	**Down**
0605	**Down**

Concentrations of PCE in seep 0601 were evaluated for a trend in PCE concentrations (Table 12), and a downward trend was indicated. Data from seeps 0602 and 0605 were evaluated for trends in *cis*-1,2-DCE concentrations (Table 12), and downward trends were calculated for both seeps.

A separate trend analysis of TCE data collected since 2012 was performed (Table 13). As previously noted, the influences of surface water entering the subsurface appear to have been reduced. Similar patterns in concentration changes have been observed in wells 0315 and 0347 starting in 2012. Downward trends were calculated for seeps 0602, 0605, 0606, and 0607 and wells 0315, 0347, and 0386. The nonparametric slope calculated for the trend analysis for well 0347 suggests that the MCL may be reached by 2027. The nonparametric analysis typically represents the decrease of contaminant concentrations in groundwater over time and provides estimates of cleanup time frames.

Table 13. Trend Analysis Results for TCE in Parcels 6, 7, and 8 (2012–2017)

Location	Trend
0601	None
0602	**Down**
0605	**Down**
0606	**Down**
0607	**Down**
0315	**Down**
0347	**Down**
0386	**Down**
0389	None

4.3.2 Tritium

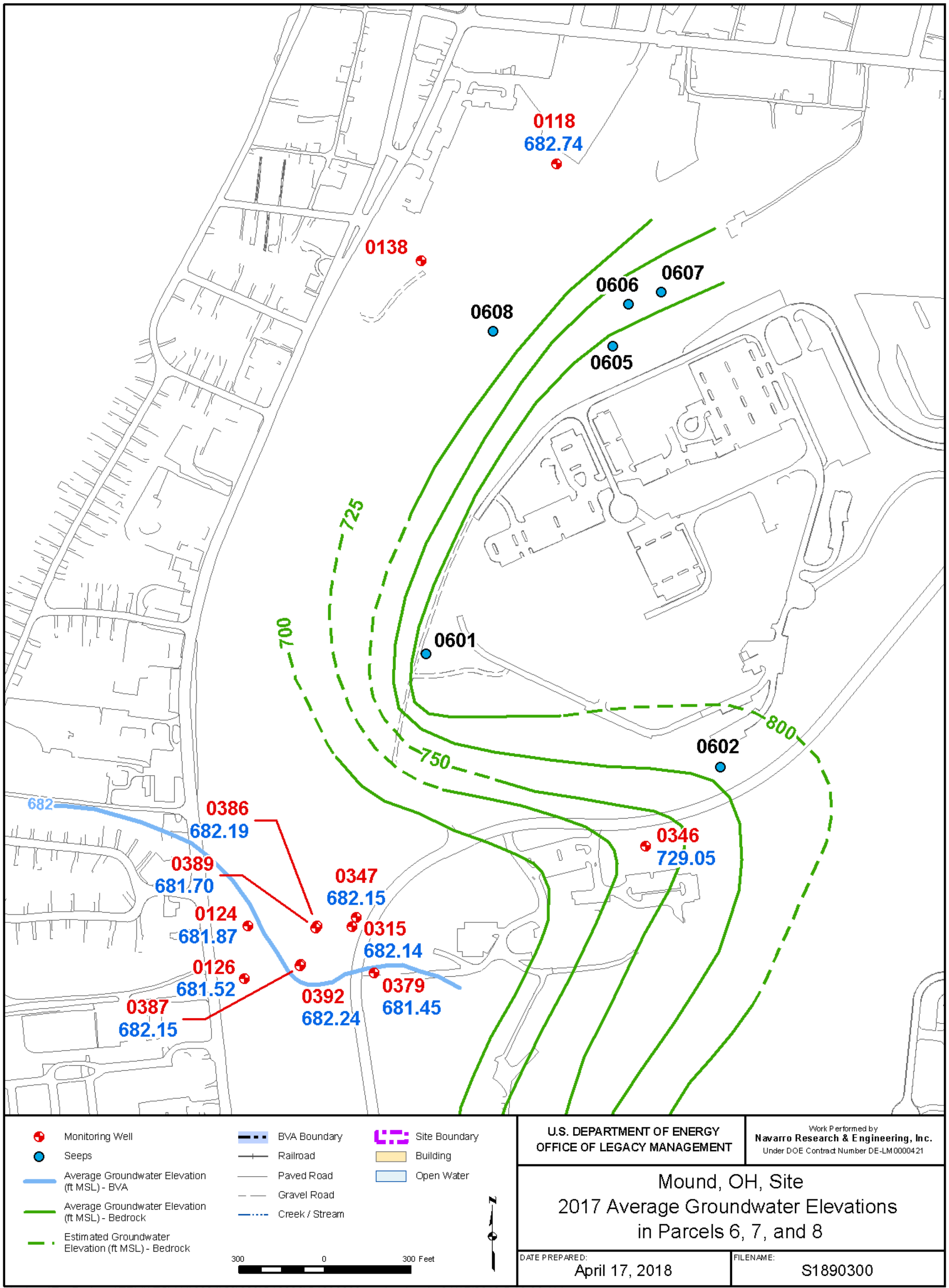
Trend analysis for tritium data collected since 2005 was performed for all of the seeps and wells where detectable levels have been consistently measured. Downward trends in tritium were calculated in all of the seeps and wells (Table 14). Summary reports providing details for each statistical evaluation for each monitoring location are in Appendix B.

Table 14. Summary of Trend Analysis Results for Tritium in the Main Hill Seeps and Downgradient Wells (2005−2017)

Location	Trend
0601	**Down**
0602	**Down**
0605	**Down**
0606	**Down**
0607	**Down**
0138	**Down**
0346	**Down**
0347	**Down**
0379	**Down**

4.4 Groundwater Elevations

A map of the average groundwater elevations measured in the Parcels 6, 7, and 8 area during 2017 (Figure 16) represents the two flow regimes present at the Mound site: bedrock and the unconsolidated materials of the BVA. The approximate location of contact of the BVA with the bedrock is indicated on this figure. Groundwater originating from the well Main Hill area flows within the bedrock, following the bedrock topography. This groundwater enters the BVA along this contact, and flow within the BVA is parallel to the bedrock contact. Appendix C presents a summary of the groundwater elevations measured during 2017.



U.S. DEPARTMENT OF ENERGY
OFFICE OF LEGACY MANAGEMENT

Work Performed by
Navarro Research & Engineering, Inc.
Under DOE Contract Number DE-LM0000421

Mound, OH, Site
2017 Average Groundwater Elevations
in Parcels 6, 7, and 8

DATE PREPARED:
April 17, 2018

FILENAME:
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Figure 16. 2017 Averages for Groundwater Elevations in Parcels 6, 7, and 8

4.5 Data Evaluation

4.5.1 VOCs

Concentrations of TCE in the Main Hill seeps and source wells continued to exceed the MCL in 2017. The highest concentrations were measured in seeps 0602 and 0605 and well 0347. None of these values exceeded trigger levels. Concentrations of the degradation product *cis*-1,2-DCE were reported in all the seeps. Concentrations of *trans*-1,2-DCE (less than 1 µg/L) were reported in seep 0602. Concentrations of VOCs were only detected in two of the far downgradient wells (see Table 10) at concentrations less than 1 µg/L.

Data collected over the past several years indicate variable concentrations of VOCs, primarily TCE, in the groundwater in Parcels 6, 7, and 8 as exhibited from the data from seep 0602 (Figure 9) and wells 0315 and 0347 (Figure 11). Seep 0602 and the downgradient wells 0315 and 0347 are in the tributary valley, which is along the southern edge of the Main Hill. As discussed in Section 1.3, the tributary valley is a narrow tongue of glacial deposits connected to the BVA that overlies the fractured bedrock at the site. Water infiltrating on the Main Hill moves through the fractured bedrock and ultimately discharges into the unconsolidated materials. TCE-impacted groundwater that originated on the Main Hill discharges to seeps or the tributary valley (DOE 2017). Annual average TCE concentrations from wells within the tributary valley show that the deep wells that are screened directly above the bedrock (wells 0347, 0386, and 0387) have the highest TCE concentrations and monitor the TCE-impacted groundwater discharging from the bedrock.

Table 15 summarizes the results from annual trend analyses of VOC data in Parcels 6, 7, and 8 since 2007. Results show that upward trends in TCE concentrations observed in the seeps have reverted to either no trends or downward trends starting in 2015. From to 2016, only one out of five seeps had downward trends, whereas in 2017, four out of five seeps now (2017) show downward trends in TCE concentrations. No trends or upward trends have been observed in the source wells 0315 and 0347, except for well 0315 where a downward trend was determined for 2017. Downward trends in TCE concentrations were observed in the BVA near wells 0386 and 0389 in 2008 and 2013, respectively. Downward trends in PCE and *cis*-1,2-DCE in seeps 0601 and 0605, respectively, started in 2011. Downward trends in *cis*-1,2-DCE in seep 0602 started in 2016. These downward trends may be attributable to previous efforts to reduce the impact of surface water entering the subsurface on the Main Hill (DOE 2014a; DOE 2014b). Seep 0602 showed the greatest fluctuations in VOC concentrations (refer to Figure 9).

Table 15. Summary of Trend Analysis Results for VOCs in Parcels 6, 7, and 8

Location	Analyte	Year										
		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Seep 0601	TCE	U	N	N	N	N	N	N	N	N	N	N
Seep 0602		U	U	U	U	U	U	N	N	N	N	D
Seep 0605		D	D	D	D	D	D	D	D	D	D	D
Seep 0606		---	---	---	N	N	N	N	N	N	N	D
Seep 0607		N	N	N	N	N	N	N	N	N	N	D
Well 0315		N	N	U	N	N	N	N	N	N	N	D
Well 0347		N	N	N	N	N	U	U	U	N	N	N
Well 0386		N	D	D	D	D	D	N	D	D	D	D
Well 0389		N	N	N	N	N	N	D	D	D	D	D
Seep 0601	PCE	---	---	N	N	D	D	D	D	D	D	D
Seep 0602	cDCE	---	---	---	---	N	N	N	N	N	D	D
Seep 0605		---	---	---	---	D	D	D	D	D	D	D

Abbreviations:
D = downward trend
N = no trend (either upward or downward)
U = upward trend

4.5.2 Tritium

Tritium levels in the Main Hill seeps continued to be higher than those in the downgradient groundwater wells. The highest tritium activity was observed in seep 0601, which is onsite; this location has historically exceeded the MCL of 20 nCi/L; however, this year levels were lower than the MCL. Detectable levels of tritium were measured in four wells (0138, 0346, 0347, and 0379) downgradient of the seeps; however, most of the levels were similar to background. None of the groundwater wells had tritium levels that exceeded the MCL of 20 nCi/L.

Table 16 summarizes the results from annual trend analysis of tritium data in Parcels 6, 7, and 8 since 2007. Results of the trend analysis of tritium data indicate downward trends for all of the seeps and wells starting in 2011 with the exception of well 0347, where no trends were determined from 2011 through 2013 and downward trends have been observed since 2014. The downward trends determined from post-remediation data support the interpretation that the majority of the source was removed from the Main Hill area during remediation and that flushing and the radioactive decay should continue to lower the levels.

Table 16. Summary of Trend Analysis Results for Tritium in Parcels 6, 7, and 8

Location	Analyte	Year										
		2007	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Seep 0601	Tritium	D	D	D	D	D	D	D	D	D	D	D
Seep 0602		N	N	N	N	D	D	D	D	D	D	D
Seep 0605		---	---	---	D	D	D	D	D	D	D	D
Seep 0606		D	D	D	D	D	D	D	D	D	D	D
Seep 0607		D	D	D	D	D	D	D	D	D	D	D
Well 0138		D	D	D	D	D	D	D	D	D	D	D
Well 0346		N	N	N	D	D	D	D	D	D	D	D
Well 0347		N	N	N	D	N	N	N	D	D	D	D
Well 0379		N	N	D	D	D	D	D	D	D	D	D

Abbreviations:
D = downward trend
N = no trend (either upward or downward)

4.6 Recommendations

The evaluation of the 2017 data does not indicate that the VOC monitoring program should be changed. TCE concentrations greater than the MCL continued to be measured in several seeps and in downgradient monitoring wells. The concentrations of VOCs continue to be variable at a few locations, although recent data (since 2012) indicate decreasing VOC concentrations at most locations. Quarterly sampling will continue at the seep and monitoring well locations in 2018 to determine if the system may be stabilizing since efforts were taken to reduce surface water infiltration into the subsurface (DOE 2014a; DOE 2014b).

No changes to the tritium monitoring program are warranted at this time; semiannual sampling for tritium will continue in 2018. Samples will continue to be collected during the first and third quarters of the year to capture seasonal variation.

5.0 Inspection of the Monitoring System

A routine maintenance program has been established for the long-term groundwater monitoring locations at the Mound site. This program includes periodic inspections that focus on the integrity of each well and the condition of the protective casing and surface pad, the surrounding area, and the route of access. These inspections are usually performed during each sampling event.

Overall, the wells were in good condition, and some routine repainting and vegetation removal were performed in 2017.

A new monitoring well, designated P064, was installed in August 2017 as part of the Phase I MNA remedy monitoring network. The well is screened in the outwash from 670 to 680 feet above mean sea level (ft MSL) to monitor the groundwater quality in the BVA. The well was constructed of 2-inch PVC materials, as an above-ground completion. Because of its location away from vehicular traffic, bollards were not installed around this well.

Monitoring well P064

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6.0 Data Validation

All data collected were validated in accordance with procedures specified in the Sitewide Operations and Maintenance Plan (DOE 2015). This procedure also fulfills the requirements of applicable procedures in the *Mound Methods Compendium* (MD 80045). Data validation was documented in reports prepared for each data package. All 2017 data, including data validation qualifiers, are summarized in Appendix D.

Laboratory performance is assessed by a review and evaluation of the following quality indicators:

- Sample shipping and receiving practices
- Chain of custody
- Laboratory blanks
- Preparation blanks
- Laboratory replicates
- Serial dilutions
- Detection limits
- Peak integrations
- Matrix spikes and matrix spike duplicates
- Holding times
- Instrument calibrations
- Interference check samples
- Radiochemical uncertainty
- Laboratory control samples
- Sample dilutions
- Surrogate recoveries
- Confirmation analyses
- Electronic data

A total of six report identification numbers (RINs) were established for the 2017 environmental sampling efforts at the Mound site. A RIN is a set of samples that is relinquished to the laboratory using a Chain of Custody form. Data Assessment Reports are prepared for each RIN and are presented in Appendix E.

The laboratory prepares an analytical package for each RIN that includes a summary of results, a complete set of supporting analytical data for every analysis reported, and an electronic data deliverable that is used to upload analytical data into databases for validation and qualification before the data are released. Every RIN received from the laboratory is thoroughly reviewed and evaluated before the data package is finalized and released to the public. Table 17 lists the RINs associated with this report.

Table 17. RINs for Calendar Year 2017 Sampling

RIN	Area	Sampling Date(s)
17018249	Parcels 6, 7, and 8	February 6–8, 2017
17018250	Phase I	February 6, 2017
17048418	Parcels 6, 7, and 8	May 1–2, 2017
17078634	Parcels 6, 7, and 8	July 24–25, 2017
17078637	Phase I	July 25, 2017
17108750	Parcels 6, 7, and 8	November 6–8, 2017

The Data Assessment Reports also summarize and assess the sampling quality control for each sampling event. The following items are included:

- Sampling protocol
- Trip blanks
- Outliers
- Equipment blanks
- Field duplicates

7.0 References

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DOE (U.S. Department of Energy), 2015. *Operations and Maintenance Plan for the U.S. Department of Energy*, *Mound, Ohio, Site*, LMS/MND/S08406, Office of Legacy Management, January.

DOE (U.S. Department of Energy), 2017. *Sitewide Groundwater Monitoring Report Mound, Ohio, Site, Calendar Year 2016*, LMS/MND/S15892, Office of Legacy Management, June.

Mound Methods Compendium, Issue 2, MD-80045, prepared by BWXT of Ohio Inc.

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Appendix A

Well Construction Summary

Location ID	Program	Northing	Easting	Ground Elevation (ft MSL)	TOC Elevation (ft MSL)	Well Depth (ft)	Top of Screen Elevation (ft MSL)	Bottom of Screen Elevation (ft MSL)	Screen Length (ft)	Well Material	Screened Formation
0118	Parcels 6, 7, 8	600464.95	1464737.80	705.36	704.86	40.1	674.73	664.73	10	4-inch SS	BVA
0124	Parcels 6, 7, 8	597789.14	1463654.10	704.18	705.12	55.9	659.18	649.18	10	4-inch SS	BVA
0126	Parcels 6, 7, 8	597603.58	1463643.30	704.61	705.54	54.8	660.78	650.78	10	4-inch SS	BVA
0138	Parcels 6, 7, 8	600124.02	1464263.30	698.59	697.76	40.2	667.59	657.59	10	4-inch SS	BVA
0315	Phase I	597786.28	1464020.40	722.57	723.99	54.8	679.17	669.17	10	4-inch SS	BVA
0346	Parcels 6, 7, 8	598070.11	1465048.90	743.50	742.97	45.5	702.50	697.50	5	4-inch SS	BVA
0347	Parcels 6, 7, 8	597819.31	1464034.10	723.76	725.20	68.4	666.76	656.76	10	4-inch SS	BVA
0353	Phase I	596686.11	1464609.40	744.04	745.33	19.3	731.04	726.04	5	4-inch SS	Bedrock
0379	Parcels 6, 7, 8	597624.41	1464095.90	715.24	716.11	40.9	685.24	675.24	10	4-inch SS	BVA
0386	Parcels 6, 7, 8	597789.23	1463896.00	725.16	724.79	86.6	648.16	638.16	10	4-inch SS	BVA
0387	Parcels 6, 7, 8	597654.63	1463839.50	721.26	720.89	81.6	644.26	639.26	5	4-inch SS	BVA
0389	Parcels 6, 7, 8	597781.29	1463891.90	724.96	724.65	51.7	682.96	672.96	10	4-inch SS	BVA
0392	Parcels 6, 7, 8	597648.77	1463838.30	721.18	720.84	44.7	681.18	676.18	5	4-inch SS	BVA
0400	Phase I	596122.80	1464333.10	703.22	705.11	34.4	680.72	670.72	10	2-inch SS	BVA
0402	Phase I	596407.78	1464208.00	702.48	704.02	32.3	681.74	671.74	10	2-inch SS	BVA
0411	Phase I	596808.81	1465077.10	834.83	836.57	39.7	806.89	796.89	10	2-inch SS	Bedrock
0443	Phase I	596886.22	1465177.11	856.89	858.78	39.6	829.20	819.20	10	2-inch PVC	Bedrock
0444	Phase I	596463.35	1465001.58	770.71	773.00	32.8	750.20	740.20	10	2-inch PVC	Bedrock
0445	Phase I	596448.12	1464738.54	741.29	743.43	42.5	710.93	700.93	10	2-inch PVC	Bedrock
P033	Phase I	596208.15	1464233.80	706.03	705.83	24.8	686.03	681.03	5	2-inch PVC	BVA
P064	Phase I	596106.72	1464537.47	726.82	729.98	56.9	680.08	670.08	10	2-inch PVC	BVA
0601	Parcels 6, 7, 8	598743.22	1464280.80	817.52						Seep	Bedrock
0602	Parcels 6, 7, 8	598346.65	1465311.40	779.61						Seep	Bedrock
0605	Parcels 6, 7, 8	599824.63	1464935.40	817.70						Seep	Bedrock
0606	Parcels 6, 7, 8	699971.45	1464989.00	789.23						Seep	Bedrock
0607	Parcels 6, 7, 8	600015.30	1465105.70	797.00						Seep	Bedrock
0617	Phase I	596539.80	1464855.80	766.07						Seep	Bedrock

Abbreviations:
PVC = polyvinyl chloride; SS = stainless steel; TOC = top of casing

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Appendix B

Mann-Kendall Trending Summaries

Mann-Kendall Test for Monotonic Trend (from Visual Sample Plan [VSP] software version 7.10, software copyright 2018 Battelle Memorial Institute)

The purpose of the Mann-Kendall (MK) test (Mann 1945, Kendall 1975, Gilbert 1987) is to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time. A monotonic upward (downward) trend means that the variable consistently increases (decreases) through time, but the trend may or may not be linear.

Selected Statistical Testing Approach

The MK test can be used in place of a parametric linear regression analysis that is used to test if the slope of the estimated linear regression line is different from zero. The regression analysis requires that the residuals from the fitted regression line be normally distributed, an assumption not required by the MK test. Hence, the MK test is a nonparametric (distribution-free) test.

Calculations to Determine Whether a Trend Exists

The MK test is used to decide whether to reject the null hypothesis (H_o) that no monotonic trend exists in favor of the alternative hypothesis (H_a) that a monotonic trend exists.

One of three alternative hypotheses is chosen:

1. A monotonic downward trend exists
2. Either a monotonic upward or monotonic downward trend exists
3. A monotonic upward trend exists

The data obtained over time must be convincing beyond a reasonable doubt before the MK test will reject the H_o and accept the H_a hypothesis.

The MK test is conducted as follows (from Gilbert 1987, pp. 209–213):

1. List the data in the order in which they were collected over time, $x_1, x_2, \ldots, x_n$, which denote the measurements obtained at times 1, 2, …, n, respectively. The data are not necessarily (and need not be) collected at equally spaced time intervals, although equally spaced sampling over time is often preferred.

2. Determine the sign of all $n(n-1)/2$ possible differences $x_j - x_k$, where $j > k$. These differences are

   $$x_2 - x_1, x_3 - x_1, \ldots, x_n - x_1, x_3 - x_2, x_4 - x_2, \ldots, x_n - x_{n-2}, x_n - x_{n-1}$$

3. Let $\text{sgn}(x_j - x_k)$ be an indicator function that takes on the values 1, 0, or –1 according to the sign of $x_j - x_k$, that is:

   $$\text{sgn}(x_j - x_k) = 1 \qquad \text{if } x_j - x_k > 0$$

$\text{sgn}(x_j - x_k) = 0 \qquad \text{if } x_j - x_k = 0,$
or if the sign of $x_j - x_k$ cannot be determined
due to nondetects

$\text{sgn}(x_j - x_k) = -1 \qquad \text{if } x_j - x_k < 0$

For example, if $x_j - x_k > 0$, then the observation at time j, denoted by x_j, is greater than the observation at time k, denoted by x_k.

4. Compute

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(x_j - x_k)$$

which is the number of positive differences minus the number of negative differences. If S is a positive number, observations obtained later in time tend to be *larger* than observations made earlier. If S is a negative number, then observations made later in time tend to be *smaller* than observations made earlier.

5. If $n \leq 10$, follow the procedure described in Gilbert (1987, page 209, Section 16.4.1) by looking up S in a table of probabilities (Gilbert 1987, Table A18, page 272). If this probability is less than α (the probability of concluding a trend exists when there is none), then reject the null hypothesis and conclude the trend exists. If n cannot be found in the table of probabilities (which can happen if there are tied data values), the next value farther from zero in the table is used. For example, if $S = 12$ and there is no value for $S = 12$ in the table, it is handled the same as $S = 13$.

   If $n > 10$, continue with steps 6 through 8 to determine whether a trend exists. This follows the procedure described in Gilbert (1987, page 211, Section 16.4.2).

6. Compute the variance of S as follows:

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p - 1)(2t_p + 5)\right]$$

where g is the number of tied groups and t_p is the number of observations in the pth group. For example, in the sequence of measurements in time (23, 24, 29, 6, 29, 24, 24, 29, 23) we have $g = 3$ tied groups, for which $t_1 = 2$ for the tied value 23, $t_2 = 3$ for the tied value 24, and $t_3 = 3$ for the tied value 29.

7. Compute the MK test statistic, Z_{MK}, as follows:

$$Z_{MK} = \frac{S-1}{\sqrt{VAR(S)}} \quad \text{if} \quad S > 0$$

$$Z_{MK} = 0 \quad \text{if} \quad S = 0$$

$$Z_{MK} = \frac{S+1}{\sqrt{VAR(S)}} \quad \text{if} \quad S < 0$$

A positive value of Z_{MK} indicates that the data tend to increase with time; a negative value of Z_{MK} indicates that the data tend to decrease with time.

8. Finally, the hypothesis is tested. H_o is rejected and H_a is accepted if $Z_{MK} \leq -Z_{1-\alpha}$ where:

- H_o (null hypothesis): no monotonic trend exists
- H_a (alternative hypothesis): a downward monotonic trend exists

Alpha (α) is the Type I error rate, which is the user-specified small probability that can be tolerated that the MK test will falsely reject the null hypothesis (i.e., will conclude a trend exists when there is none)

$Z_{1-\alpha}$ is the $100(1 - \alpha)^{th}$ percentile of the standard normal distribution. For example, if $\alpha = 0.05$, then $Z_{1-\alpha} = 1.64485$. Values of $Z_{1-\alpha}$ are provided in many statistics books (for example, Gilbert 1987, Table A1, page 254) and statistical software packages.

The following parameters were used, as specified by the VSP user:

alpha (α)	0.05 (5%)
beta (β)	0.1 (10%)
standard deviation of residuals from trend line	3%

Assumptions

The following assumptions underlie the MK test:

1. When no trend is present, the measurements (observations or data) obtained over time are independent and identically distributed. The assumption of independence means that the observations are not serially correlated over time.
2. The observations obtained over time are representative of the true conditions at sampling times.
3. The sample collection, handling, and measurement methods provide unbiased and representative observations of the underlying populations over time.

The MK test does not require that the measurements or the residuals about a trend line be normally distributed or that the trend, if present, be linear. However, when VSP computes the number of samples required to detect a linear trend, VSP assumes that the residuals about an assumed linear trend line are normally distributed, as explained previously.

The MK test can be computed if there are missing values (no measurements for some sampling times), but the performance of the test will be adversely affected. The assumption of independence requires that the time between samples be sufficiently long so that there is no correlation between measurements collected at different times. Consult Helsel (2005, pp. 209–215) for doing nonparametric regression (trend) analyses when data are less than one or more detection limits.

References

Cleveland, W.S., 1979. “Robust Locally Weighted Regression and Smoothing Scatterplots,” *Journal of the American Statistical Association* 74(368):829–836.

Gilbert, R.O., 1987. *Statistical Methods for Environmental Pollution Monitoring,* Wiley & Sons, New York.

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Hirsch, R.M., J.R. Slack, and R.A. Smith, 1982. “Techniques of trend analysis for monthly water quality data,” *Water Resources Research* 18(1):107–121.

Kendall, M.G., 1975. *Rank Correlation Methods*, 4th ed., Charles Griffin, London.

Mann, H.B., 1945. “Non-parametric tests against trend,” *Econometrica* 13:163–171.

Data Analysis for Seep 0601 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	Trichloroethene		Time	Trichloroethene		Time	Trichloroethene
1/31/2012	4.16		2/19/2014	1.98		1/25/2016	6.52
4/25/2012	0.16		5/12/2014	2.8		4/25/2016	7.3
7/24/2012	0.16		8/26/2014	6.73		7/25/2016	5.28
10/25/2012	10.3		10/27/2014	8.03		10/24/2016	7.85
2/11/2013	6.3		1/29/2015	6.68		2/6/2017	7.15
5/30/2013	6.1		4/27/2015	3.98		5/2/2017	3.62
8/27/2013	6.52		7/29/2015	6.94		7/25/2017	6.26
10/28/2013	7.34		10/28/2015	1.04		11/7/2017	3.72

SUMMARY STATISTICS for Trichloroethene								
n	24							
Min	-2.647699							
Max	1.459651							
Range	4.1073							
Mean	0							
Median	0.2786674							
Variance	1.0615							
StdDev	1.0303							
Std Error	0.21031							
Skewness	-1.4373							
Interquartile Range	1.1617							
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
-2.648	-2.634	-2.051	-0.4128	0.2787	0.7489	0.8973	1.32	1.46

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

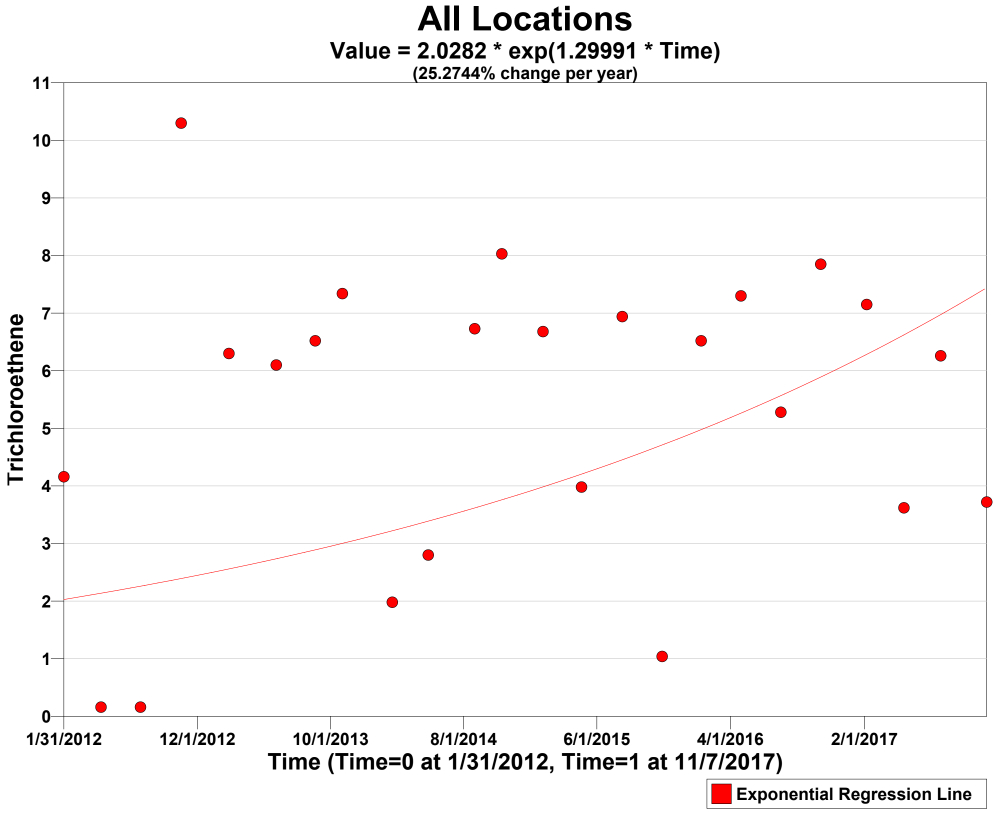
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

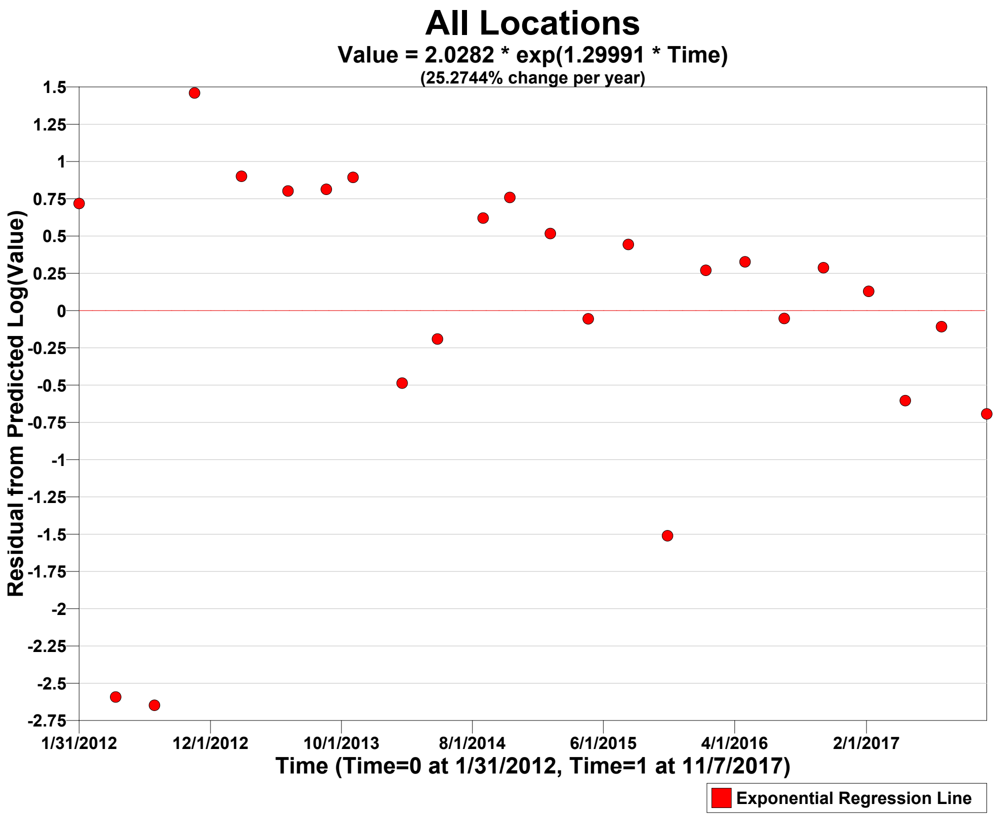
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

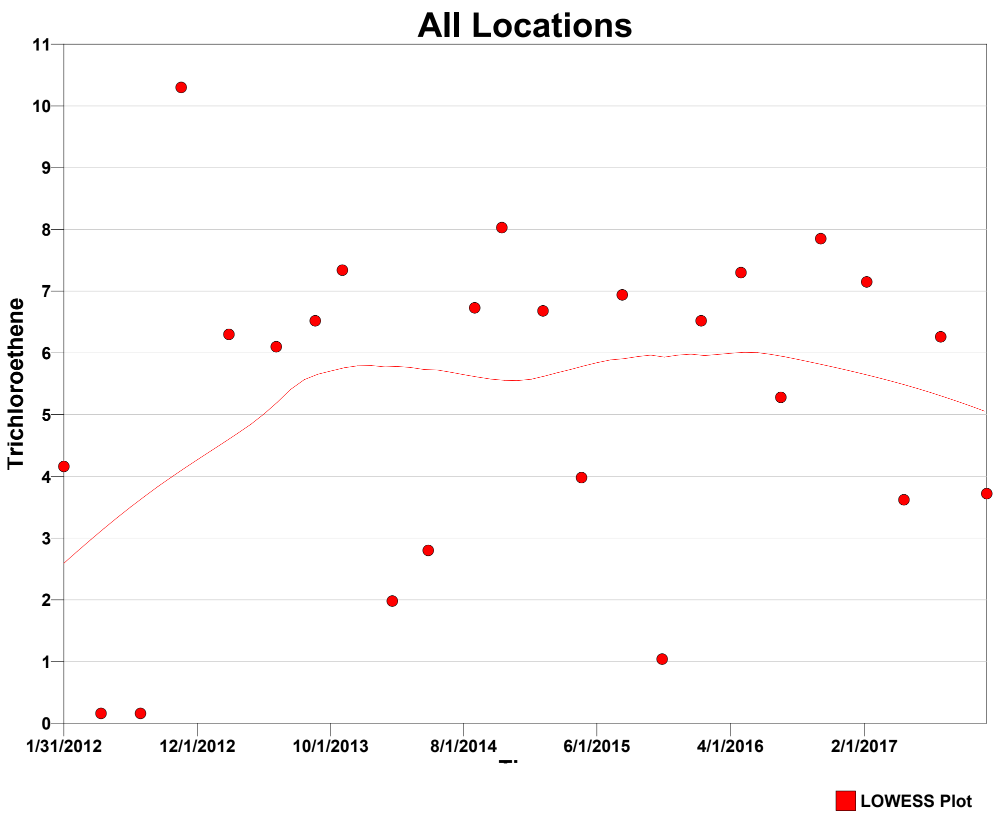
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 2.0282 * exp(1.29991 * Time)
(25.2744% change per year)
Residual from Predicted Log(Value)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
-2.75
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 1/31/2012, Time=1 at 11/7/2017)
Exponential Regression Line


All Locations
Trichloroethene
11
10
9
8
7
6
5
4
3
2
1
0
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=24) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.85549
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	28	
MK Test Statistic	Z_{MK}	0.670131	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	28	
MK Test Statistic	Z_{MK}	0.670131	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

This report was automatically produced* by Visual Sample Plan (VSP) software version 7.10.

This design was last modified 3/23/2018 5:09:03 PM.

Software and documentation available at http://vsp.pnnl.gov

* - The report contents may have been modified or reformatted by end-user of software.

Data Analysis for Seep 0601 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/17/2005	4.3		7/29/2009	5.71		2/19/2014	1.98
5/17/2005	4.7		10/26/2009	5.97		5/12/2014	2.8
7/28/2005	4.9		1/25/2010	1.95		8/26/2014	6.73
11/3/2005	5.8		5/5/2010	0.11		10/27/2014	8.03
1/30/2006	4.8		7/26/2010	7.46		1/29/2015	6.68
5/18/2006	3.9		10/25/2010	7.48		4/27/2015	3.98
9/26/2006	8		1/25/2011	3.94		7/29/2015	6.94
12/5/2006	6.18		5/10/2011	4.62		10/28/2015	1.04
2/27/2007	5.08		7/27/2011	5.78		1/25/2016	6.52
5/17/2007	6.32		10/25/2011	4.95		4/25/2016	7.3
8/22/2007	6.84		1/31/2012	4.16		7/25/2016	5.28
11/29/2007	5.25		4/25/2012	0.16		10/24/2016	7.85
2/28/2008	3.41		7/24/2012	0.16		2/6/2017	7.15
5/19/2008	3.63		10/25/2012	10.3		5/2/2017	3.62
8/4/2008	5.83		2/11/2013	6.3		7/25/2017	6.26
11/17/2008	4.82		5/30/2013	6.1		11/7/2017	3.72
2/9/2009	3.55		8/27/2013	6.52			
5/5/2009	5.28		10/28/2013	7.34			

SUMMARY STATISTICS for Trichloroethene								
n				52				
Min				-3.629486				
Max				0.9147347				
Range				4.5442				
Mean				0				
Median				0.2467825				
Variance				0.87328				
StdDev				0.93449				
Std Error				0.12959				
Skewness				-2.9013				
Interquartile Range				0.54462				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-3.629	-3.251	-0.748	-0.0641	0.2468	0.4805	0.59	0.6574	0.9147

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme

cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

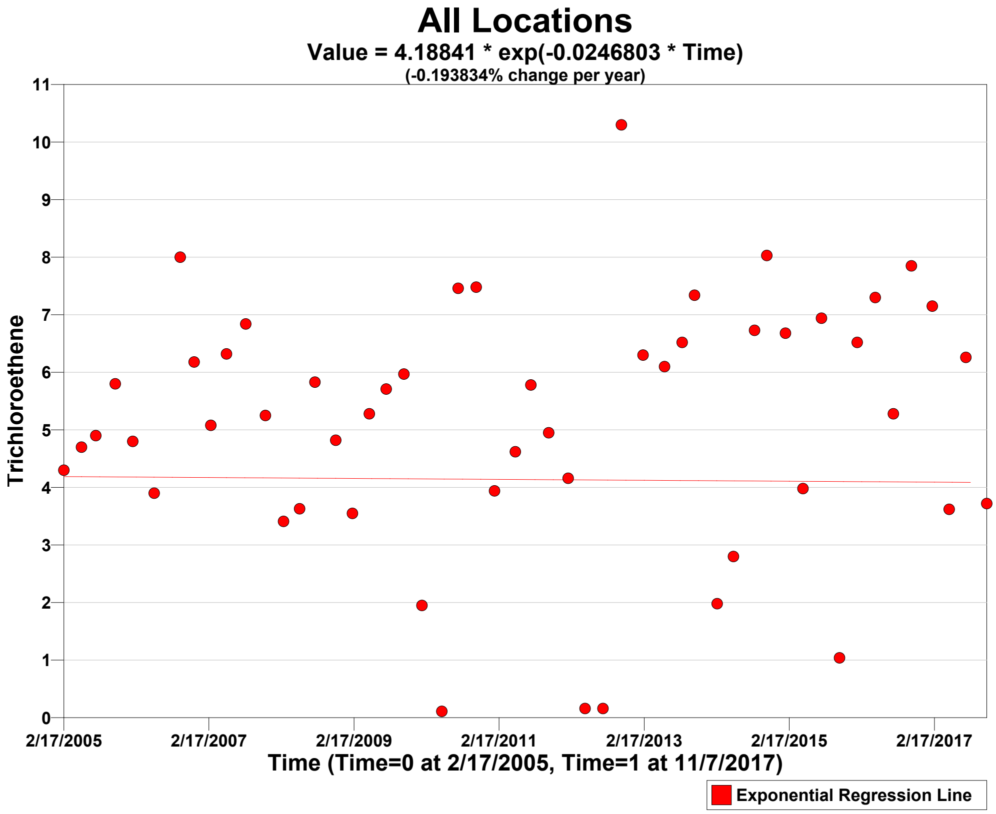
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

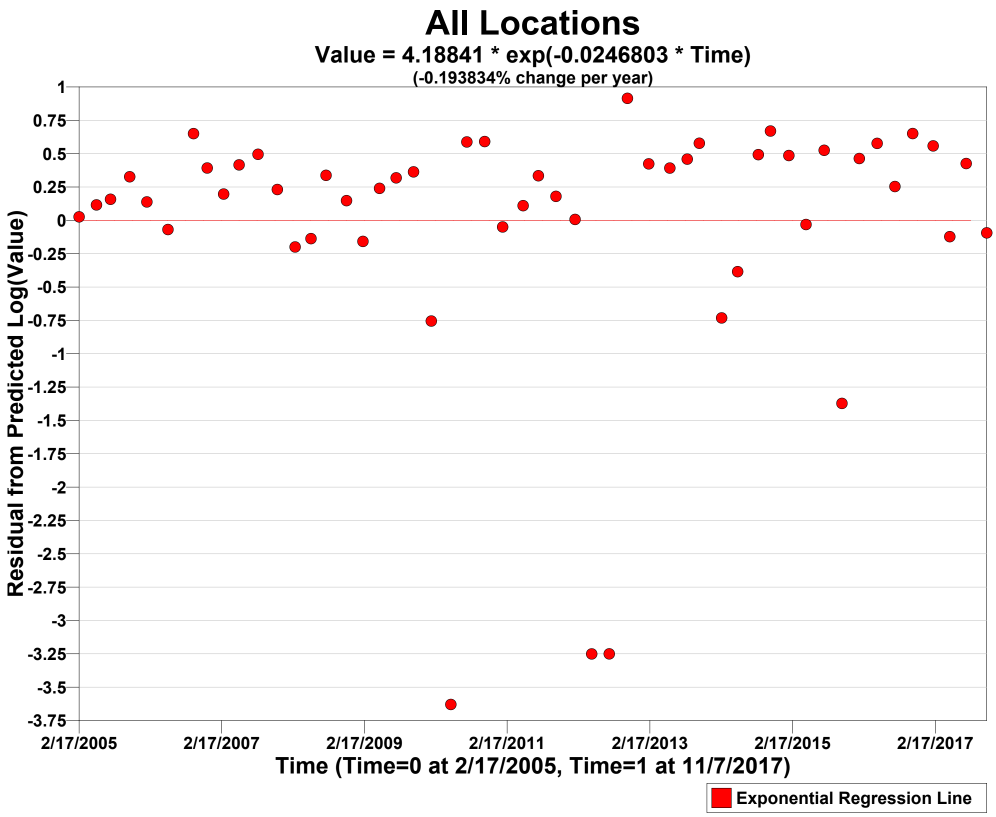
Data Plots

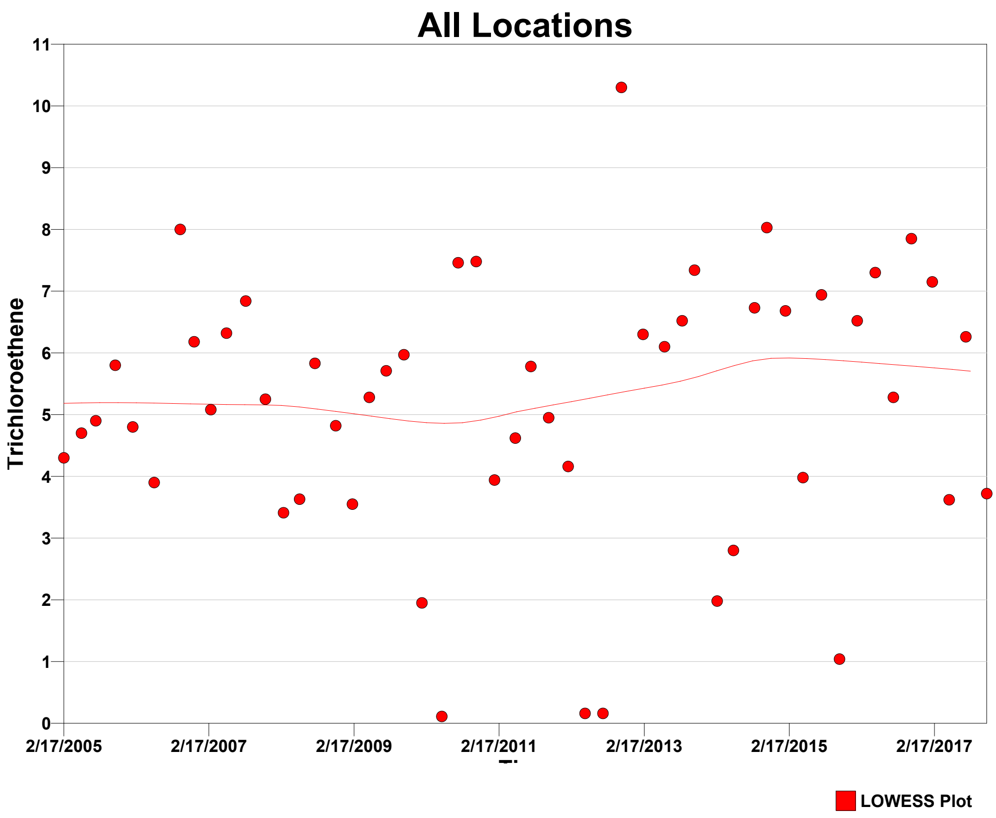
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 4.18841 * exp(-0.0246803 * Time)
(-0.193834% change per year)
Residual from Predicted Log(Value)
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
-2.75
-3
-3.25
-3.5
-3.75
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
11
10
9
8
7
6
5
4
3
2
1
0
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=52) is greater than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Lilliefors Test Statistic	0.28076
Lilliefors 5% Critical Value	0.12287

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	147	
MK Test Statistic	Z_{MK}	1.1522	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	147	
MK Test Statistic	Z_{MK}	1.1522	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

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Data Analysis for Seep 0601 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations					
Time	**Tritium**	**Time**	**Tritium**	**Time**	**Tritium**
2/17/2005	361200	5/19/2008	68100	10/25/2011	46200
5/17/2005	450460	8/4/2008	133000	1/31/2012	26800
5/26/2005	525340	11/17/2008	82900	4/25/2012	49200
7/28/2005	789040	2/9/2009	46300	7/24/2012	53200
11/3/2005	463100	5/5/2009	67100	2/11/2013	26300
1/30/2006	178480	7/29/2009	104000	8/27/2013	46900
5/18/2006	99900	10/26/2009	64500	2/19/2014	11000
9/26/2006	204000	1/25/2010	27400	8/26/2014	36900
12/5/2006	123000	5/5/2010	89.3	1/29/2015	22300
2/27/2007	117000	7/26/2010	68100	7/29/2015	29000
5/17/2007	146000	10/25/2010	96100	1/25/2016	23500
8/22/2007	161000	1/25/2011	38300	7/25/2016	29200
11/29/2007	88000	5/10/2011	32700	2/6/2017	19200
2/28/2008	61200	7/27/2011	54000	7/25/2017	16300

SUMMARY STATISTICS for Tritium	
n	42
Min	-138401.8
Max	526812
Range	6.6521e+005
Mean	0
Median	-34863.01
Variance	1.5436e+010
StdDev	1.2424e+005
Std Error	19171
Skewness	2.2325
Interquartile Range	1.3095e+005

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.384e+005	-1.236e+005	-1.107e+005	-8.153e+004	-3.486e+004	4.941e+004	1.608e+005	2.506e+005	5.268e+005

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
7/28/2005	789040
1/30/2006	178480
5/18/2006	99900
12/5/2006	123000

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

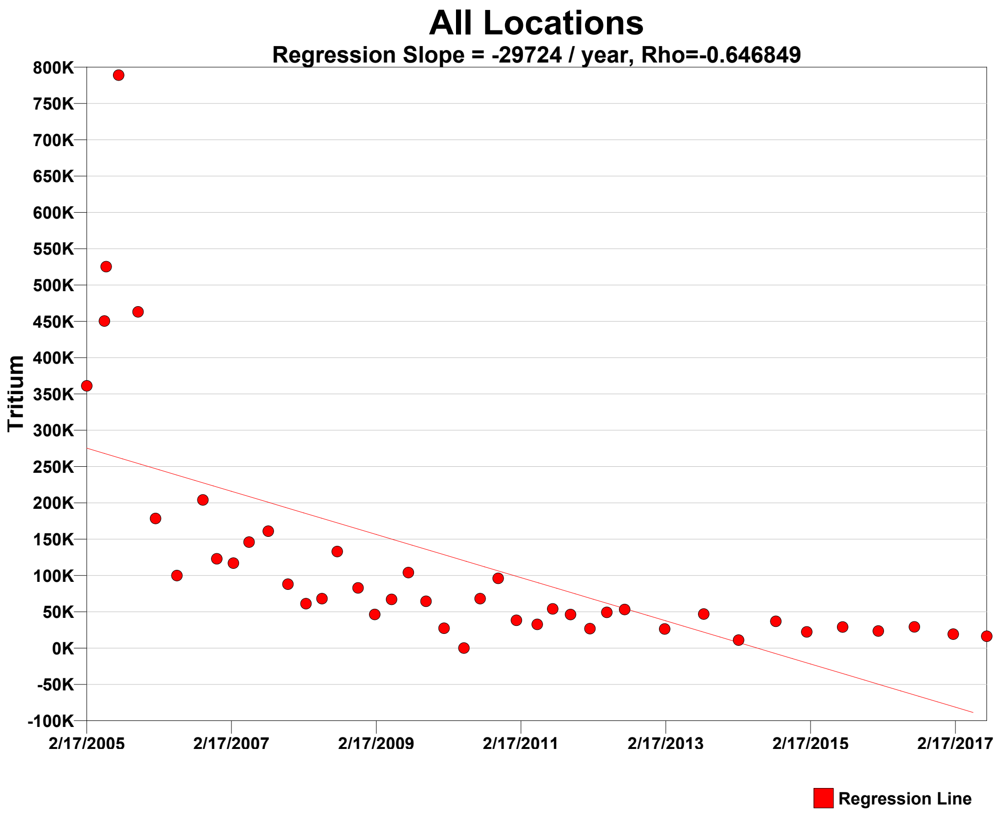
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

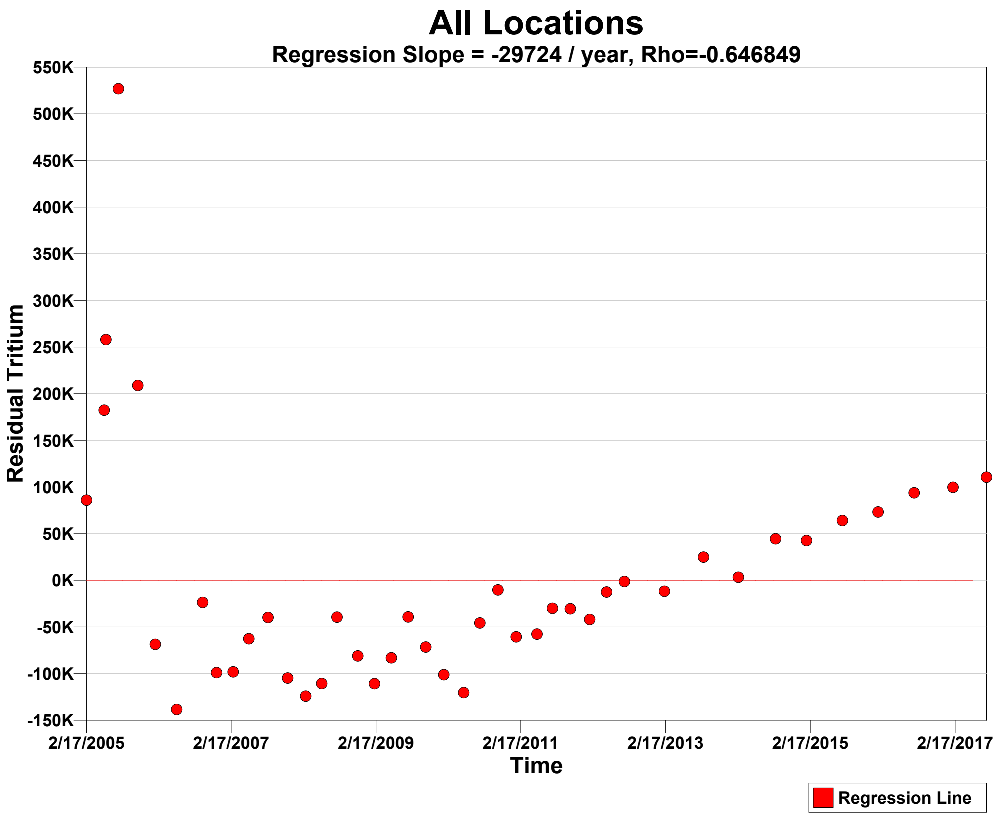
Data Plots

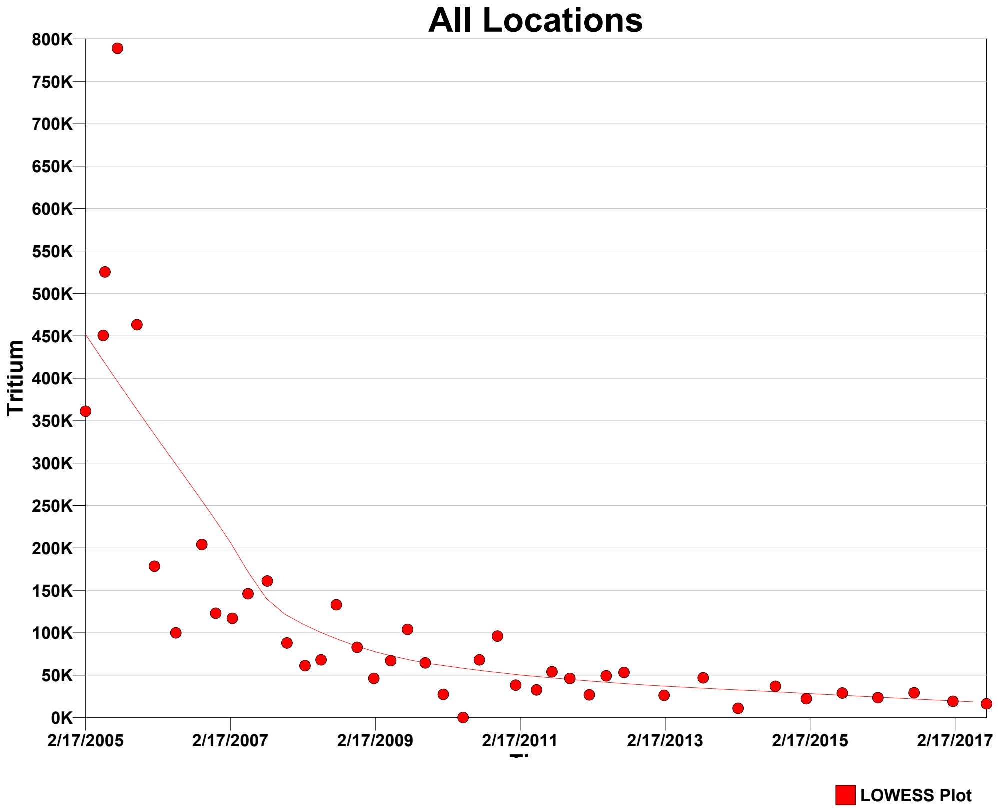
The Time vs. Measured Values Plot shows the best fitting 'least squares' linear line to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The slope of the linear line estimates the change in the data per unit time. If the linear line is a good fit to the data, then the slope of the line is an estimate of the linear trend over time in the data. If a linear line is not a good fit to the data, but an upward (or downward) tendency in the data is present, then a nonparametric estimator of monotonic change over time may be preferred to the estimated ï¿½least squaresï¿½ slope obtained assuming that a linear change over time is occurring.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the "least squares" linear line described above. The horizontal line at value zero represents a perfect fit (no difference) to the "least squares" linear line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Regression Slope = -29724 / year, Rho=-0.646849
Residual Tritium
550K
500K
450K
400K
350K
300K
250K
200K
150K
100K
50K
0K
-50K
-100K
-150K
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time
🟥 Regression Line


All Locations
Tritium
800K
750K
700K
650K
600K
550K
500K
450K
400K
350K
300K
250K
200K
150K
100K
50K
0K
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=42) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.78289
Shapiro-Wilk 5% Critical Value	0.942

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-614	
MK Test Statistic	Z_{MK}	-6.64371	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0602 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	Trichloroethene		Time	Trichloroethene		Time	Trichloroethene
1/31/2012	22.2		1/29/2015	19		10/24/2016	10
2/11/2013	32.6		4/27/2015	21.4		2/6/2017	4.58
10/28/2013	4.58		10/28/2015	14.7		5/2/2017	13.6
2/19/2014	23.6		1/25/2016	12.8		7/25/2017	2.78
5/12/2014	23.5		4/25/2016	6.66		11/7/2017	12.5

SUMMARY STATISTICS for Trichloroethene								
n	15							
Min	-1.372959							
Max	0.5612171							
Range	1.9342							
Mean	0							
Median	0.2547848							
Variance	0.35857							
StdDev	0.59881							
Std Error	0.15461							
Skewness	-1.2426							
Interquartile Range	0.84901							
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
-1.373	-1.373	-1.154	-0.4231	0.2548	0.4259	0.5401	0.5612	0.5612

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	Value
10/28/2013	4.58

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

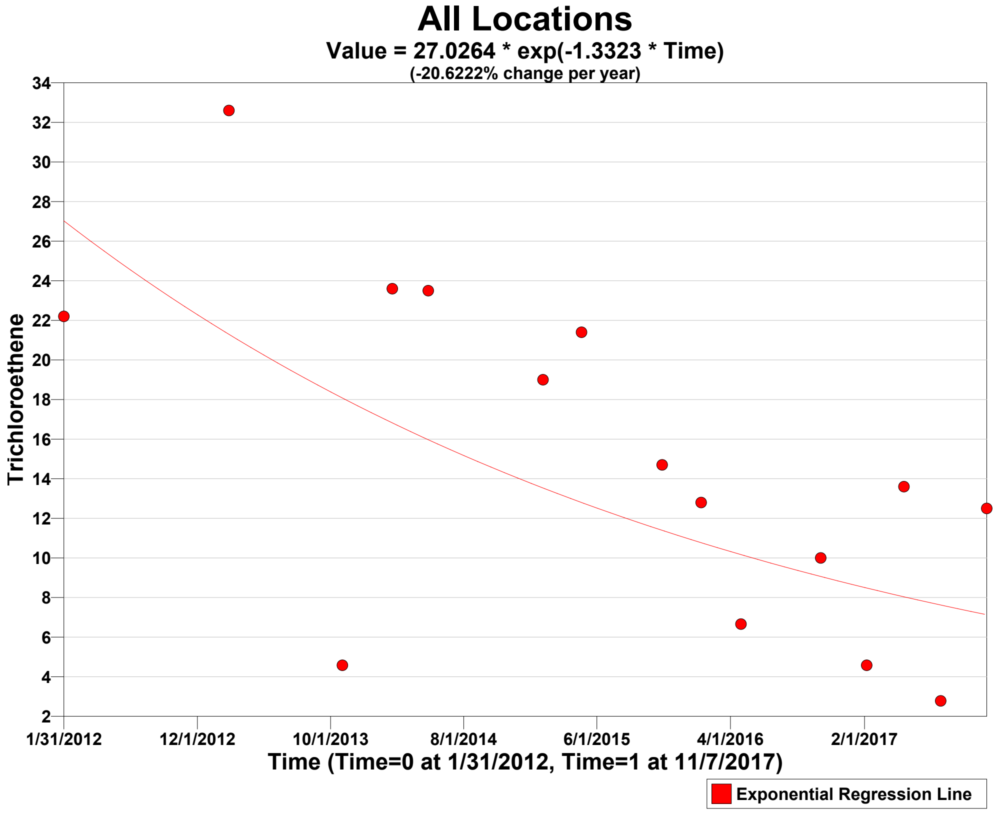
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

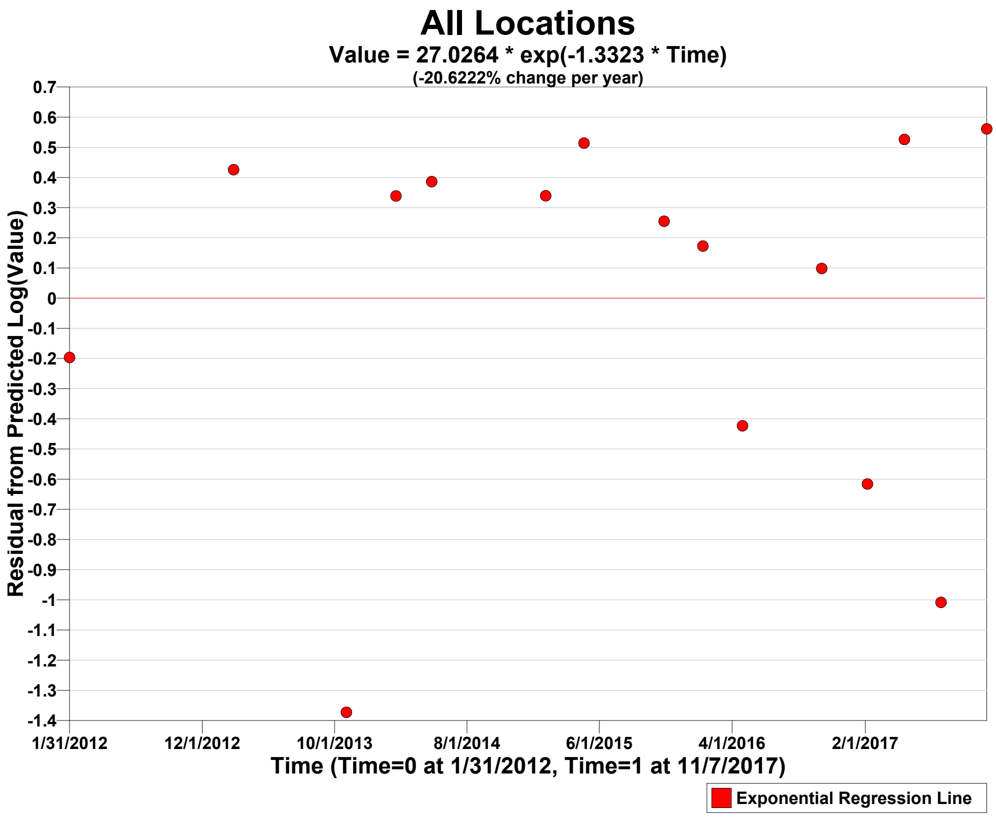
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

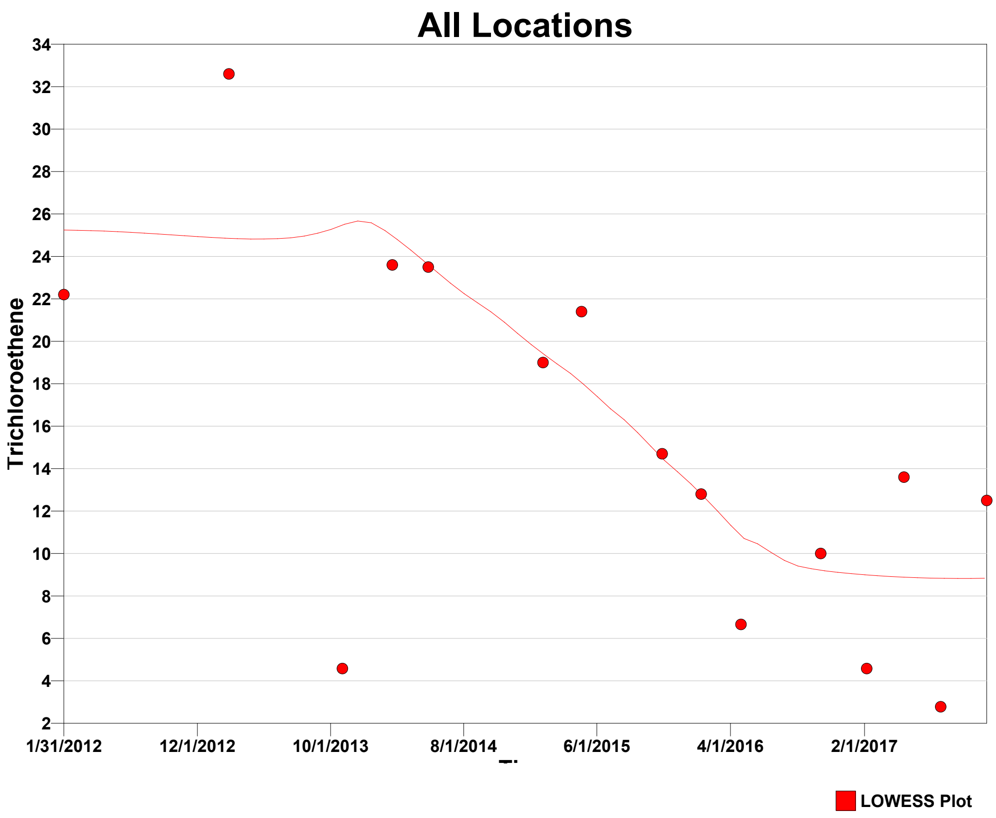
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 27.0264 * exp(-1.3323 * Time)
(-20.6222% change per year)
Residual from Predicted Log(Value)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
-1.4
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 1/31/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=15) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.83884
Shapiro-Wilk 5% Critical Value	0.881

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-58	
MK Test Statistic	Z_{MK}	-2.82423	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Mann-Kendall Test for Monotonic Trend

Summary

This report summarizes the sampling design used, associated statistical assumptions, and the method of data analysis. Sampling plan components presented here include the data quality objectives and how many samples are needed to detect a monotonic trend while meeting those objectives.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Determine if there is a monotonic trend over time
Type of Test for Trend	Nonparametric
Working (Null) Hypothesis	There is no monotonic trend
Alternative Hypothesis	A downward monotonic trend exists
Method for detecting whether a trend exists	Mann-Kendall Nonparametric Test
Method of calculating number of samples needed to detect a trend	Monte-Carlo simulation using Mann-Kendall test
Time between samples (Sample Period)	3 months
Number of samples needed to detect a trend of -1 per year within tolerable error limits [a]	26

[a] See *Calculation of Number of Samples Required to Detect a Trend* section below for details.

Primary Sampling Objective

The purpose of the Mann-Kendall (MK) test (Mann 1945, Kendall 1975, Gilbert 1987) is to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time. A monotonic upward (downward) trend means that the variable consistently increases (decreases) through time, but the trend may or may not be linear.

Selected Statistical Testing Approach

The MK test can be used in place of a parametric linear regression analysis that is used to test if the slope of the estimated linear regression line is different from zero. The regression analysis requires that the residuals from the fitted regression line be normally distributed; an assumption not required by the MK test. Hence, the MK test is a non-parametric (distribution-free) test.

Hirsch, Slack and Smith (1982, page 107) indicate that the MK test is best viewed as an exploratory analysis and is most appropriately used to identify and quantify changes over time at sampling stations.

Calculations to Determine Whether a Trend Exists

The MK test is used to decide whether to reject the null hypothesis (H_o) that no monotonic trend exists in favor of the alternative hypothesis (H_a) that a monotonic trend exists.

One of three alternative hypotheses is chosen:

1. A monotonic downward trend exists
2. Either a monotonic upward or monotonic downward trend exists
3. A monotonic upward trend exists

For the current design, the 1st option (a downward trend) was chosen.

The data obtained over time must be convincing beyond a reasonable doubt before the MK test will reject the H_o and accept the H_a.

The MK test is conducted as follows (from Gilbert 1987, pp. 209-213):

1. List the data in the order in which they were collected over time, $x_1, x_2, \ldots, x_n$, which denote the measurements obtained at times 1, 2, ï¿½, n, respectively. The data are not necessarily (and need not be) collected at equally spaced time intervals, although equally spaced sampling over time is often preferred.

2. Determine the sign of all *n(n-1)/2* possible differences $x_j - x_k$, where j > k. These differences are

   $x_2\text{-}x_1, x_3\text{-}x_1, \ldots, x_n\text{-}x_1, x_3\text{-}x_2, x_4\text{-}x_2, \ldots, x_n\text{-}x_{n-2}, x_n\text{-}x_{n-1}$

3. Let $\mathrm{sgn}(x_j - x_k)$ be an indicator function that takes on the values 1, 0, or -1 according to the sign of $x_j - x_k$, that is,

   $\mathrm{sgn}(x_j - x_k) = 1$ if $x_j - x_k > 0$
   $\mathrm{sgn}(x_j - x_k) = 0$ if $x_j - x_k = 0$, or if the sign of $x_j - x_k$ cannot be determined due to non-detects
   $\mathrm{sgn}(x_j - x_k) = -1$ if $x_j - x_k < 0$

   For example, if $x_j - x_k > 0$, then the observation at time j, denoted by x_j, is greater than the observation at time k, denoted by x_k.

4. Compute

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \mathrm{sgn}(x_j - x_k) \qquad (1)$$

   which is the number of positive differences minus the number of negative differences. If S is a positive number, observations obtained later in time tend to be *larger* than observations made earlier. If S is a negative number, then observations made later in time tend to be *smaller* than observations made earlier.

5. If $n \le 10$, follow the procedure described in Gilbert (1987, page 209, Section 16.4.1) by looking up S in a table of probabilities (Gilbert 1987, Table A18, page 272). If this probability is less than α (the probability of concluding a trend exists when there is none), then reject the null hypothesis and conclude the trend exists. If *n* cannot be found in the table of probabilities (which can happen if there are tied data values), the next value farther from zero in the table is used. For example, if S=12 and there is no value for S=12 in the table, it is handled the same as S=13.

   If *n*>10, continue with steps 6 through 8 to determine whether a trend exists. This follows the procedure described in Gilbert (1987, page 211, Section 16.4.2).

6. Compute the variance of S as follows:

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p - 1)(2t_p + 5) \right] \qquad (2)$$

   where g is the number of tied groups and t_p is the number of observations in the p^{th} group. For example, in the sequence of measurements in time (23, 24, 29, 6, 29, 24, 24, 29, 23) we have g = 3 tied groups, for which t_1=2 for the tied value 23, t_2=3 for the tied value 24, and t_3=3 for the tied value 29.

7. Compute the MK test statistic, Z_{MK}, as follows:

$$Z_{MK} = \frac{S-1}{\sqrt{VAR(S)}} \quad \text{if} \quad S > 0$$

$$= 0 \quad \text{if} \quad S = 0 \qquad (3)$$

$$= \frac{S+1}{\sqrt{VAR(S)}} \quad \text{if} \quad S < 0$$

A positive value of Z_{MK} indicates that the data tend to increase with time; a negative value of Z_{MK} indicates that the data tend to decrease with time.

8. Finally, the hypothesis is tested. H_o is rejected and H_a is accepted if $Z_{MK} \leq -Z_{1-\alpha}$ where:

H_o (null hypothesis): no monotonic trend exists

H_a (alternative hypothesis): a downward monotonic trend exists

Alpha (α) is the Type I error rate, which is the user-specified small probability that can be tolerated that the MK test will falsely reject the null hypothesis (i.e. will conclude a trend exists when there is none)

$Z_{1-\alpha}$ is the $100(1-\alpha)^{th}$ percentile of the standard normal distribution. For example, if $\alpha = 0.05$, then $Z_{1-\alpha} = 1.64485$. Values of $Z_{1-\alpha}$ are provided in many statistics books (for example Gilbert 1987, Table A1, page 254) and statistical software packages.

Calculation of Number of Samples Required to Detect a Trend
VSP uses a Monte-Carlo simulation to determine the required number of points in time, n, to take a measurement in order to detect a trend for specified small probabilities that the MK test will make decision errors. If a non-linear trend is actually present, then the value of n computed by VSP is only an approximation to the correct n. The simulation, which is a binary search on the number of samples needed, proceeds as follows:

1. The required probability of detecting a trend (if present) is set at $1-\beta$ where β is the user-specified probability of falsely accepting the null hypothesis.

2. The required number of samples, n, is initially set to 4, which is the minimum number of samples that can be analyzed using the Mann-Kendall test.

3. A set of n numbers ($x_1, x_2, x_3, \ldots, x_n$) is created that conforms to an exponential curve, but has random deviations from that curve. The exponential curve is defined by the user in terms of percent change (negative or positive) per unit time. The user also indicates the standard deviation of normally distributed residuals about the trend. This standard deviation is also specified as a percentage.

Since the exponential curve represents a straight-line on the log scale, the data points are found on the natural log scale then converted to real space for use in the Mann-Kendall test.

a. A set of *n* numbers ($r_1, r_2, r_3, \ldots, r_n$) is randomly chosen from a normal distribution having a mean of zero and a standard deviation of δ, where

$$\delta = \ln\left(\frac{100+P}{100}\right)$$

where:
ln is the natural logarithm of the quantity

P is the user-specified percent standard deviation of the residuals

b. The change per sample period on the natural log scale, Δ, is calculated based on the user-specified percent change per unit time and sample period:

$$\Delta = \ln\left(\frac{100+P}{100}\right)\frac{T_S}{T_U}$$

where:
ln is the natural logarithm of the quantity
P is the user-specified percent change per unit time
T_U is the unit time (in days)
T_S is the sample period (in days)

c. A multiple of Δ is added to each random number to create the necessary slope on the natural log scale. The resulting numbers are converted to real space by the natural antilog function: [x_1=exp(r_1), x_2=exp($r_2+\Delta$), x_3=exp($r_3+2\Delta$), ... , x_n=exp($r_n+(n-1)\Delta$)], where exp is the natural antilog function.

4. The MK test (described above) is conducted on the set of numbers (x_1, x_2, ... , x_n) using the user-specified alpha error rate (α). If the null hypothesis is rejected, which indicates that the MK test detected a trend, then one is added to the count of trend detections.

5. Steps 3 and 4 are repeated 1000 times. The count of trend detections is then divided by 1000 to compute an estimate of the probability, P_d, that the MK test will detect a trend of the magnitude specified in Step 3 above.

6. P_d is compared to 1-β. If P_d equals 1-β then the target probability of detection has been achieved with n samples. In that case the simulation ends and VSP reports that n samples are required. If $P_d < 1-\beta$ then n is increased and steps 3 through 6 are repeated. If $P_d > 1-\beta$ then n is decreased and steps 3 through 6 are repeated. The process continues until P_d equals 1-β or n does not change.

The following table summarizes the parameters used, as specified by the VSP user, and the results of the simulation:

Trend	
Change of interest to detect	-1% / year
Time between samples (Sample Period)	3 months
Parameters	
Alpha (α)	0.05 (5%)
Beta (β)	0.1 (10%)
Standard deviation of residuals from trend line	3%
Results	
Samples required, n (Sampling every 3 months)	26

Assumptions
The following assumptions underlie the MK test:

1. When no trend is present, the measurements (observations or data) obtained over time are independent and identically distributed. The assumption of independence means that the observations are not serially correlated over time.
2. The observations obtained over time are representative of the true conditions at sampling times.
3. The sample collection, handling, and measurement methods provide unbiased and representative observations of the underlying populations over time.

The MK test does not require that the measurements or the residuals about a trend tine be normally distributed or that the trend, if present, be linear. However, when VSP computes the number of samples required to detect a linear trend, VSP assumes that the residuals about an assumed linear trend line are normally distributed as explained previously.

The MK test can be computed if there are missing values (no measurements for some sampling times), but the performance of the test will be adversely affected. The assumption of independence requires that the time between samples be sufficiently long so that there is no correlation between measurements collected at different times. Consult Helsel (2005, pages 209-215) for doing nonparametric regression (trend) analyses when data are less than one or more detection limits.

Data Analysis for cDCE

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**cDCE**		**Time**	**cDCE**		**Time**	**cDCE**
5/17/2005	2.7		2/9/2009	19.1		2/19/2014	19.4
7/28/2005	8.3		5/5/2009	17.8		5/12/2014	15.2
1/30/2006	21		10/26/2009	18.1		1/29/2015	9.89
5/18/2006	19		1/25/2010	34.7		4/27/2015	7.5
9/27/2006	16		5/5/2010	12.2		10/28/2015	4.56
12/5/2006	17.8		1/25/2011	38		1/25/2016	7.35
2/27/2007	23.9		4/25/2011	8.11		4/25/2016	4.54
5/17/2007	19.7		5/10/2011	30.5		10/24/2016	14.8
11/29/2007	18.2		10/25/2011	22.6		2/6/2017	5.82
2/28/2008	30.6		1/31/2012	14.9		5/2/2017	8.74
5/19/2008	26.3		2/11/2013	42.3		7/25/2017	8.3
12/29/2008	17.9		10/28/2013	12.2		11/7/2017	8.3

SUMMARY STATISTICS for cDCE								
n				36				
Min				-2.021786				
Max				1.200695				
Range				3.2225				
Mean				0				
Median				0.05655506				
Variance				0.35339				
StdDev				0.59447				
Std Error				0.099078				
Skewness				-0.92349				
Interquartile Range				0.54695				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-2.022	-1.057	-0.8441	-0.1984	0.05656	0.3485	0.7817	1.004	1.201

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
2/11/2013	42.3

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

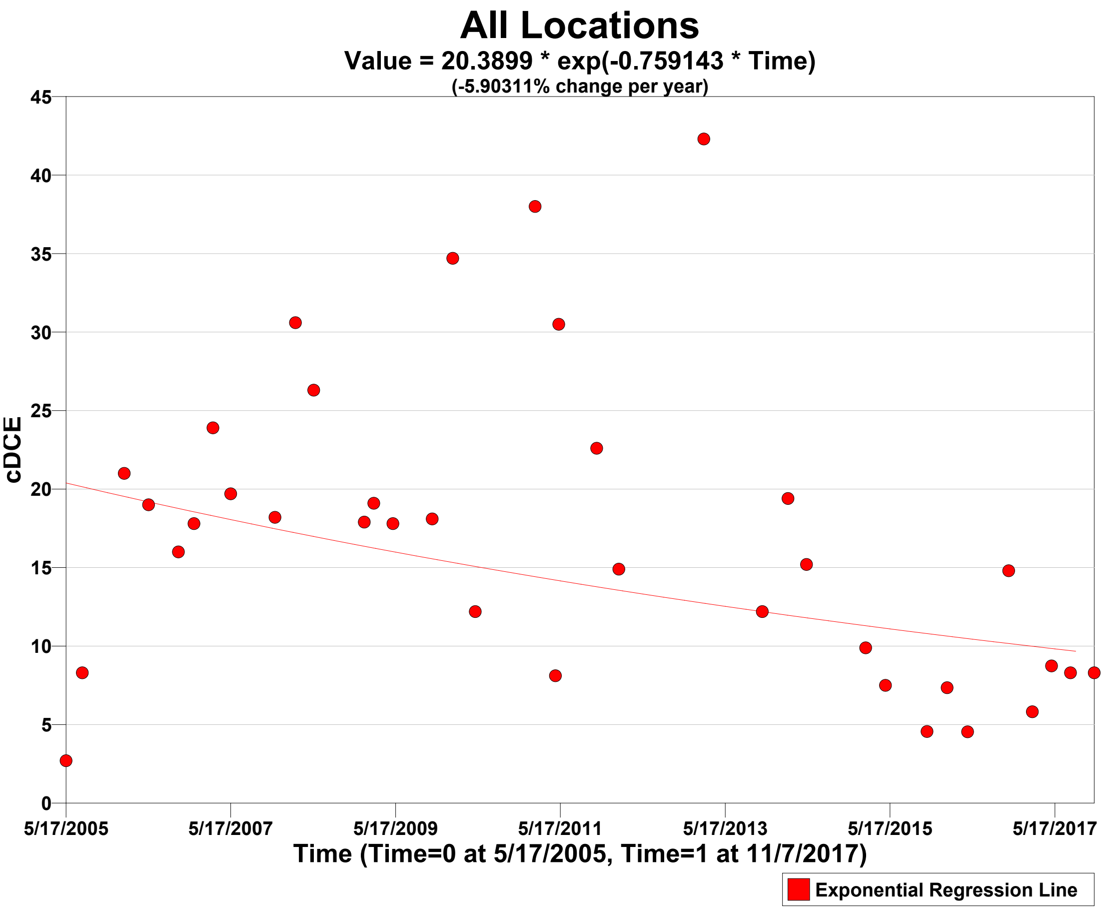
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

Data Plots

The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

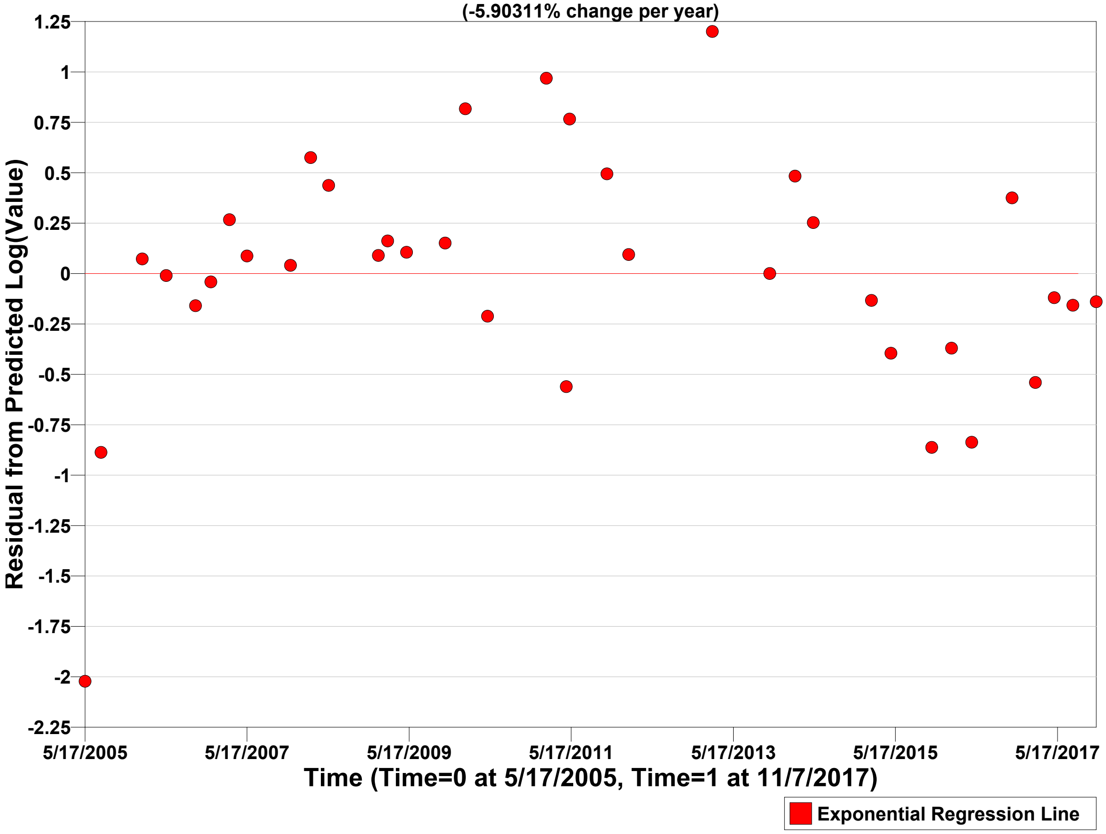
The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.

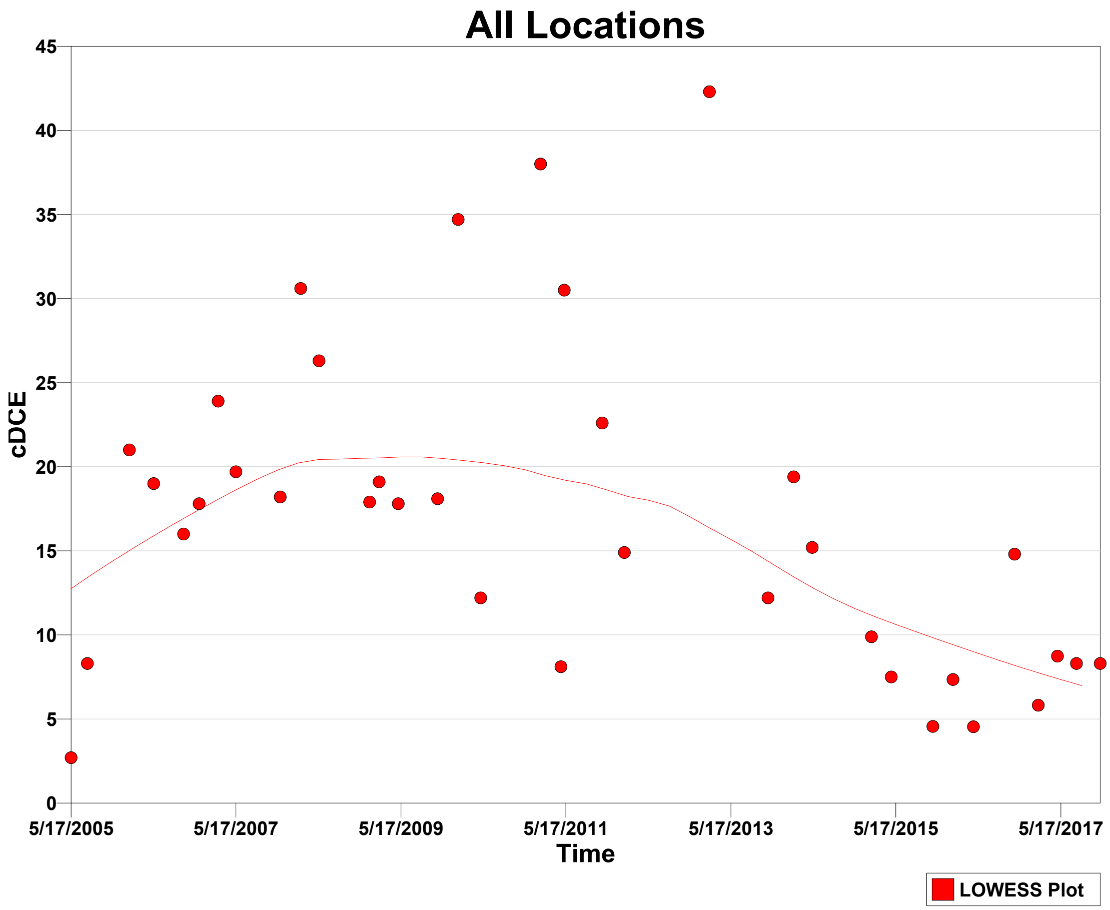

All Locations
Value = 20.3899 * exp(-0.759143 * Time)
(-5.90311% change per year)
cDCE
45
40
35
30
25
20
15
10
5
0
5/17/2005
5/17/2007
5/17/2009
5/17/2011
5/17/2013
5/17/2015
5/17/2017
Time (Time=0 at 5/17/2005, Time=1 at 11/7/2017)
Exponential Regression Line

All Locations

Value = 20.3899 * exp(-0.759143 * Time)

(-5.90311% change per year)





Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=36) is less than 50.

Normal Distribution Test of Residuals for cDCE	
Shapiro-Wilk Test Statistic	0.94484
Shapiro-Wilk 5% Critical Value	0.935

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test		
Sum of Signs	S	-185
MK Test Statistic	Z_{MK}	-2.50756
Alpha	α	0.05
Critical Value	$-Z_{1-\alpha}$	-1.64485

Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

References

Cleveland, William S., **Robust Locally Weighted Regression and Smoothing Scatterplots**, 1979, *Journal of the American Statistical Association*, Vol. 74, No. 368. p. 829-836.

Gilbert, R.O., 1987. **Statistical Methods for Environmental Pollution Monitoring**, Wiley & Sons, New York.

Helsel, D.R. 2005. **Nondetects and Data Analysis, Statistics for Censored Environmental Data**, Wiley & Sons, New York.

Hirsch, R.M., J.R. Slack, and R.A. Smith. 1982. **Techniques of trend analysis for monthly water quality data,** *Water Resources Research* 18(1):107-121.

Kendall, M.G. 1975. **Rank Correlation Methods,** 4th edition, Charles Griffin, London.

Mann, H.B. 1945. **Non-parametric tests against trend,** *Econometrica* 13:163-171.

Data Analysis for Seep 0602 - Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
5/17/2005	3.7		2/9/2009	56.1		2/19/2014	23.6
7/28/2005	6.9		5/5/2009	49.6		5/12/2014	23.5
1/30/2006	19		10/26/2009	18.9		1/29/2015	19
5/18/2006	19		1/25/2010	54.5		4/27/2015	21.4
9/27/2006	15		5/5/2010	23.3		10/28/2015	14.7
12/5/2006	25.6		1/25/2011	139		1/25/2016	12.8
2/27/2007	26.3		4/25/2011	49.9		4/25/2016	6.66
5/17/2007	27.6		5/10/2011	70.1		10/24/2016	10
11/29/2007	26.8		10/25/2011	16.9		2/6/2017	4.58
2/28/2008	63.3		1/31/2012	22.2		5/2/2017	13.6
5/19/2008	58.9		2/11/2013	32.6		7/25/2017	2.78
12/29/2008	53.4		10/28/2013	4.58		11/7/2017	12.5

SUMMARY STATISTICS for Trichloroethene								
n				36				
Min				-2.178183				
Max				1.887334				
Range				4.0655				
Mean				0				
Median				0.005048101				
Variance				0.70235				
StdDev				0.83806				
Std Error				0.13968				
Skewness				-0.46505				
Interquartile Range				1.1154				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-2.178	-1.636	-1.376	-0.4238	0.005048	0.6916	0.878	1.324	1.887

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
10/26/2009	18.9
1/25/2011	139
5/10/2011	70.1

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme

cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

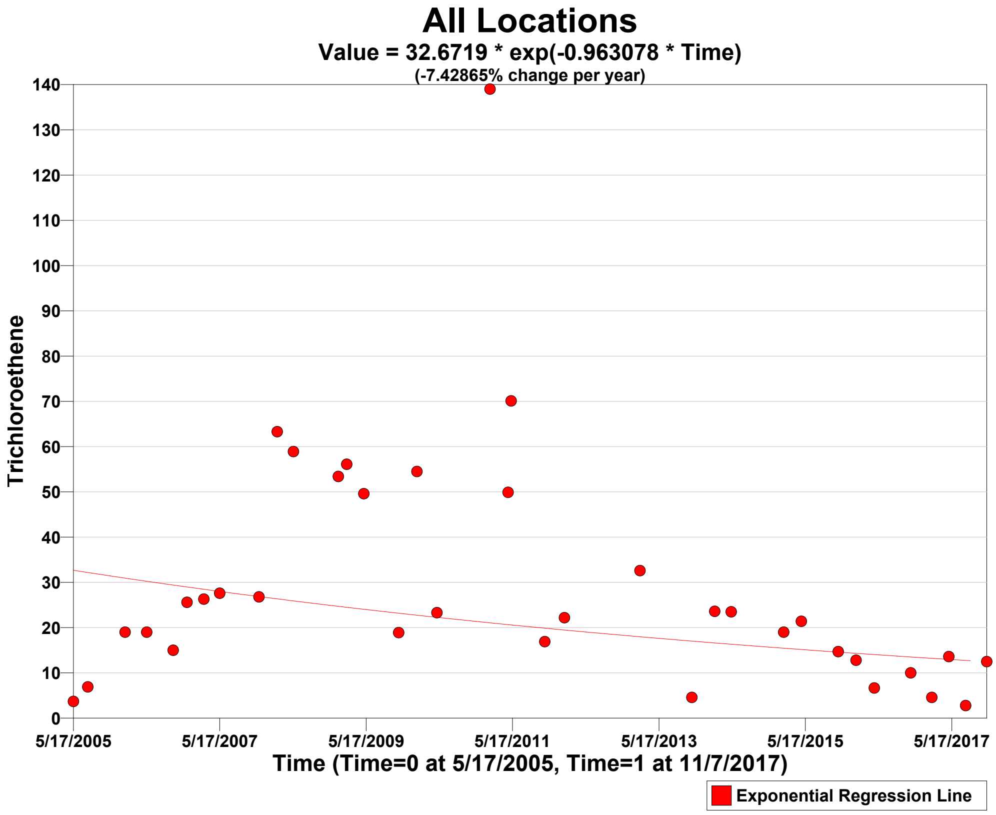
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

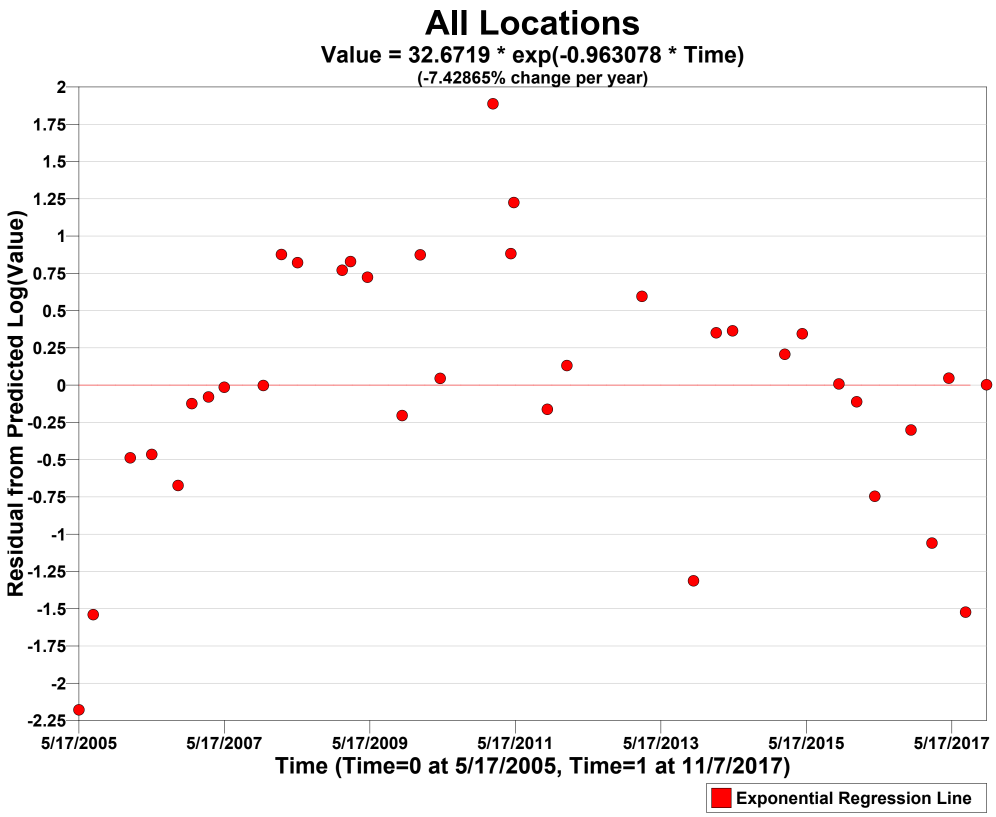
Data Plots

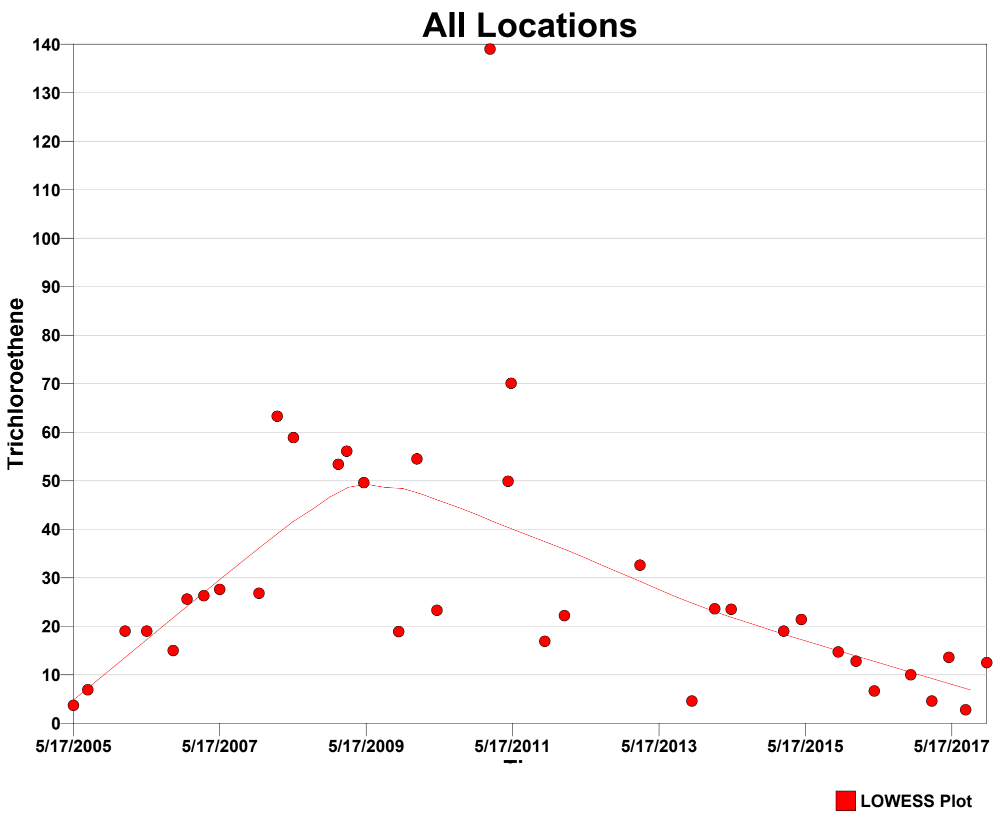
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 32.6719 * exp(-0.963078 * Time)
(-7.42865% change per year)
Residual from Predicted Log(Value)
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
5/17/2005
5/17/2007
5/17/2009
5/17/2011
5/17/2013
5/17/2015
5/17/2017
Time (Time=0 at 5/17/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
5/17/2005
5/17/2007
5/17/2009
5/17/2011
5/17/2013
5/17/2015
5/17/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=36) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.96786
Shapiro-Wilk 5% Critical Value	0.935

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-162	
MK Test Statistic	Z_{MK}	-2.19391	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Software and documentation available at http://vsp.pnnl.gov

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Data Analysis for Seep 0602 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
4/20/2005	41770		2/28/2008	27200		10/25/2011	14500
5/17/2005	22740		5/19/2008	25100		1/31/2012	8120
7/28/2005	21090		12/29/2008	15400		2/11/2013	8810
1/30/2006	13160		2/9/2009	14200		2/19/2014	4570
5/18/2006	17380		5/5/2009	14800		1/29/2015	7280
9/27/2006	82700		10/26/2009	22500		1/25/2016	5740
12/5/2006	48900		1/25/2010	11900		2/6/2017	4110
2/27/2007	30500		5/5/2010	14700		7/25/2017	3210
5/17/2007	36800		1/25/2011	10100			
11/29/2007	45100		5/10/2011	7240			

SUMMARY STATISTICS for Tritium	
n	28
Min	-0.8845869
Max	1.078028
Range	1.9626
Mean	0
Median	0.03734007
Variance	0.17874
StdDev	0.42278
Std Error	0.079897
Skewness	0.33344
Interquartile Range	0.46706

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.8846	-0.7342	-0.5136	-0.2332	0.03734	0.2338	0.5989	0.9052	1.078

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
9/27/2006	82700

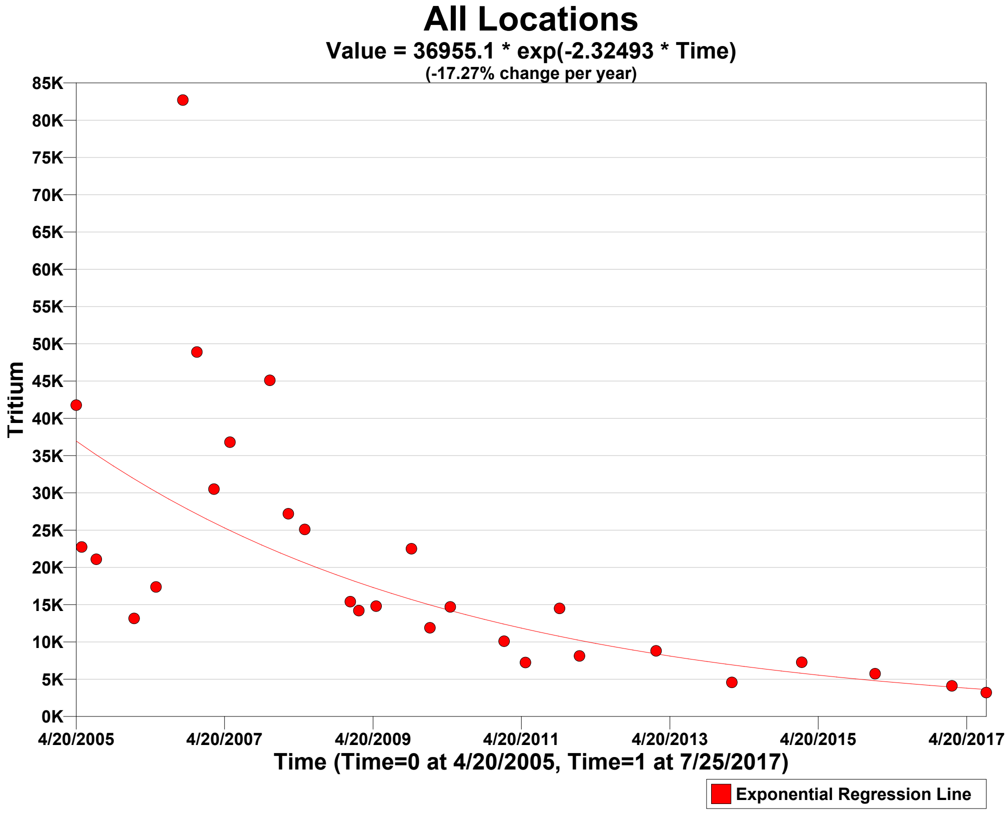
Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

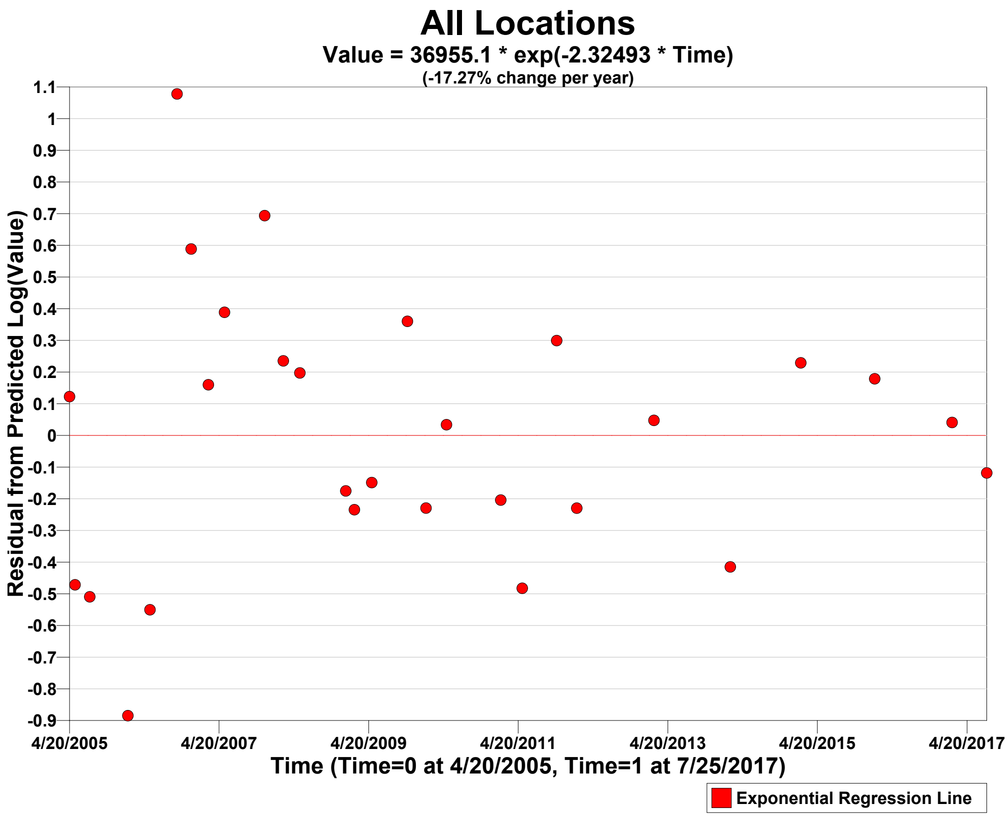
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

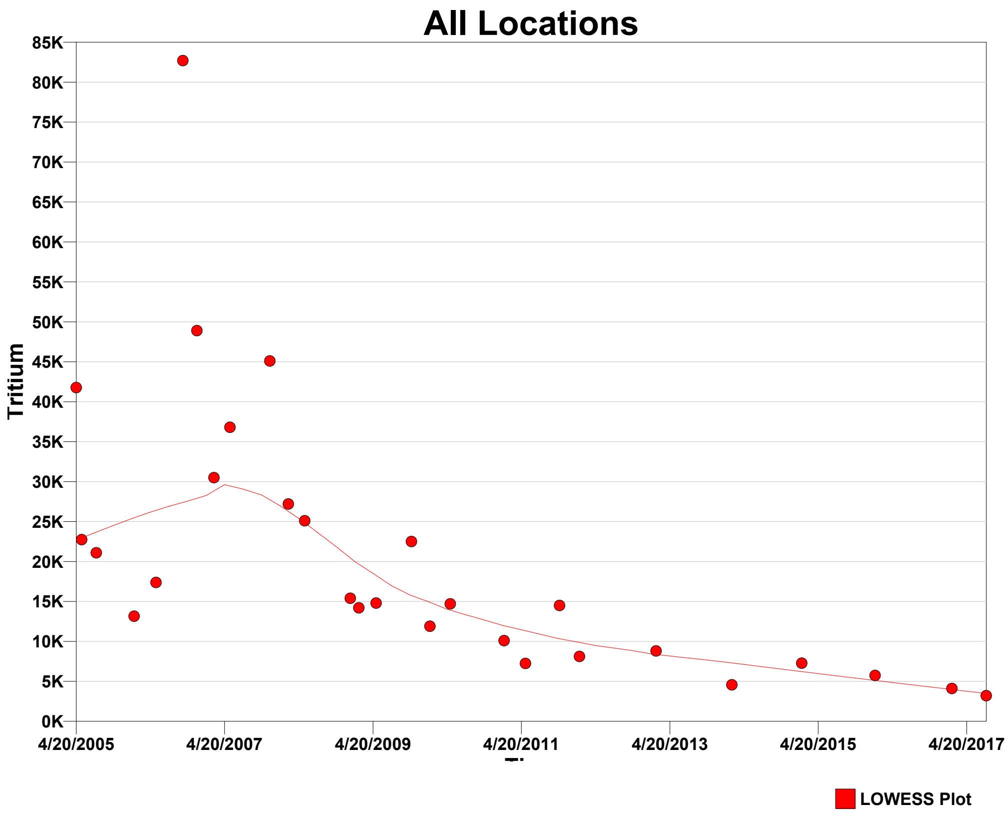
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 36955.1 * exp(-2.32493 * Time)
(-17.27% change per year)
Residual from Predicted Log(Value)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
4/20/2005
4/20/2007
4/20/2009
4/20/2011
4/20/2013
4/20/2015
4/20/2017
Time (Time=0 at 4/20/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Tritium
85K
80K
75K
70K
65K
60K
55K
50K
45K
40K
35K
30K
25K
20K
15K
10K
5K
0K
4/20/2005
4/20/2007
4/20/2009
4/20/2011
4/20/2013
4/20/2015
4/20/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=28) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.98298
Shapiro-Wilk 5% Critical Value	0.924

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-260	
MK Test Statistic	Z_{MK}	-5.11694	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0605 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
1/31/2012	9.16		5/12/2014	9.43		4/25/2016	14.2
4/25/2012	15.4		8/26/2014	11.8		7/25/2016	7.28
10/25/2012	19.8		10/27/2014	14.8		10/24/2016	9.82
2/11/2013	13.9		1/29/2015	13		2/6/2017	9.21
5/30/2013	14.7		4/27/2015	10.9		5/2/2017	6.22
8/27/2013	11		7/29/2015	12.3		7/25/2017	9.88
10/28/2013	13.5		10/28/2015	7.23		11/7/2017	4.3
2/19/2014	8.69		1/25/2016	10.2			

SUMMARY STATISTICS for Trichloroethene								
n	23							
Min	-0.559843							
Max	0.4455662							
Range	1.0054							
Mean	0							
Median	0.05831475							
Variance	0.070237							
StdDev	0.26502							
Std Error	0.055261							
Skewness	-0.54806							
Interquartile Range	0.40942							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.5598	-0.5507	-0.4342	-0.2046	0.05831	0.2048	0.3293	0.4258	0.4456

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

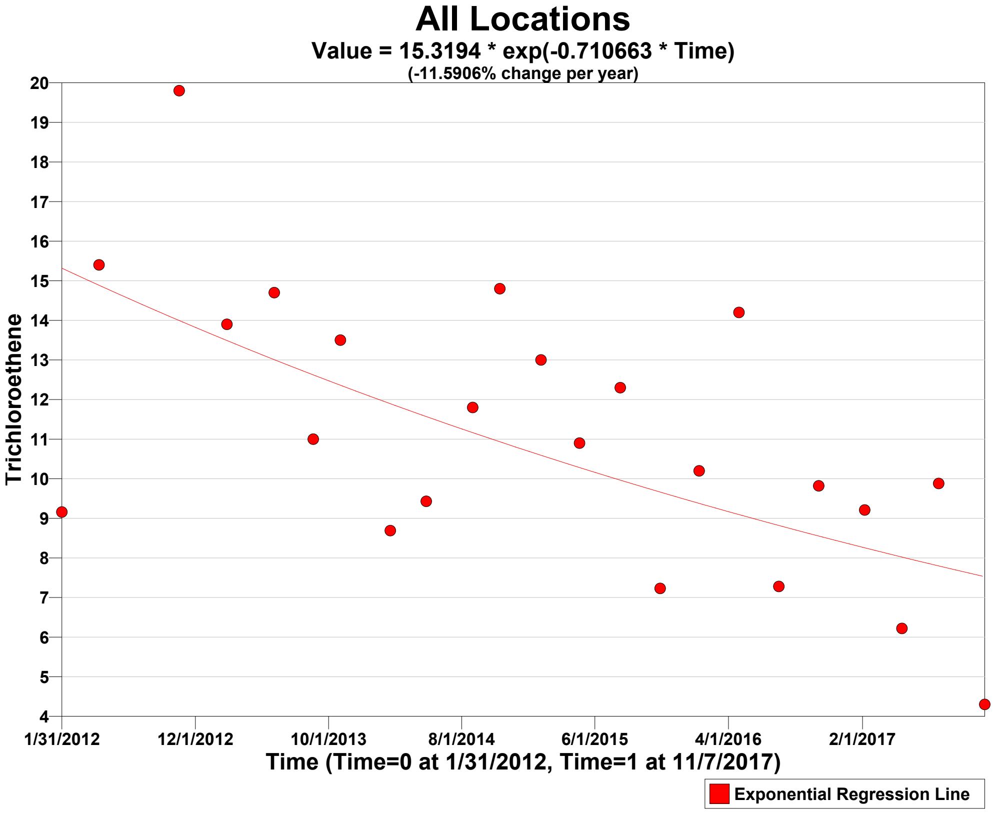
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

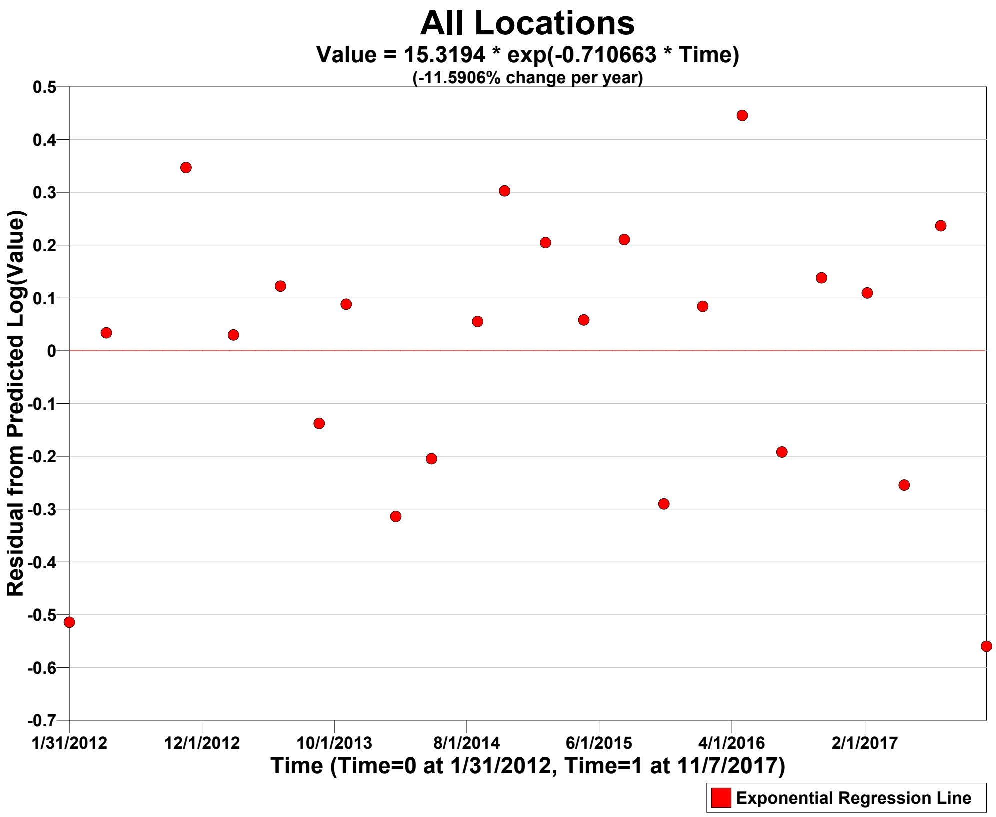
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

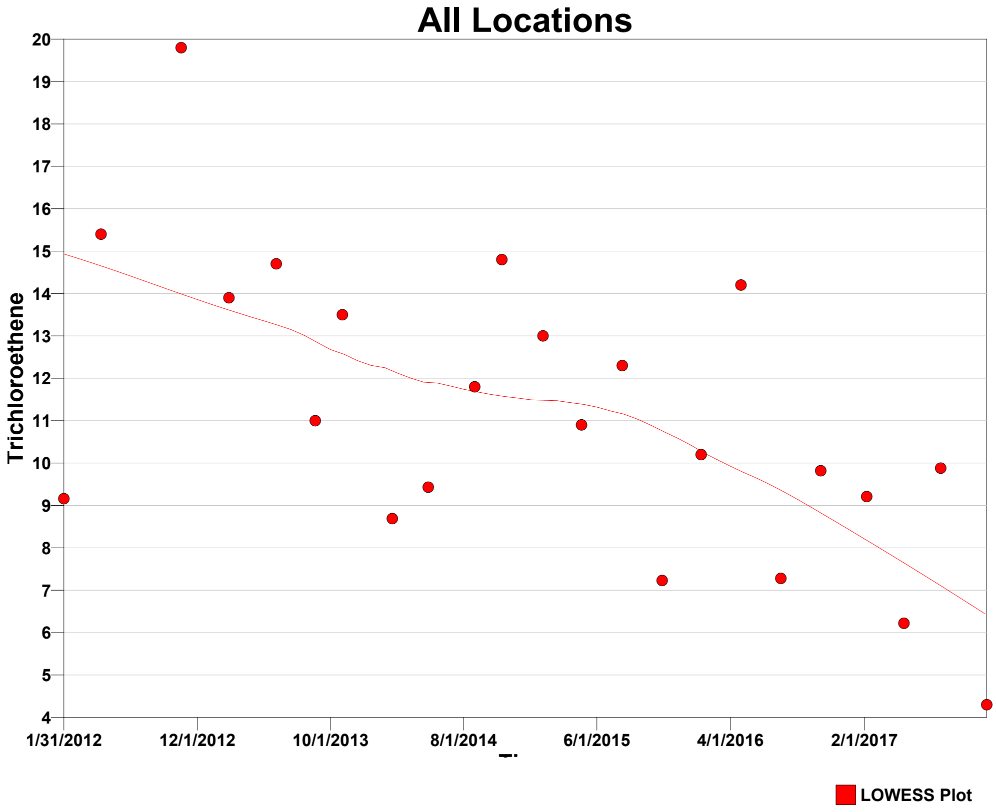
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 15.3194 * exp(-0.710663 * Time)
(-11.5906% change per year)
Residual from Predicted Log(Value)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 1/31/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=23) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.95234
Shapiro-Wilk 5% Critical Value	0.914

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-111	
MK Test Statistic	Z_{MK}	-2.90515	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Software and documentation available at http://vsp.pnnl.gov

* - The report contents may have been modified or reformatted by end-user of software.

Mann-Kendall Test for Monotonic Trend

Summary

This report summarizes the sampling design used, associated statistical assumptions, and the method of data analysis. Sampling plan components presented here include the data quality objectives and how many samples are needed to detect a monotonic trend while meeting those objectives.

The following table summarizes the sampling design developed.

SUMMARY OF SAMPLING DESIGN	
Primary Objective of Design	Determine if there is a monotonic trend over time
Type of Test for Trend	Nonparametric
Working (Null) Hypothesis	There is no monotonic trend
Alternative Hypothesis	A downward monotonic trend exists
Method for detecting whether a trend exists	Mann-Kendall Nonparametric Test
Method of calculating number of samples needed to detect a trend	Monte-Carlo simulation using Mann-Kendall test
Time between samples (Sample Period)	3 months
Number of samples needed to detect a trend of -1 per year within tolerable error limits [a]	26

[a] See *Calculation of Number of Samples Required to Detect a Trend* section below for details.

Primary Sampling Objective

The purpose of the Mann-Kendall (MK) test (Mann 1945, Kendall 1975, Gilbert 1987) is to statistically assess if there is a monotonic upward or downward trend of the variable of interest over time. A monotonic upward (downward) trend means that the variable consistently increases (decreases) through time, but the trend may or may not be linear.

Selected Statistical Testing Approach

The MK test can be used in place of a parametric linear regression analysis that is used to test if the slope of the estimated linear regression line is different from zero. The regression analysis requires that the residuals from the fitted regression line be normally distributed; an assumption not required by the MK test. Hence, the MK test is a non-parametric (distribution-free) test.

Hirsch, Slack and Smith (1982, page 107) indicate that the MK test is best viewed as an exploratory analysis and is most appropriately used to identify and quantify changes over time at sampling stations.

Calculations to Determine Whether a Trend Exists

The MK test is used to decide whether to reject the null hypothesis (H_o) that no monotonic trend exists in favor of the alternative hypothesis (H_a) that a monotonic trend exists.

One of three alternative hypotheses is chosen:
1. A monotonic downward trend exists
2. Either a monotonic upward or monotonic downward trend exists
3. A monotonic upward trend exists

For the current design, the 1st option (a downward trend) was chosen.

The data obtained over time must be convincing beyond a reasonable doubt before the MK test will reject the H_o and accept the H_a.

The MK test is conducted as follows (from Gilbert 1987, pp. 209-213):

1. List the data in the order in which they were collected over time, $x_1, x_2, \ldots, x_n$, which denote the measurements obtained at times 1, 2, ï¿½, n, respectively. The data are not necessarily (and need not be) collected at equally spaced time intervals, although equally spaced sampling over time is often preferred.

2. Determine the sign of all *n(n-1)/2* possible differences $x_j - x_k$, where j > k. These differences are

$x_2-x_1, x_3-x_1, \ldots, x_n-x_1, x_3-x_2, x_4-x_2, \ldots, x_n-x_{n-2}, x_n-x_{n-1}$

3. Let $\text{sgn}(x_j - x_k)$ be an indicator function that takes on the values 1, 0, or -1 according to the sign of $x_j - x_k$, that is,

$\text{sgn}(x_j - x_k) = 1$ if $x_j - x_k > 0$
$\text{sgn}(x_j - x_k) = 0$ if $x_j - x_k = 0$, or if the sign of $x_j - x_k$ cannot be determined due to non-detects
$\text{sgn}(x_j - x_k) = -1$ if $x_j - x_k < 0$

For example, if $x_j - x_k > 0$, then the observation at time j, denoted by x_j, is greater than the observation at time k, denoted by x_k.

4. Compute

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(x_j - x_k) \qquad (1)$$

which is the number of positive differences minus the number of negative differences. If S is a positive number, observations obtained later in time tend to be *larger* than observations made earlier. If S is a negative number, then observations made later in time tend to be *smaller* than observations made earlier.

5. If $n \leq 10$, follow the procedure described in Gilbert (1987, page 209, Section 16.4.1) by looking up S in a table of probabilities (Gilbert 1987, Table A18, page 272). If this probability is less than α (the probability of concluding a trend exists when there is none), then reject the null hypothesis and conclude the trend exists. If *n* cannot be found in the table of probabilities (which can happen if there are tied data values), the next value farther from zero in the table is used. For example, if S=12 and there is no value for S=12 in the table, it is handled the same as S=13.

If $n > 10$, continue with steps 6 through 8 to determine whether a trend exists. This follows the procedure described in Gilbert (1987, page 211, Section 16.4.2).

6. Compute the variance of S as follows:

$$VAR(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p - 1)(2t_p + 5) \right] \qquad (2)$$

where g is the number of tied groups and t_p is the number of observations in the p^{th} group. For example, in the sequence of measurements in time (23, 24, 29, 6, 29, 24, 24, 29, 23) we have g = 3 tied groups, for which t_1=2 for the tied value 23, t_2=3 for the tied value 24, and t_3=3 for the tied value 29.

7. Compute the MK test statistic, Z_{MK}, as follows:

$$Z_{MK} \begin{cases} = \dfrac{S-1}{\sqrt{VAR(S)}} & \text{if} \quad S > 0 \\ = \quad 0 & \text{if} \quad S = 0 \\ = \dfrac{S+1}{\sqrt{VAR(S)}} & \text{if} \quad S < 0 \end{cases} \tag{3}$$

A positive value of Z_{MK} indicates that the data tend to increase with time; a negative value of Z_{MK} indicates that the data tend to decrease with time.

8. Finally, the hypothesis is tested. H_o is rejected and H_a is accepted if $Z_{MK} \leq -Z_{1-\alpha}$ where:

H_o (null hypothesis): no monotonic trend exists

H_a (alternative hypothesis): a downward monotonic trend exists

Alpha (α) is the Type I error rate, which is the user-specified small probability that can be tolerated that the MK test will falsely reject the null hypothesis (i.e. will conclude a trend exists when there is none)

$Z_{1-\alpha}$ is the $100(1-\alpha)^{th}$ percentile of the standard normal distribution. For example, if $\alpha = 0.05$, then $Z_{1-\alpha} = 1.64485$. Values of $Z_{1-\alpha}$ are provided in many statistics books (for example Gilbert 1987, Table A1, page 254) and statistical software packages.

Calculation of Number of Samples Required to Detect a Trend

VSP uses a Monte-Carlo simulation to determine the required number of points in time, n, to take a measurement in order to detect a trend for specified small probabilities that the MK test will make decision errors. If a non-linear trend is actually present, then the value of n computed by VSP is only an approximation to the correct n. The simulation, which is a binary search on the number of samples needed, proceeds as follows:

1. The required probability of detecting a trend (if present) is set at $1-\beta$ where β is the user-specified probability of falsely accepting the null hypothesis.

2. The required number of samples, n, is initially set to 4, which is the minimum number of samples that can be analyzed using the Mann-Kendall test.

3. A set of n numbers ($x_1, x_2, x_3, \ldots, x_n$) is created that conforms to an exponential curve, but has random deviations from that curve. The exponential curve is defined by the user in terms of percent change (negative or positive) per unit time. The user also indicates the standard deviation of normally distributed residuals about the trend. This standard deviation is also specified as a percentage.

Since the exponential curve represents a straight-line on the log scale, the data points are found on the natural log scale then converted to real space for use in the Mann-Kendall test.

a. A set of *n* numbers ($r_1, r_2, r_3, \ldots, r_n$) is randomly chosen from a normal distribution having a mean of zero and a standard deviation of δ, where

$$\delta = \ln\left(\frac{100+P}{100}\right)$$

where:

ln is the natural logarithm of the quantity

P is the user-specified percent standard deviation of the residuals

b. The change per sample period on the natural log scale, Δ, is calculated based on the user-specified percent change per unit time and sample period:

$$\Delta = \ln\left(\frac{100+P}{100}\right)\frac{T_S}{T_U}$$

where:
ln is the natural logarithm of the quantity
P is the user-specified percent change per unit time
T_U is the unit time (in days)
T_S is the sample period (in days)

c. A multiple of Δ is added to each random number to create the necessary slope on the natural log scale. The resulting numbers are converted to real space by the natural antilog function: [x_1=exp(r_1), x_2=exp($r_2+\Delta$), x_3=exp($r_3+2\Delta$), ... , x_n=exp($r_n+(n-1)\Delta$)], where exp is the natural antilog function.

4. The MK test (described above) is conducted on the set of numbers (x_1, x_2, ... , x_n) using the user-specified alpha error rate (α). If the null hypothesis is rejected, which indicates that the MK test detected a trend, then one is added to the count of trend detections.

5. Steps 3 and 4 are repeated 1000 times. The count of trend detections is then divided by 1000 to compute an estimate of the probability, P_d, that the MK test will detect a trend of the magnitude specified in Step 3 above.

6. P_d is compared to $1-\beta$. If P_d equals $1-\beta$ then the target probability of detection has been achieved with n samples. In that case the simulation ends and VSP reports that n samples are required. If $P_d < 1-\beta$ then n is increased and steps 3 through 6 are repeated. If $P_d > 1-\beta$ then n is decreased and steps 3 through 6 are repeated. The process continues until P_d equals $1-\beta$ or n does not change.

The following table summarizes the parameters used, as specified by the VSP user, and the results of the simulation:

Trend	
Change of interest to detect	-1% / year
Time between samples (Sample Period)	3 months
Parameters	
Alpha (α)	0.05 (5%)
Beta (β)	0.1 (10%)
Standard deviation of residuals from trend line	3%
Results	
Samples required, n (Sampling every 3 months)	26

Assumptions
The following assumptions underlie the MK test:

1. When no trend is present, the measurements (observations or data) obtained over time are independent and identically distributed. The assumption of independence means that the observations are not serially correlated over time.
2. The observations obtained over time are representative of the true conditions at sampling times.
3. The sample collection, handling, and measurement methods provide unbiased and representative observations of the underlying populations over time.

The MK test does not require that the measurements or the residuals about a trend tine be normally distributed or that the trend, if present, be linear. However, when VSP computes the number of samples required to detect a linear trend, VSP assumes that the residuals about an assumed linear trend line are normally distributed as explained previously.

The MK test can be computed if there are missing values (no measurements for some sampling times), but the performance of the test will be adversely affected. The assumption of independence requires that the time between samples be sufficiently long so that there is no correlation between measurements collected at different times. Consult Helsel (2005, pages 209-215) for doing nonparametric regression (trend) analyses when data are less than one or more detection limits.

Data Analysis for cDCE

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**cDCE**		**Time**	**cDCE**		**Time**	**cDCE**
2/17/2005	26		5/5/2009	8.8		10/28/2013	1.34
5/17/2005	30		7/29/2009	6.83		2/19/2014	2.9
7/28/2005	50		10/26/2009	4.35		5/12/2014	3.1
11/3/2005	17		1/25/2010	4.52		8/26/2014	9.93
1/30/2006	21		5/5/2010	4.49		10/27/2014	1.56
5/18/2006	16		7/26/2010	1.91		1/29/2015	3.56
9/26/2006	1.9		12/7/2010	6.25		4/27/2015	1.86
12/5/2006	9.91		1/25/2011	4.48		7/29/2015	1.09
2/27/2007	20.4		5/10/2011	1.62		10/28/2015	2.19
5/17/2007	32.2		7/27/2011	7.08		1/25/2016	1.18
8/22/2007	31.7		10/25/2011	3.22		4/25/2016	2.03
11/29/2007	9.54		1/31/2012	2.39		7/25/2016	1.02
2/28/2008	7.58		4/25/2012	1.41		10/24/2016	5.92
5/19/2008	5.15		10/25/2012	2.47		2/6/2017	2.72
8/4/2008	2.53		2/11/2013	3.02		5/2/2017	1.87
11/17/2008	12.4		5/30/2013	1.98		7/25/2017	1.72
2/9/2009	7.92		8/27/2013	1.49		11/7/2017	0.95

SUMMARY STATISTICS for cDCE	
n	51
Min	-1.876455
Max	1.475209
Range	3.3517
Mean	0
Median	-0.01085298
Variance	0.4347
StdDev	0.65932
Std Error	0.092323
Skewness	-0.086904
Interquartile Range	0.77265

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.876	-1.106	-0.9232	-0.3868	-0.01085	0.3858	1.014	1.255	1.475

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
7/28/2005	50
11/3/2005	17
9/26/2006	1.9
12/5/2006	9.91
5/17/2007	32.2
8/22/2007	31.7
8/4/2008	2.53
8/26/2014	9.93

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

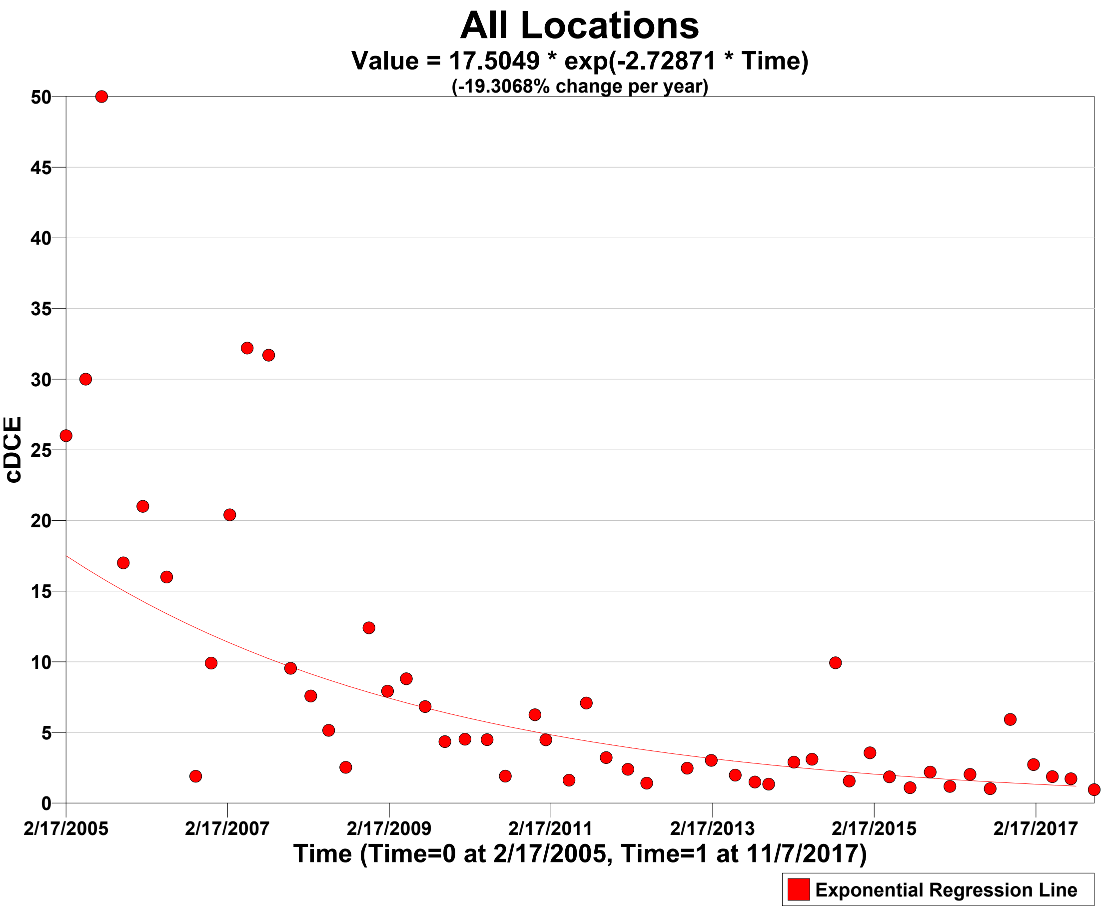
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

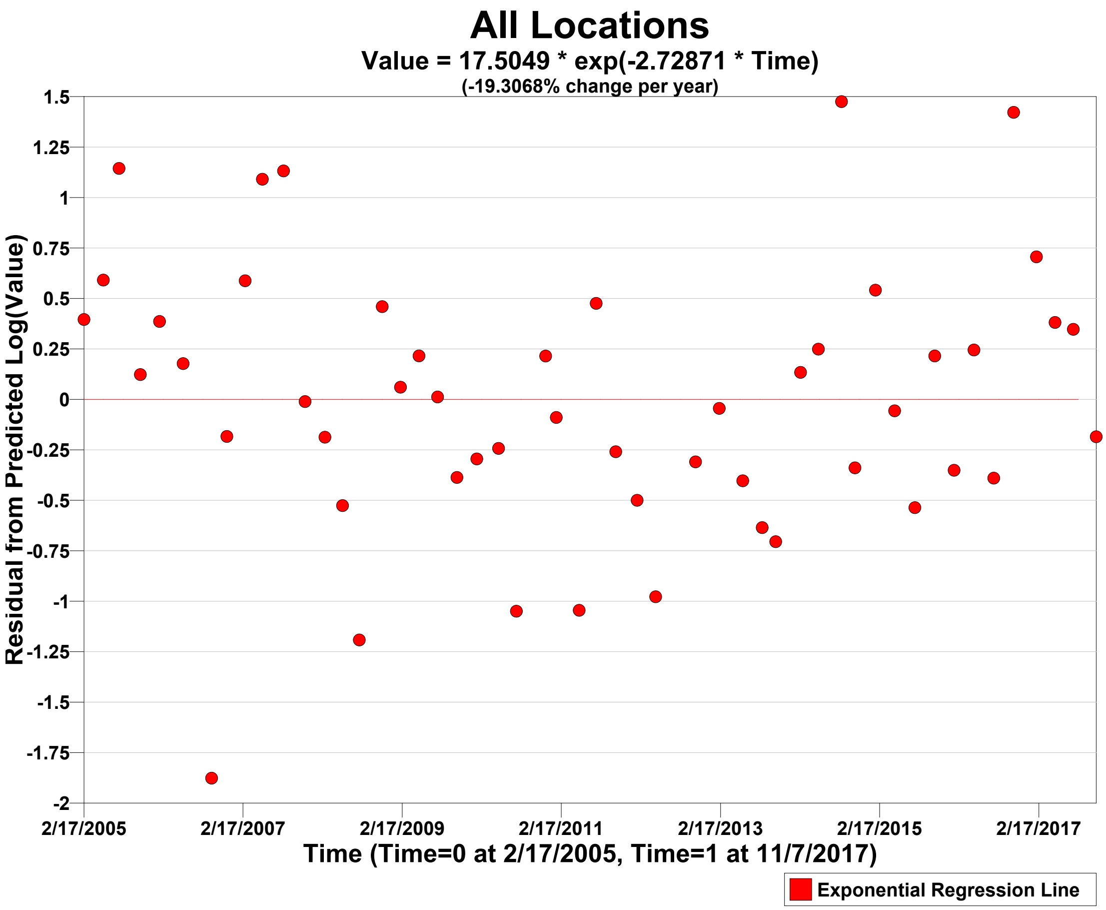
Data Plots

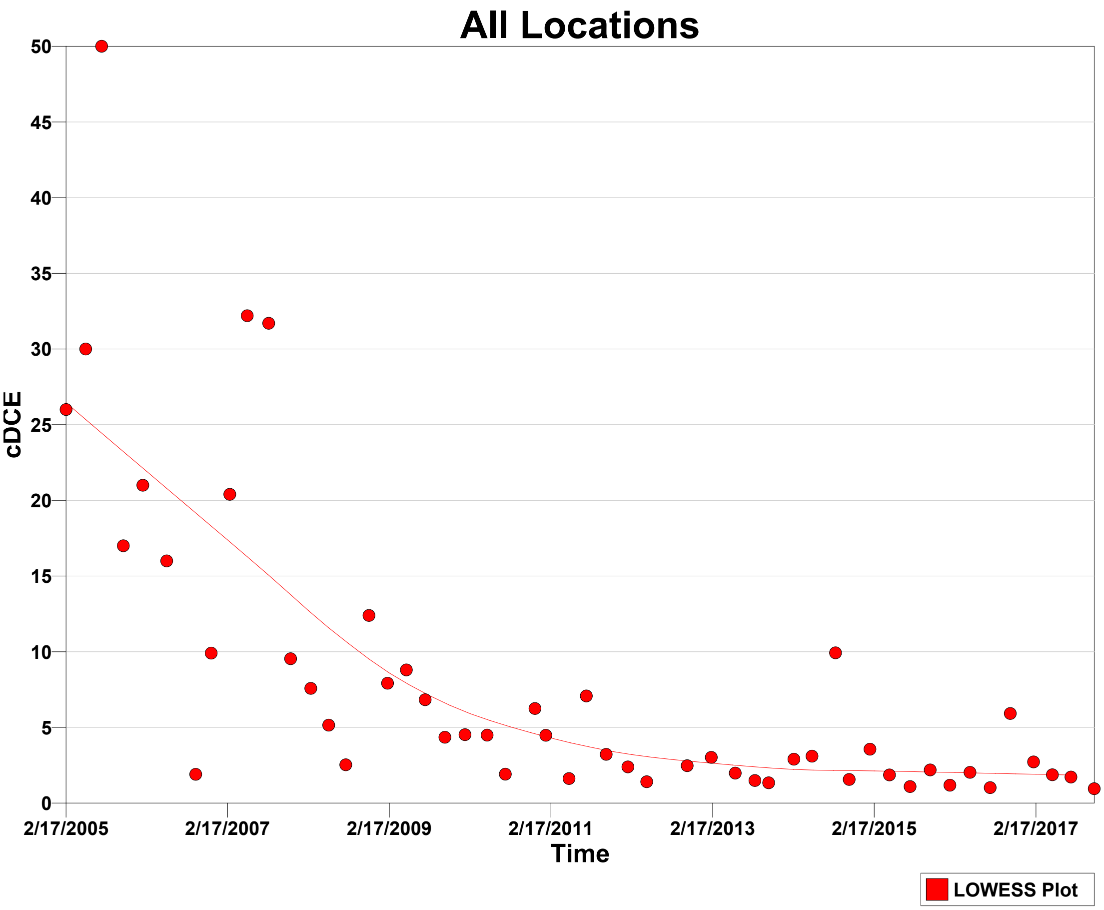
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.


All Locations
Value = 17.5049 * exp(-2.72871 * Time)
(-19.3068% change per year)
cDCE
50
45
40
35
30
25
20
15
10
5
0
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Value = 17.5049 * exp(-2.72871 * Time)
(-19.3068% change per year)
Residual from Predicted Log(Value)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 11/7/2017)
Exponential Regression Line



Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=51) is greater than 50.

Normal Distribution Test of Residuals for cDCE	
Lilliefors Test Statistic	0.074286
Lilliefors 5% Critical Value	0.12406

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test		
Sum of Signs	S	-761
MK Test Statistic	Z_{MK}	-6.17288
Alpha	α	0.05
Critical Value	$-Z_{1-\alpha}$	-1.64485

Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

References
Cleveland, William S., **Robust Locally Weighted Regression and Smoothing Scatterplots**, 1979, *Journal of the American Statistical Association*, Vol. 74, No. 368. p. 829-836.

Gilbert, R.O., 1987. **Statistical Methods for Environmental Pollution Monitoring**, Wiley & Sons, New York.

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Hirsch, R.M., J.R. Slack, and R.A. Smith. 1982. **Techniques of trend analysis for monthly water quality data,** *Water Resources Research* 18(1):107-121.

Kendall, M.G. 1975. **Rank Correlation Methods,** 4th edition, Charles Griffin, London.

Mann, H.B. 1945. **Non-parametric tests against trend,** *Econometrica* 13:163-171.

Data Analysis for Seep 0605 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/17/2005	28		5/5/2009	18.3		10/28/2013	13.5
5/17/2005	29		7/29/2009	14		2/19/2014	8.69
7/28/2005	97		10/26/2009	9.54		5/12/2014	9.43
11/3/2005	33		1/25/2010	9.47		8/26/2014	11.8
1/30/2006	27		5/5/2010	17.6		10/27/2014	14.8
5/18/2006	16		7/26/2010	14.4		1/29/2015	13
9/26/2006	8.8		12/7/2010	10		4/27/2015	10.9
12/5/2006	9.61		1/25/2011	12.2		7/29/2015	12.3
2/27/2007	15.6		5/10/2011	13.1		10/28/2015	7.23
5/17/2007	24.7		7/27/2011	15.9		1/25/2016	10.2
8/22/2007	12.7		10/25/2011	11.5		4/25/2016	14.2
11/29/2007	10.4		1/31/2012	9.16		7/25/2016	7.28
2/28/2008	15.3		4/25/2012	15.4		10/24/2016	9.82
5/19/2008	13.8		10/25/2012	19.8		2/6/2017	9.21
8/4/2008	13.4		2/11/2013	13.9		5/2/2017	6.22
11/17/2008	13.9		5/30/2013	14.7		7/25/2017	9.88
2/9/2009	10.5		8/27/2013	11		11/7/2017	4.3

SUMMARY STATISTICS for Trichloroethene								
n	51							
Min	-0.7739291							
Max	1.534882							
Range	2.3088							
Mean	0							
Median	-0.008828162							
Variance	0.14244							
StdDev	0.37741							
Std Error	0.052848							
Skewness	1.0232							
Interquartile Range	0.43079							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.7739	-0.6399	-0.4493	-0.208	-0.008828	0.2228	0.3658	0.492	1.535

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
7/28/2005	97
9/26/2006	8.8

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

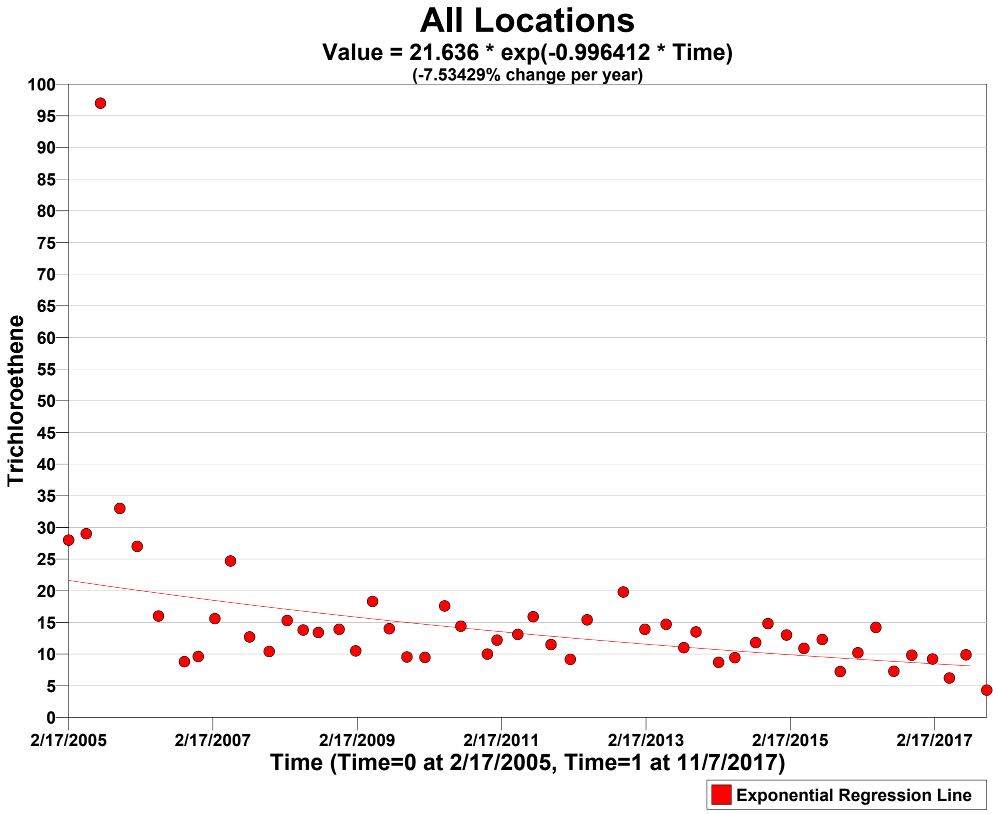
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

Data Plots

The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

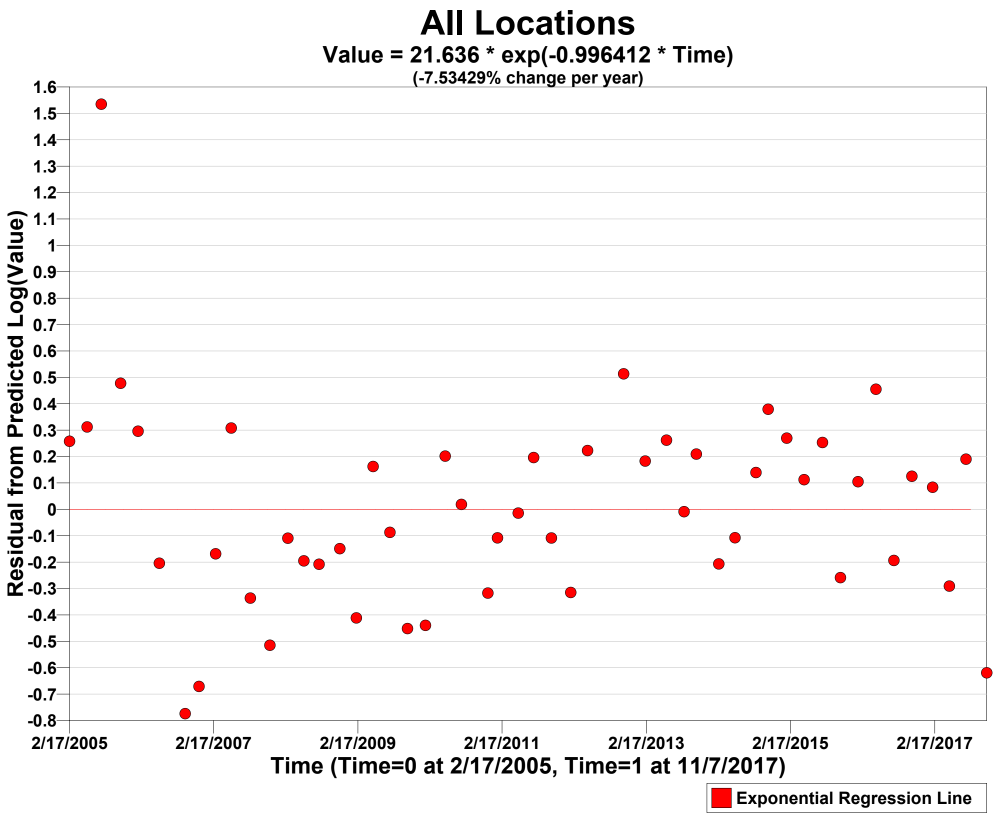
The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.

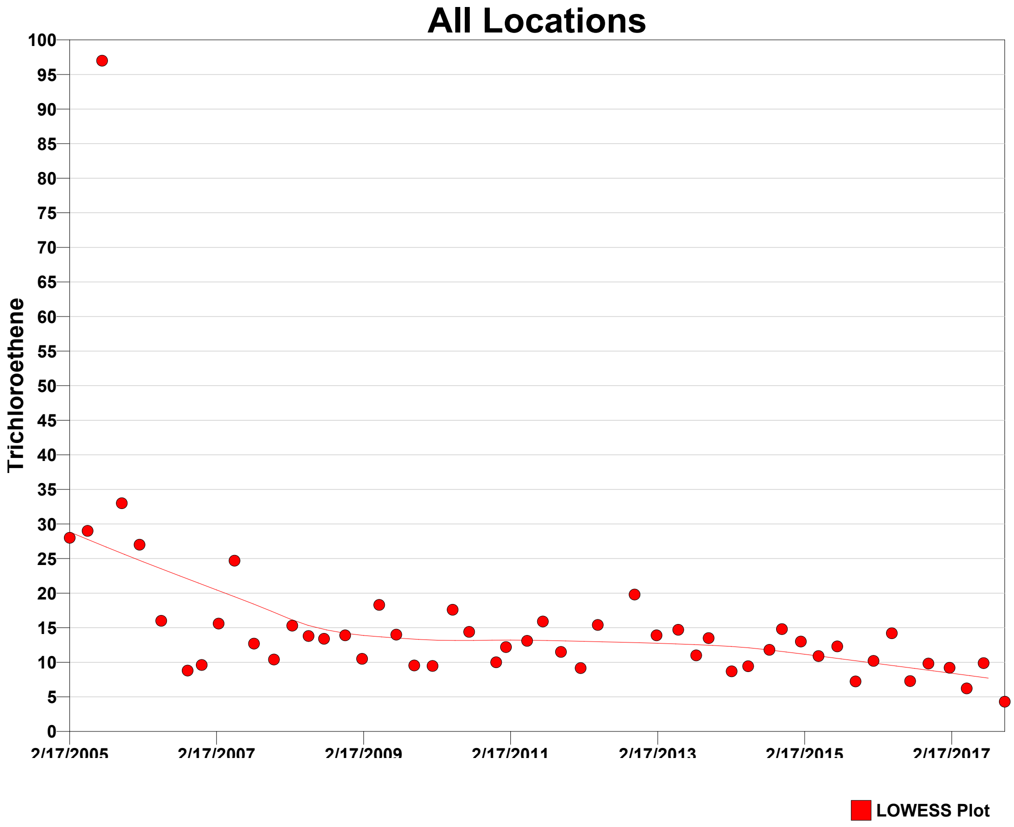


All Locations

Value = 21.636 * exp(-0.996412 * Time)

(-7.53429% change per year)


All Locations
Value = 21.636 * exp(-0.996412 * Time)
(-7.53429% change per year)
Residual from Predicted Log(Value)
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=51) is greater than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Lilliefors Test Statistic	0.10615
Lilliefors 5% Critical Value	0.12406

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-542	
MK Test Statistic	Z_{MK}	-4.39426	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Software and documentation available at http://vsp.pnnl.gov

* - The report contents may have been modified or reformatted by end-user of software.

Data Analysis for Seep 0605 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
2/17/2005	177210		5/19/2008	21300		10/25/2011	13100
5/17/2005	182750		8/4/2008	18600		1/31/2012	7820
7/28/2005	269300		11/17/2008	16900		4/25/2012	12000
11/3/2005	9390		2/9/2009	14800		2/11/2013	10700
11/22/2005	158300		5/5/2009	18400		8/27/2013	9610
1/30/2006	106520		7/29/2009	27100		2/19/2014	6300
5/18/2006	58880		10/26/2009	19300		8/26/2014	8060
9/26/2006	55800		1/25/2010	12500		1/29/2015	7910
12/5/2006	36200		5/5/2010	16000		7/29/2015	8340
2/27/2007	26500		7/26/2010	18500		1/25/2016	7460
5/17/2007	33400		12/7/2010	16700		7/25/2016	4410
8/22/2007	22200		1/25/2011	14900		2/6/2017	6480
11/29/2007	25600		5/10/2011	11900		7/25/2017	4560
2/28/2008	26100		7/27/2011	13200			

SUMMARY STATISTICS for Tritium	
n	41
Min	-1.798782
Max	1.49352
Range	3.2923
Mean	0
Median	-0.04354141
Variance	0.30653
StdDev	0.55365
Std Error	0.086466
Skewness	0.052196
Interquartile Range	0.51045

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.799	-0.56	-0.5041	-0.2977	-0.04354	0.2127	0.9135	1.057	1.494

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
2/17/2005	177210
5/17/2005	182750
7/28/2005	269300
11/3/2005	9390
11/22/2005	158300
5/18/2006	58880
9/26/2006	55800
12/5/2006	36200

2/27/2007	26500
5/17/2007	33400
8/22/2007	22200

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

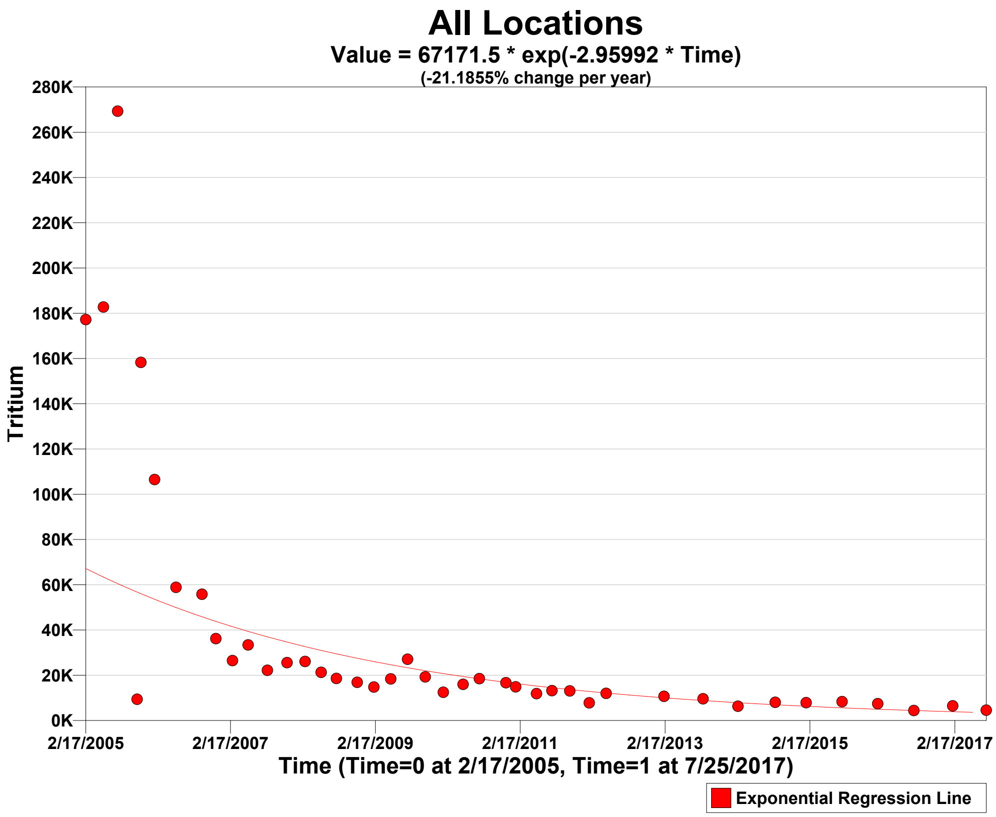
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

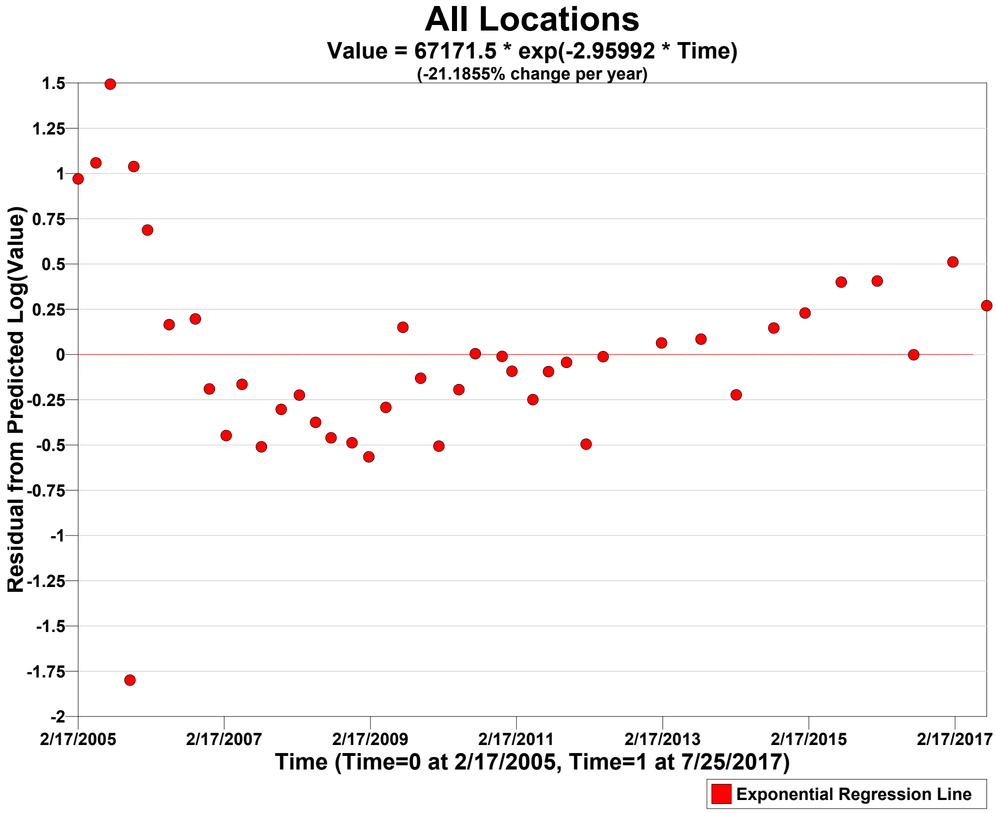
Data Plots

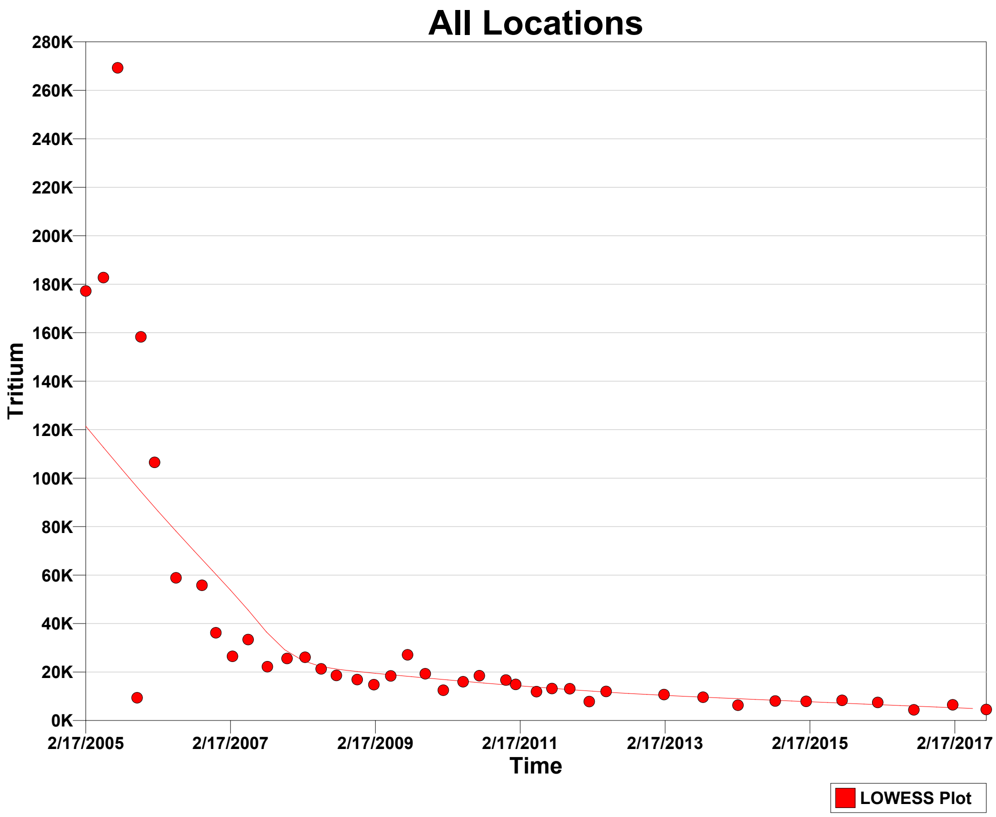
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.


All Locations
Value = 67171.5 * exp(-2.95992 * Time)
(-21.1855% change per year)
Tritium
280K
260K
240K
220K
200K
180K
160K
140K
120K
100K
80K
60K
40K
20K
0K
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Value = 67171.5 * exp(-2.95992 * Time)
(-21.1855% change per year)
Residual from Predicted Log(Value)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line



Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=41) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.92872
Shapiro-Wilk 5% Critical Value	0.941

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-656	
MK Test Statistic	Z_{MK}	-7.35692	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

Data Analysis for Seep 0606 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene (0.16)**		**Time**	**Trichloroethene (0.16)**		**Time**	**Trichloroethene (0.16)**
1/31/2012	0.56		5/12/2014	0.36		7/25/2016	0.99
4/25/2012	5.34		8/26/2014	6.06		10/24/2016	1.64
7/24/2012	6.98		10/27/2014	5.29		2/6/2017	1.7
10/25/2012	9.01		1/29/2015	1		5/2/2017	0.77
2/11/2013	2.19		4/27/2015	0.61		7/25/2017	1.95
5/30/2013	6.66		7/29/2015	6.99		11/7/2017	
8/27/2013	5		10/28/2015	4.08		11/7/2017	0.16
10/28/2013	7.72		1/25/2016	1.88			
2/19/2014	1.39		4/25/2016	1.81			

SUMMARY STATISTICS for Trichloroethene	
n	25
Min	-2.134593
Max	1.363724
Range	3.4983
Mean	0
Median	0.2397997
Variance	0.95573
StdDev	0.97761
Std Error	0.19552
Skewness	-0.89653
Interquartile Range	1.4243

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-2.135	-2.086	-1.859	-0.6101	0.2398	0.8142	0.9692	1.267	1.364

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

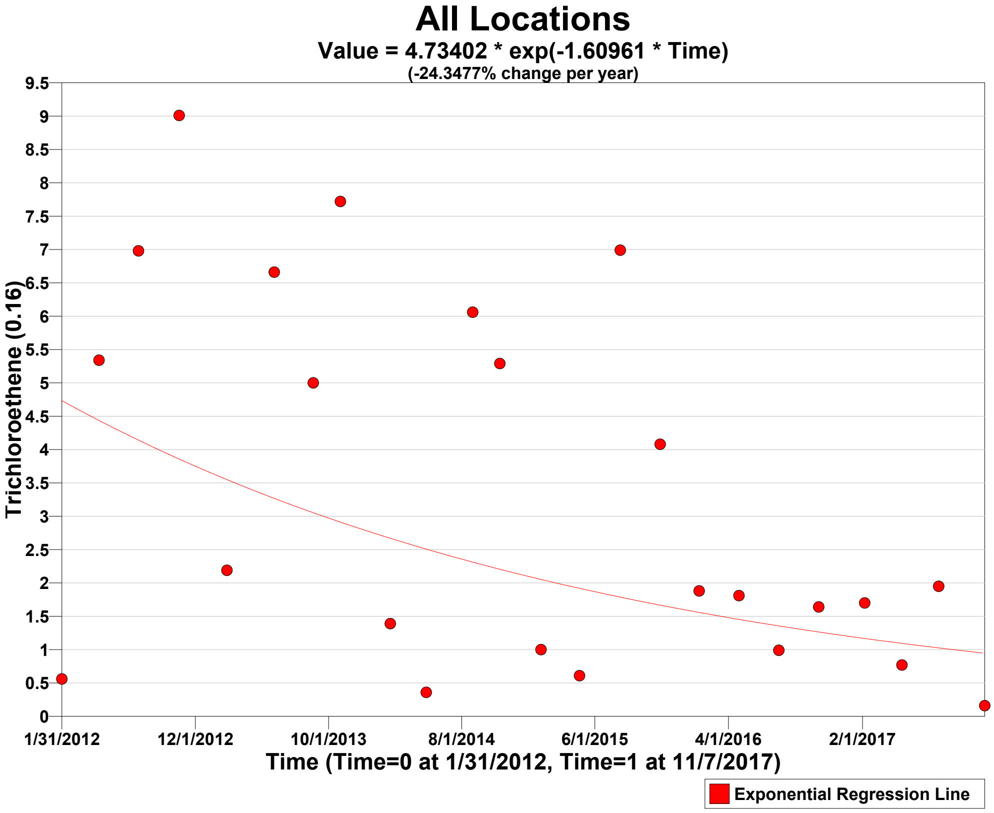
Data Plots

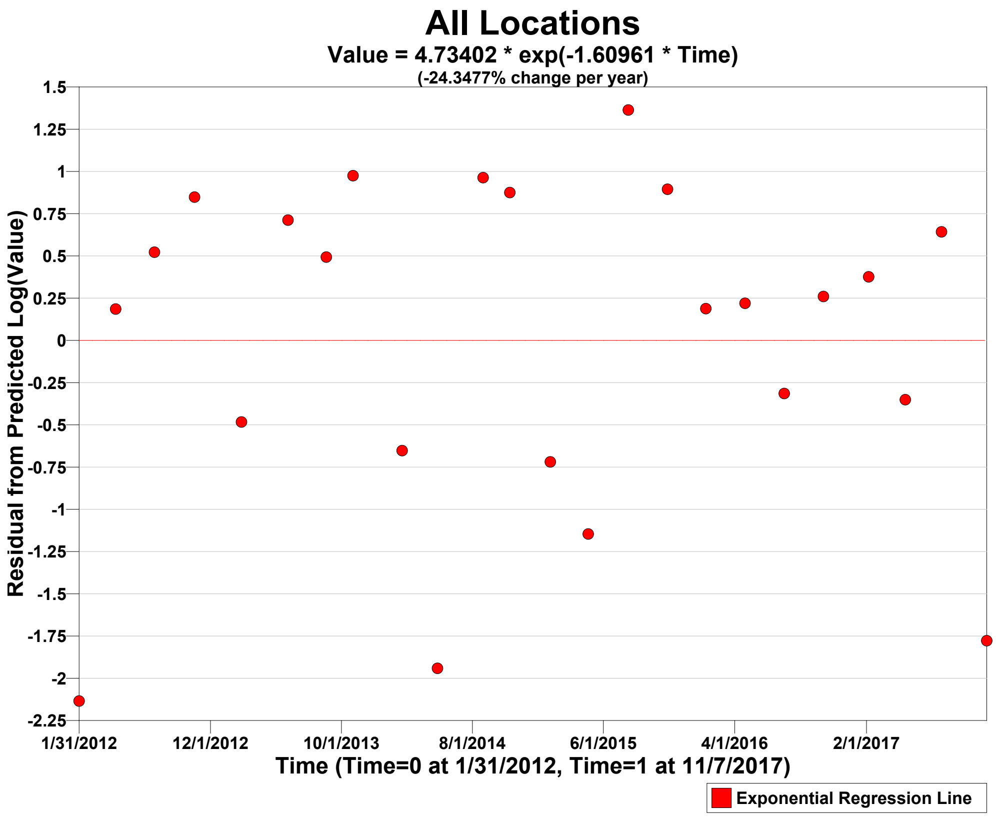
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

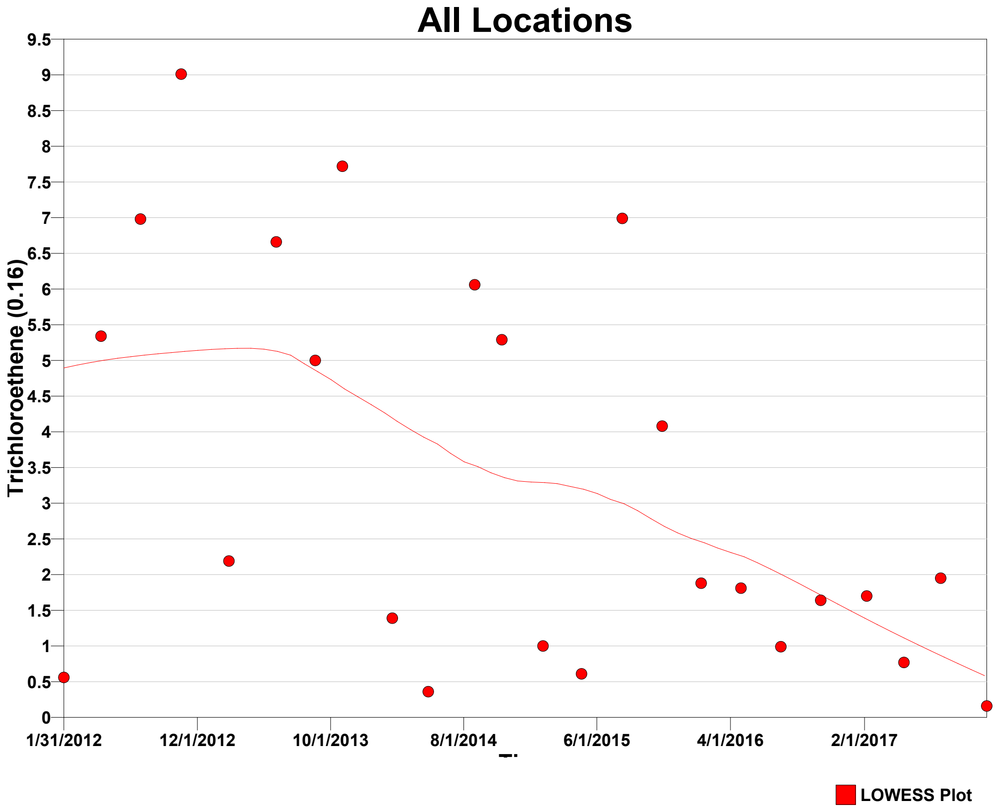
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 4.73402 * exp(-1.60961 * Time)
(-24.3477% change per year)
Residual from Predicted Log(Value)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 1/31/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene (0.16)
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1/31/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=25) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.906
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-92	
MK Test Statistic	Z_{MK}	-2.2572	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0606 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/17/2005	1.4		1/31/2012	0.56		4/27/2015	0.61
5/17/2005	8.5		4/25/2012	5.34		7/29/2015	6.99
7/28/2005	15		7/24/2012	6.98		10/28/2015	4.08
11/3/2005	24		10/25/2012	9.01		1/25/2016	1.88
1/30/2006	2.7		2/11/2013	2.19		4/25/2016	1.81
5/18/2006	5		5/30/2013	6.66		7/25/2016	0.99
5/5/2010	3.69		8/27/2013	5		10/24/2016	1.64
7/26/2010	3.16		10/28/2013	7.72		2/6/2017	1.7
10/25/2010	1.78		2/19/2014	1.39		5/2/2017	0.77
1/25/2011	0.15		5/12/2014	0.36		7/25/2017	1.95
5/10/2011	0.95		8/26/2014	6.06		11/7/2017	0.16
7/27/2011	8.72		10/27/2014	5.29			
10/25/2011	1.8		1/29/2015	1			

SUMMARY STATISTICS for Trichloroethene								
n	37							
Min	-2.989589							
Max	1.440259							
Range	4.4298							
Mean	0							
Median	0.1235755							
Variance	1.1643							
StdDev	1.079							
Std Error	0.17739							
Skewness	-0.74977							
Interquartile Range	1.5748							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-2.99	-2.178	-1.579	-0.5886	0.1236	0.9861	1.298	1.412	1.44

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
11/3/2005	24

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

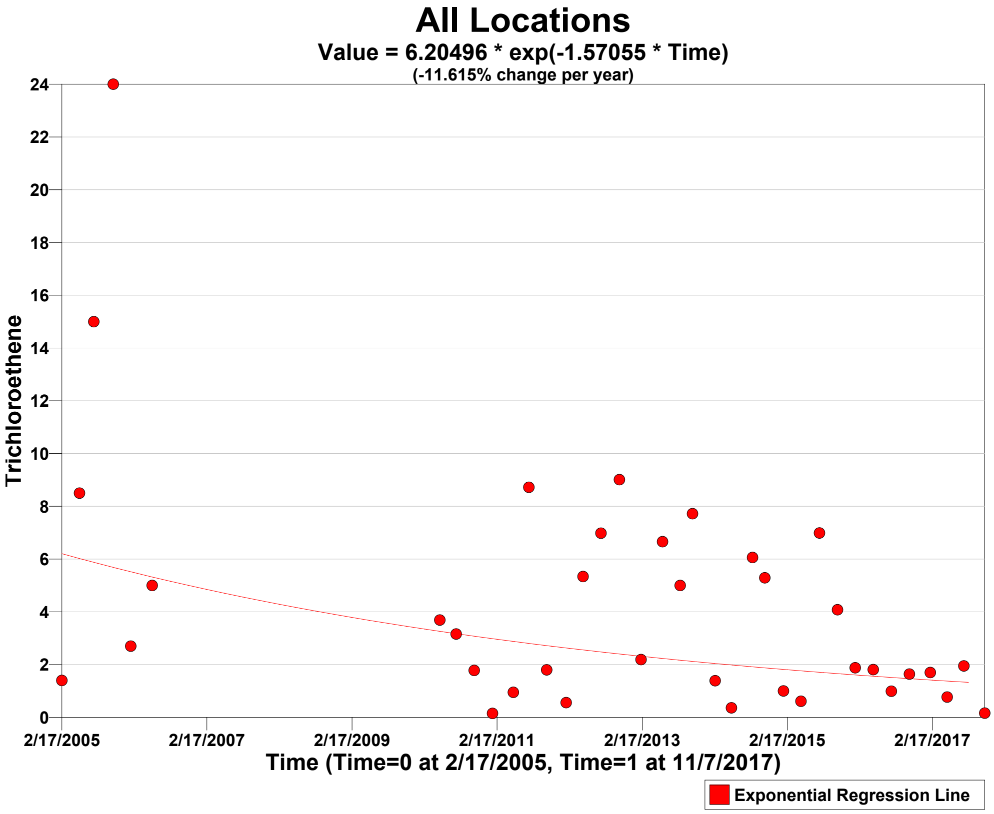
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

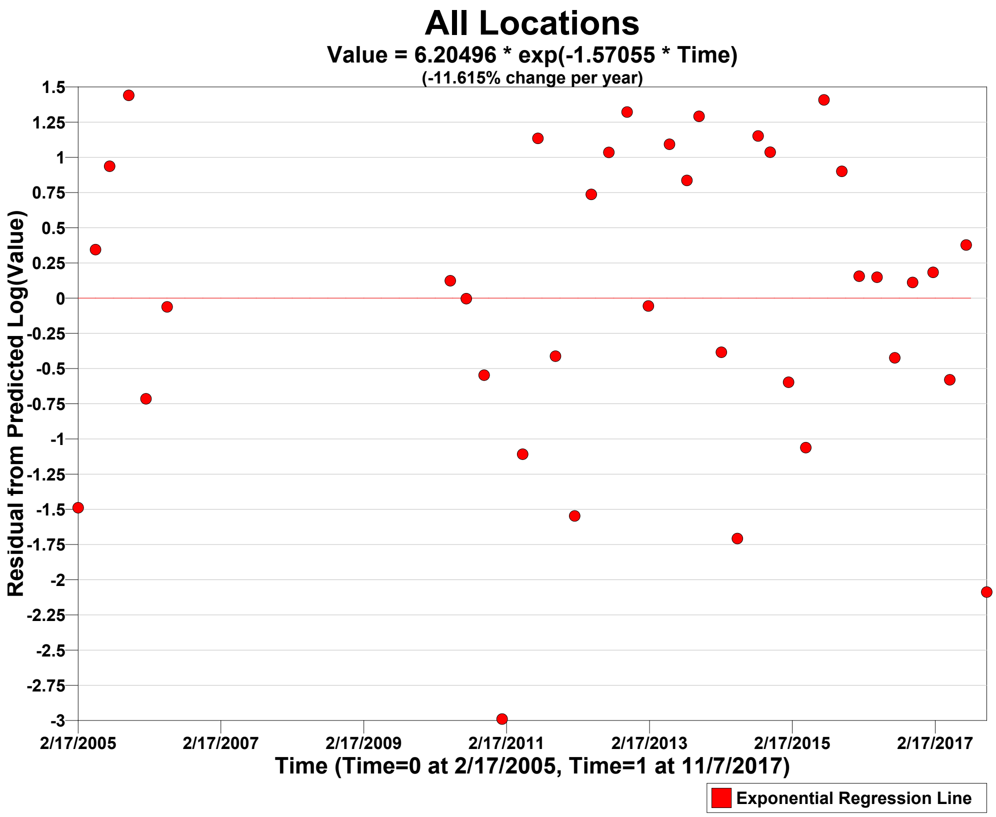
Data Plots

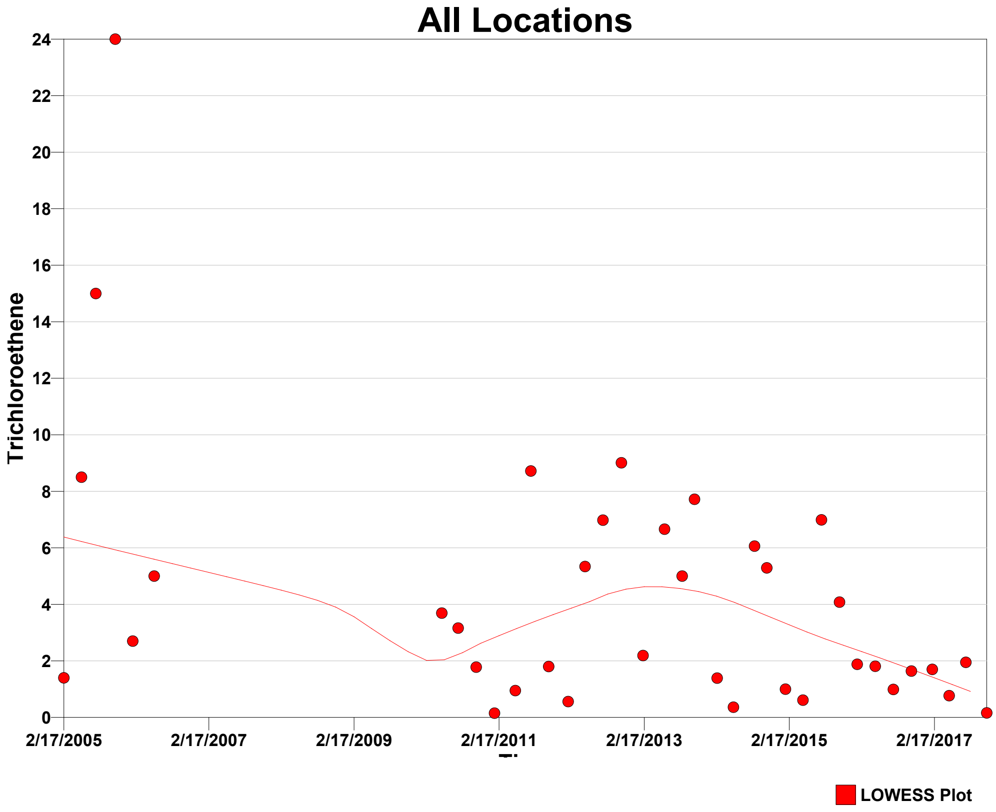
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 6.20496 * exp(-1.57055 * Time)
(-11.615% change per year)
Residual from Predicted Log(Value)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
-2.75
-3
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
24
22
20
18
16
14
12
10
8
6
4
2
0
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=37) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.9378
Shapiro-Wilk 5% Critical Value	0.936

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-171	
MK Test Statistic	Z_{MK}	-2.2236	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0606 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
2/17/2005	57800		1/25/2011	5900		2/19/2014	3290
5/17/2005	64460		5/10/2011	5760		8/26/2014	5020
7/28/2005	159930		7/27/2011	11100		1/29/2015	2480
11/3/2005	76640		10/25/2011	4930		7/29/2015	5580
1/30/2006	20590		1/31/2012	3640		1/25/2016	3580
5/18/2006	30620		4/25/2012	8440		7/25/2016	4790
5/5/2010	13200		7/24/2012	8860		2/6/2017	2980
7/26/2010	14600		2/11/2013	3020		7/25/2017	2840
10/25/2010	13200		8/27/2013	7370			

SUMMARY STATISTICS for Tritium								
n				26				
Min				-0.8400471				
Max				1.208517				
Range				2.0486				
Mean				0				
Median				0.1241749				
Variance				0.2481				
StdDev				0.4981				
Std Error				0.097685				
Skewness				0.095348				
Interquartile Range				0.75038				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.84	-0.8092	-0.7196	-0.4632	0.1242	0.2871	0.5695	1.005	1.209

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
2/17/2005	57800
7/28/2005	159930
1/30/2006	20590
5/18/2006	30620

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

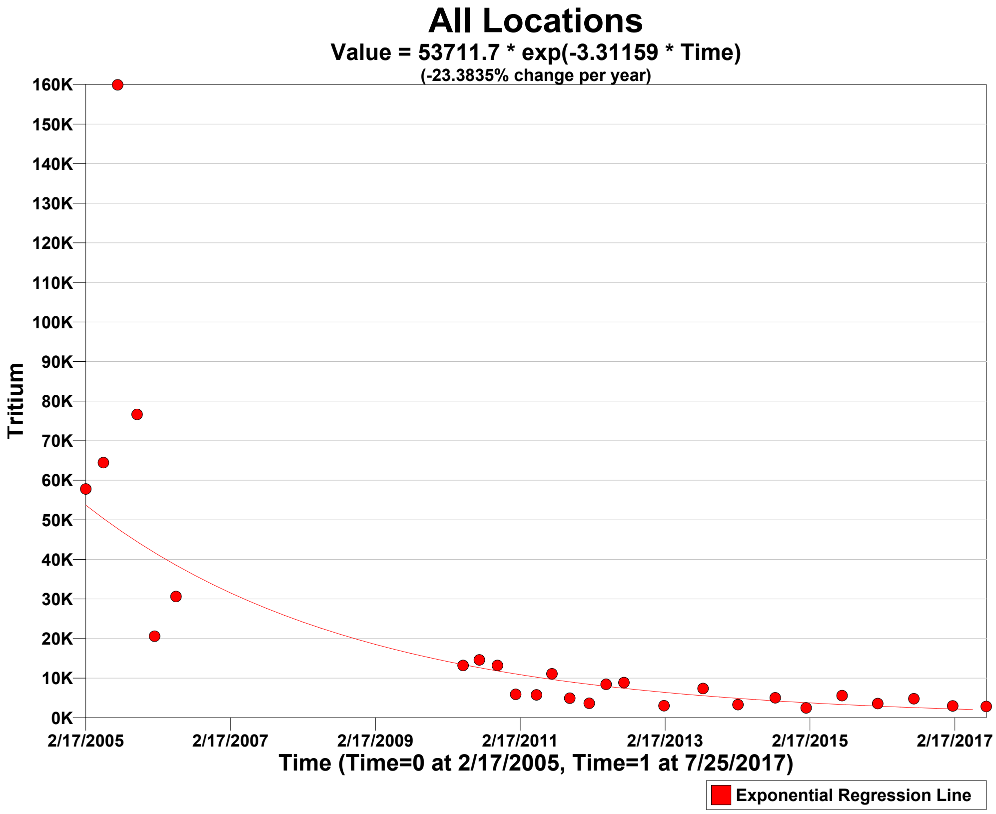
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

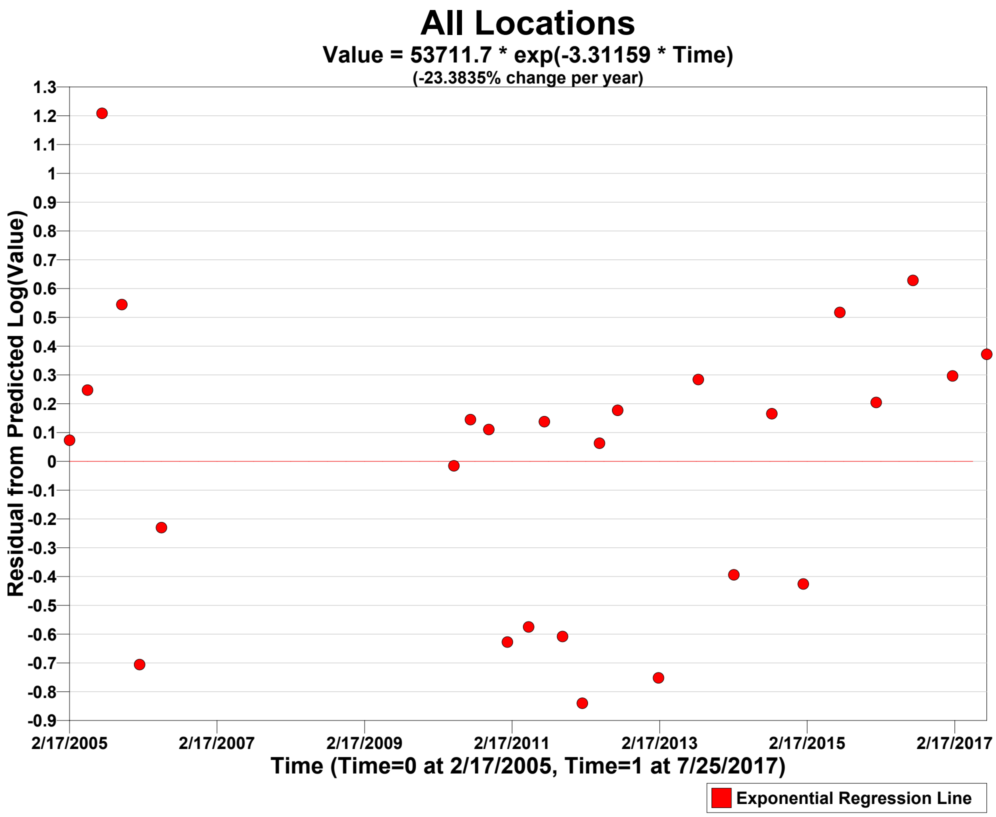
Data Plots

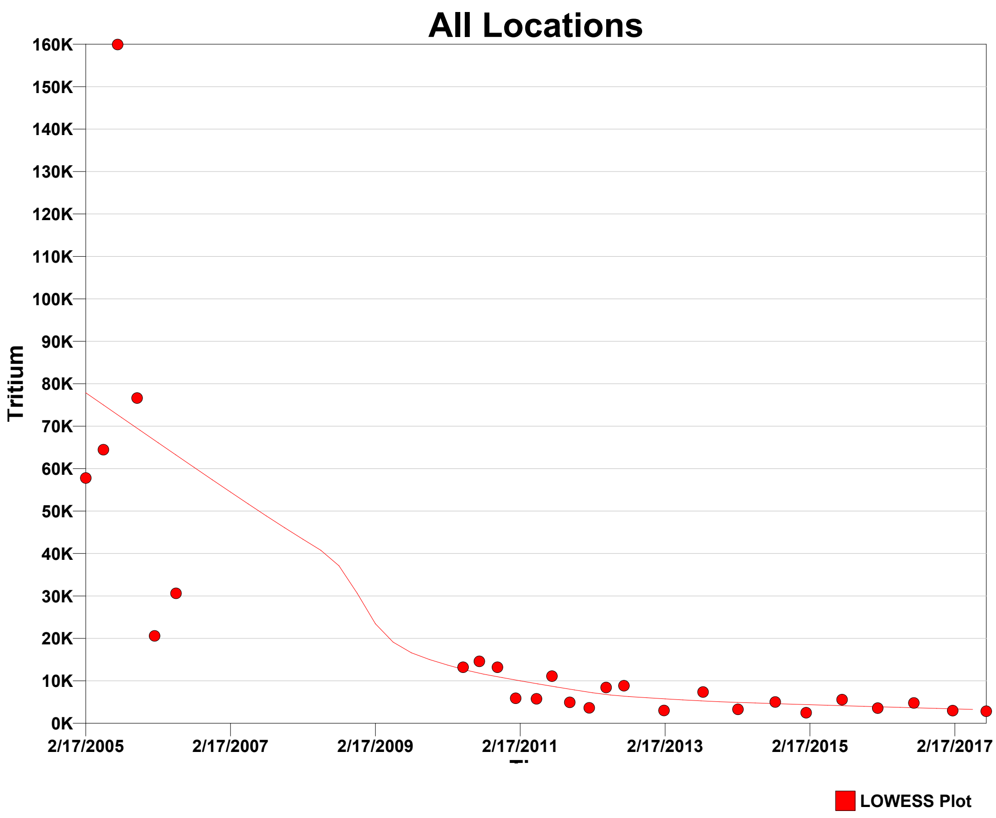
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 53711.7 * exp(-3.31159 * Time)
(-23.3835% change per year)
Residual from Predicted Log(Value)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Tritium
160K
150K
140K
130K
120K
110K
100K
90K
80K
70K
60K
50K
40K
30K
20K
10K
0K
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=26) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.94675
Shapiro-Wilk 5% Critical Value	0.92

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-236	
MK Test Statistic	Z_{MK}	-5.18102	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0607 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
1/31/2012	3.46		2/19/2014	3.18		1/25/2016	4.87
4/25/2012	9.95		5/12/2014	4.05		4/25/2016	7.31
7/24/2012	5.05		8/26/2014	7.53		7/25/2016	6.92
10/25/2012	7.45		10/27/2014	7.74		10/24/2016	5.27
2/11/2013	5.61		1/29/2015	4.86		2/6/2017	4.7
5/30/2013	9.04		4/27/2015	4.38		5/2/2017	3.3
8/27/2013	7.75		7/29/2015	6.67		7/25/2017	4.66
10/28/2013	6.41		10/28/2015	3.25		11/7/2017	1.33

SUMMARY STATISTICS for Trichloroethene	
n	24
Min	-1.052787
Max	0.4877386
Range	1.5405
Mean	0
Median	0.1103997
Variance	0.15784
StdDev	0.39729
Std Error	0.081096
Skewness	-1.0171
Interquartile Range	0.59551

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.053	-0.9673	-0.6438	-0.2611	0.1104	0.3344	0.4251	0.4807	0.4877

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

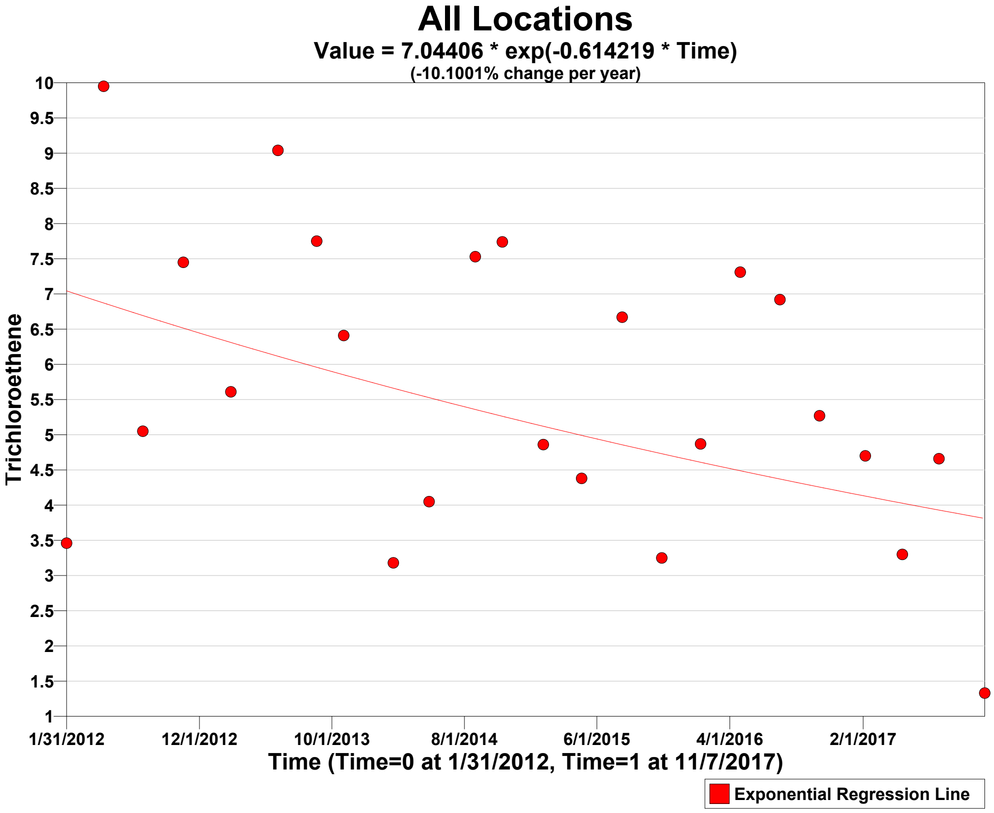
Data Plots

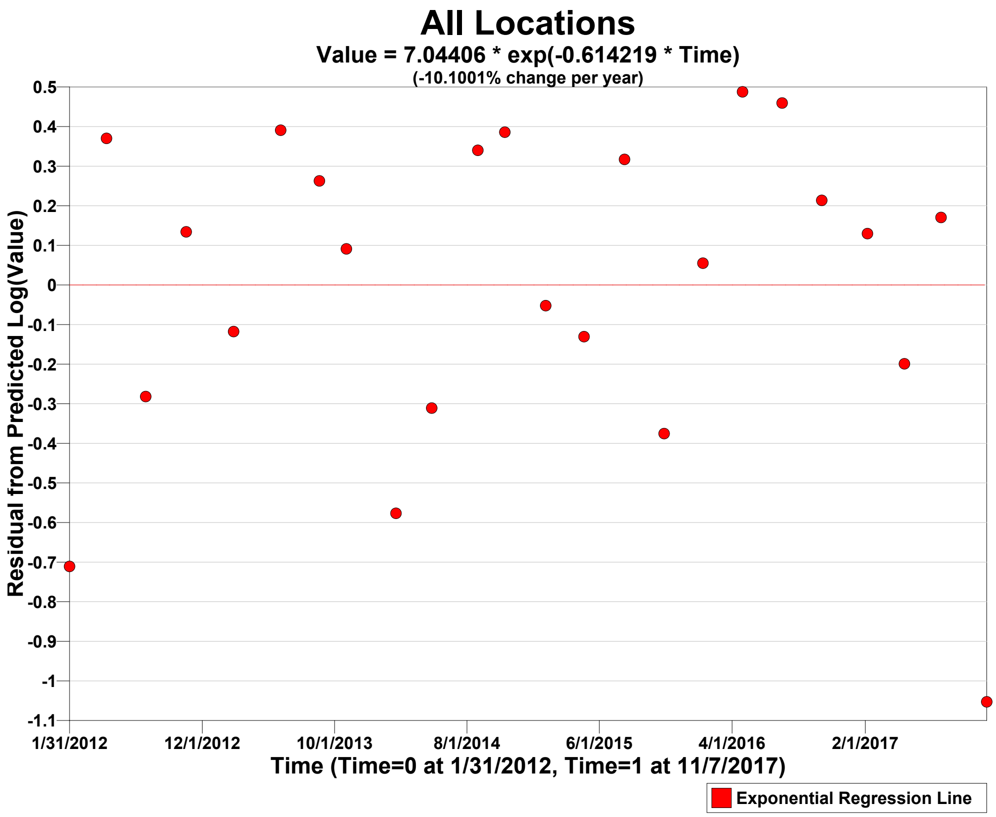
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.

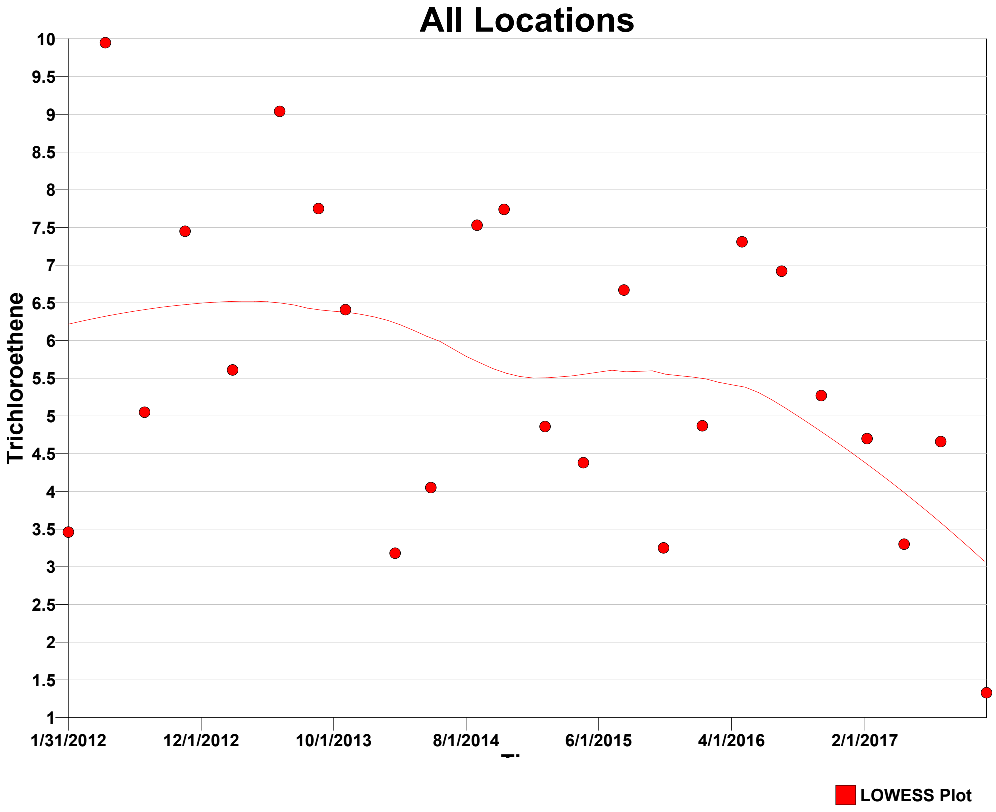




All Locations

Value = 7.04406 * exp(-0.614219 * Time)

(-10.1001% change per year)



All Locations

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=24) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.91842
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-80	
MK Test Statistic	Z_{MK}	-1.95955	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0607 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/17/2005	4.2		7/29/2009	11.5		2/19/2014	3.18
5/17/2005	8		10/26/2009	3.63		5/12/2014	4.05
7/28/2005	15		1/25/2010	2.74		8/26/2014	7.53
11/3/2005	8.7		5/5/2010	11		10/27/2014	7.74
1/30/2006	7.1		7/26/2010	4.79		1/29/2015	4.86
5/18/2006	6.2		10/25/2010	3.98		4/27/2015	4.38
9/26/2006	8.5		1/25/2011	4.9		7/29/2015	6.67
12/5/2006	5.12		5/10/2011	3.7		10/28/2015	3.25
2/27/2007	3.67		7/27/2011	8.72		1/25/2016	4.87
5/17/2007	13		10/25/2011	5.51		4/25/2016	7.31
8/22/2007	11.4		1/31/2012	3.46		7/25/2016	6.92
11/29/2007	6.38		4/25/2012	9.95		10/24/2016	5.27
2/28/2008	3.75		7/24/2012	5.05		2/6/2017	4.7
5/19/2008	6.11		10/25/2012	7.45		5/2/2017	3.3
8/4/2008	9.69		2/11/2013	5.61		7/25/2017	4.66
11/17/2008	4.77		5/30/2013	9.04		11/7/2017	1.33
2/9/2009	3.67		8/27/2013	7.75			
5/5/2009	9.43		10/28/2013	6.41			

<table>
<tr><th colspan="9">SUMMARY STATISTICS for Trichloroethene</th></tr>
<tr><th colspan="4">n</th><td colspan="5">52</td></tr>
<tr><th colspan="4">Min</th><td colspan="5">-1.191156</td></tr>
<tr><th colspan="4">Max</th><td colspan="5">0.7066023</td></tr>
<tr><th colspan="4">Range</th><td colspan="5">1.8978</td></tr>
<tr><th colspan="4">Mean</th><td colspan="5">0</td></tr>
<tr><th colspan="4">Median</th><td colspan="5">0.008260376</td></tr>
<tr><th colspan="4">Variance</th><td colspan="5">0.18427</td></tr>
<tr><th colspan="4">StdDev</th><td colspan="5">0.42926</td></tr>
<tr><th colspan="4">Std Error</th><td colspan="5">0.059528</td></tr>
<tr><th colspan="4">Skewness</th><td colspan="5">-0.38386</td></tr>
<tr><th colspan="4">Interquartile Range</th><td colspan="5">0.71087</td></tr>
<tr><th colspan="9">Percentiles</th></tr>
<tr><th>1%</th><th>5%</th><th>10%</th><th>25%</th><th>50%</th><th>75%</th><th>90%</th><th>95%</th><th>99%</th></tr>
<tr><td>-1.191</td><td>-0.6922</td><td>-0.5633</td><td>-0.3089</td><td>0.00826</td><td>0.402</td><td>0.5698</td><td>0.622</td><td>0.7066</td></tr>
</table>

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme

cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

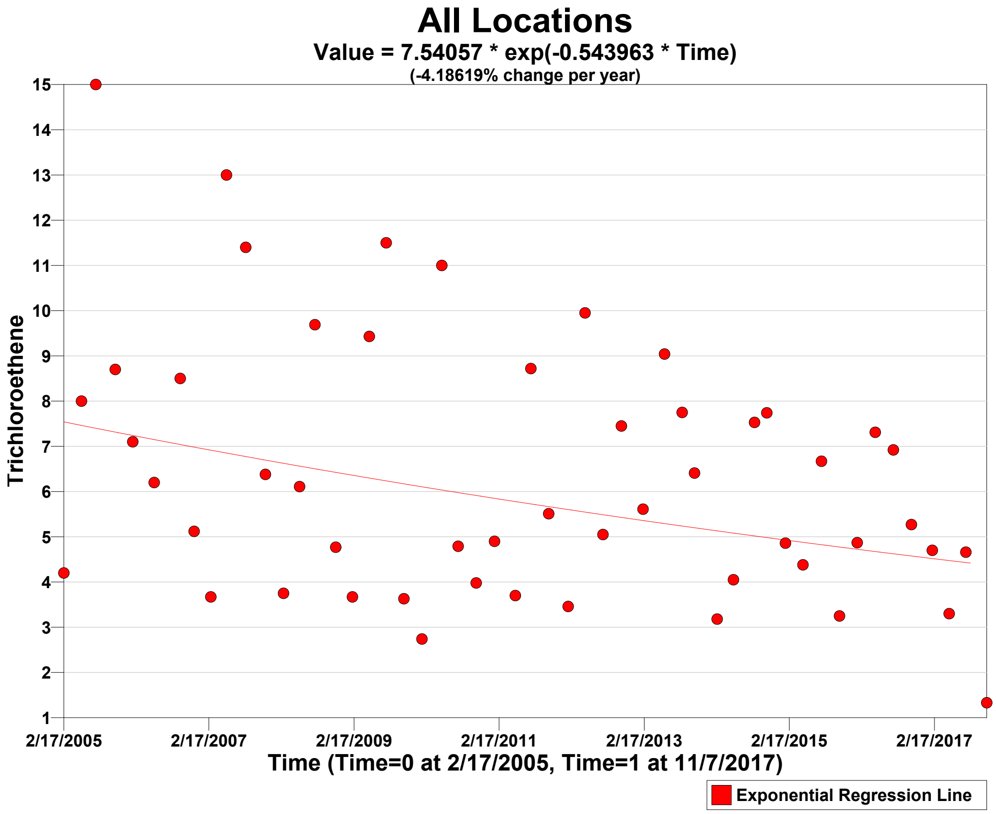
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

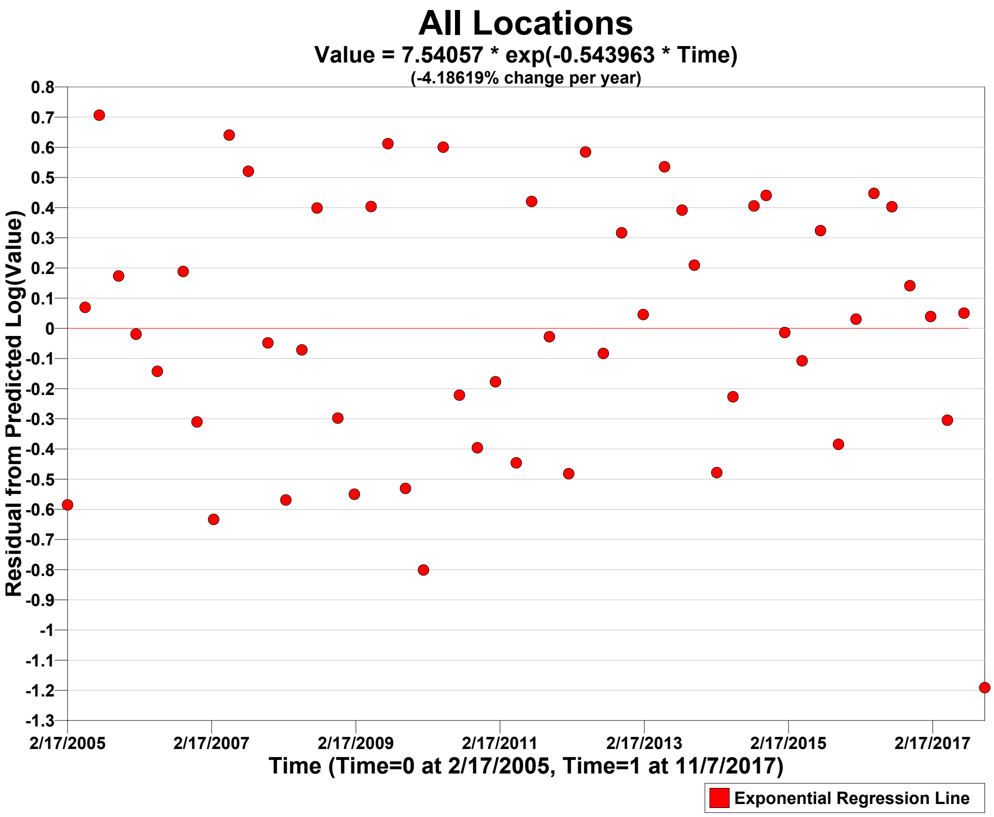
Data Plots

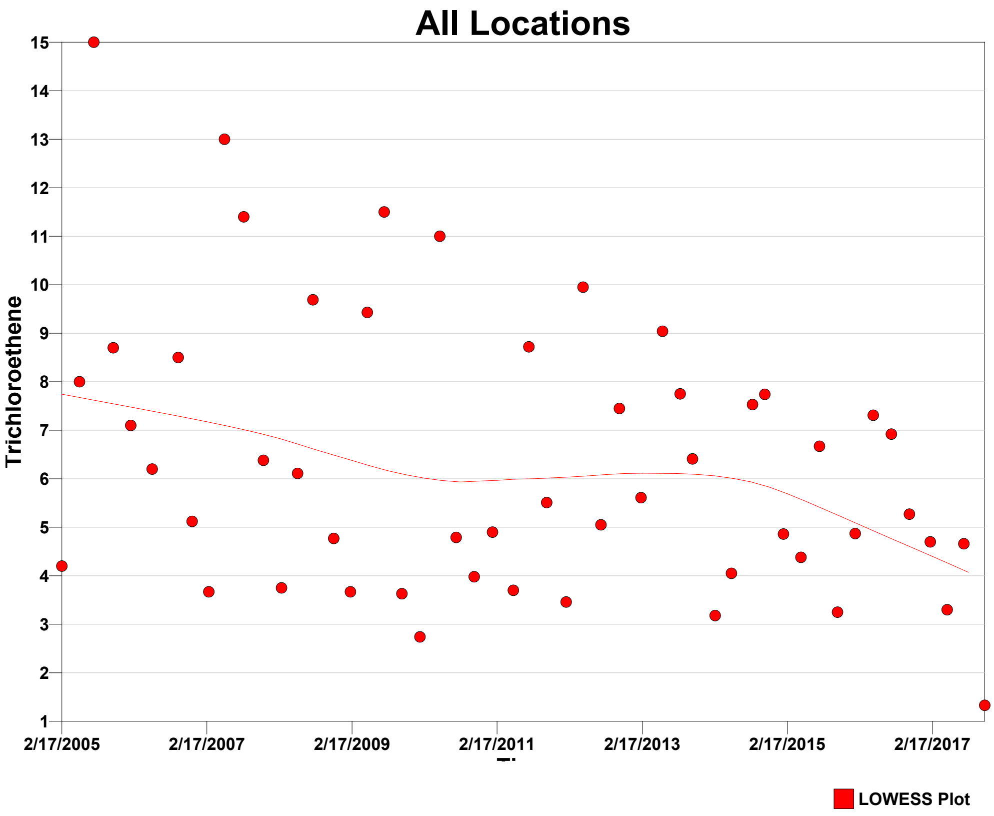
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 7.54057 * exp(-0.543963 * Time)
(-4.18619% change per year)
Residual from Predicted Log(Value)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 11/7/2017)
Exponential Regression Line


All Locations
Trichloroethene
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=52) is greater than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Lilliefors Test Statistic	0.10781
Lilliefors 5% Critical Value	0.12287

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-287	
MK Test Statistic	Z_{MK}	-2.25692	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0607 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	Tritium		Time	Tritium		Time	Tritium
2/17/2005	107450		8/4/2008	14700		1/31/2012	3430
5/17/2005	85560		11/17/2008	7680		4/25/2012	5170
7/28/2005	133130		2/9/2009	4760		7/24/2012	6120
11/3/2005	71410		5/5/2009	7660		2/11/2013	4510
1/30/2006	31830		7/29/2009	10700		8/27/2013	5100
5/18/2006	11430		10/26/2009	5750		2/19/2014	2170
9/26/2006	25300		1/25/2010	2910		8/26/2014	4160
12/5/2006	16000		5/5/2010	3880		1/29/2015	2760
2/27/2007	9030		7/26/2010	6630		7/29/2015	3900
5/17/2007	12200		10/25/2010	8840		1/25/2016	3710
8/22/2007	14100		1/25/2011	7040		7/25/2016	3080
11/29/2007	12900		5/10/2011	3710		2/6/2017	3100
2/28/2008	7190		7/27/2011	5370		7/25/2017	2080
5/19/2008	8060		10/25/2011	5690			

SUMMARY STATISTICS for Tritium								
n	41							
Min	-1.130101							
Max	1.615069							
Range	2.7452							
Mean	0							
Median	-0.01637991							
Variance	0.35573							
StdDev	0.59643							
Std Error	0.093147							
Skewness	0.67275							
Interquartile Range	0.78149							
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
-1.13	-0.8587	-0.6931	-0.4652	-0.01638	0.3163	0.9692	1.278	1.615

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	Value
2/17/2005	107450
7/28/2005	133130
1/30/2006	31830
5/18/2006	11430
9/26/2006	25300
12/5/2006	16000
2/27/2007	9030
5/17/2007	12200

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

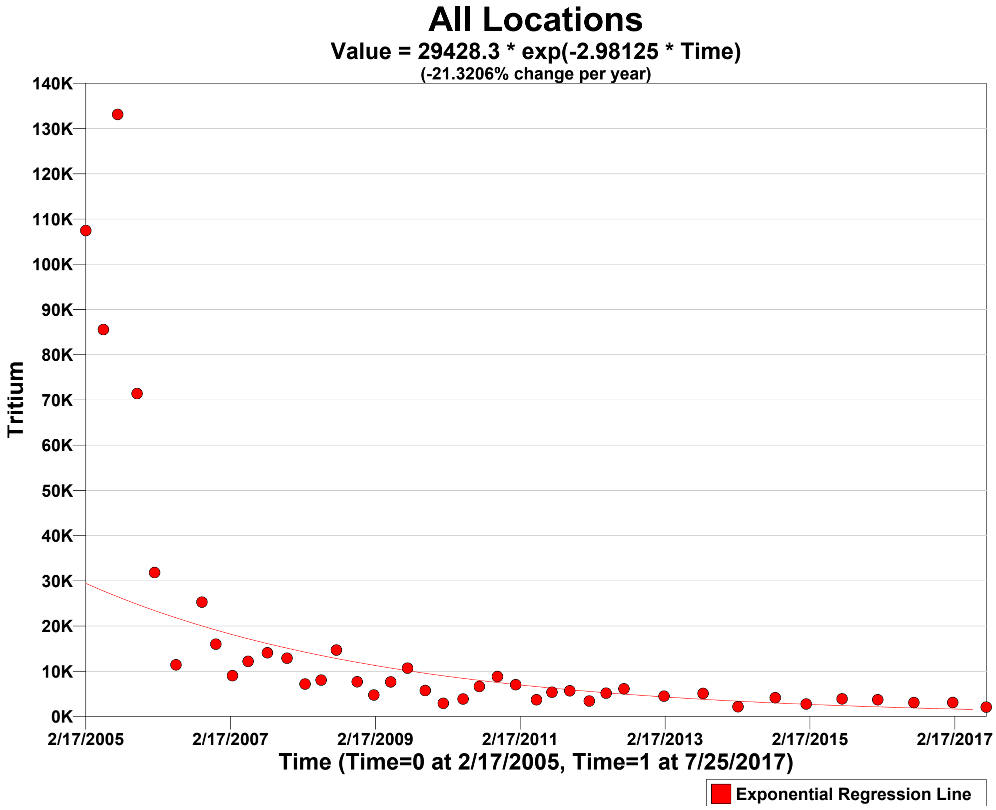
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

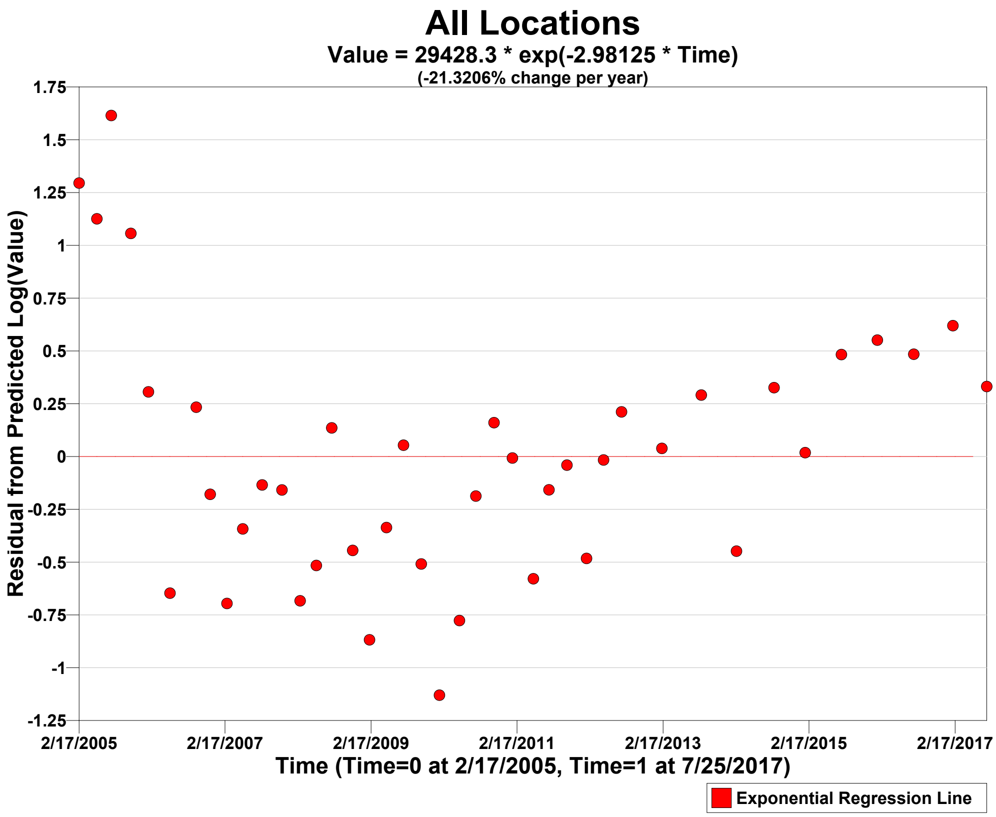
Data Plots

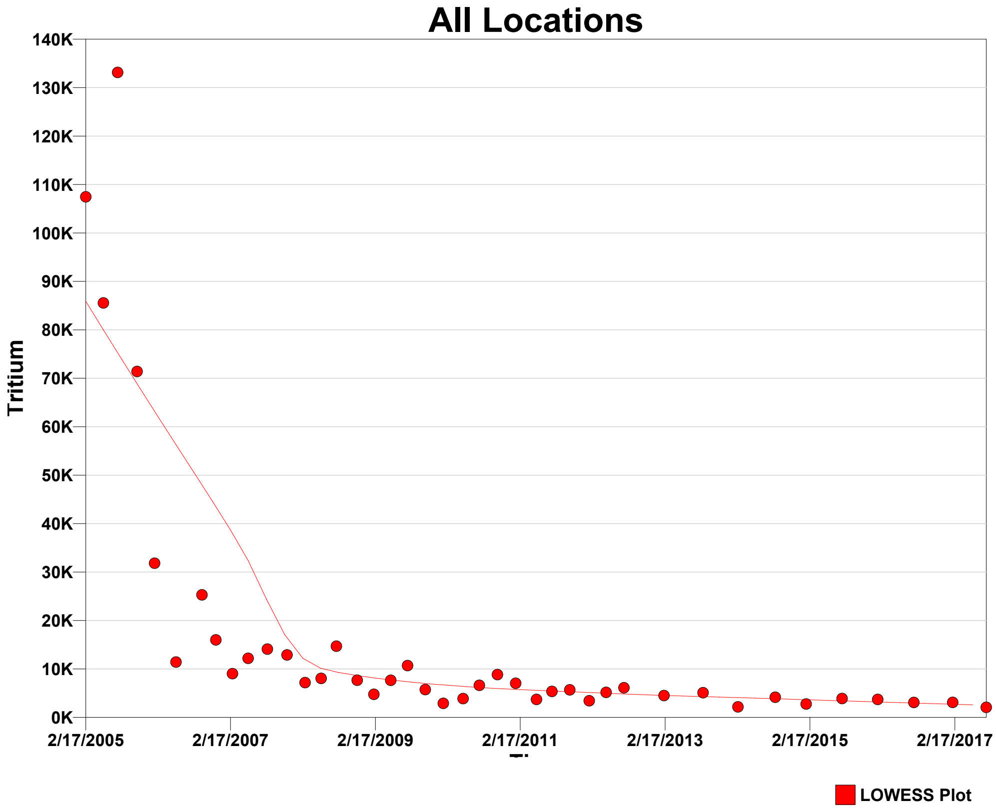
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 29428.3 * exp(-2.98125 * Time)
(-21.3206% change per year)
Residual from Predicted Log(Value)
1.75
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
Time (Time=0 at 2/17/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Tritium
140K
130K
120K
110K
100K
90K
80K
70K
60K
50K
40K
30K
20K
10K
0K
2/17/2005
2/17/2007
2/17/2009
2/17/2011
2/17/2013
2/17/2015
2/17/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=41) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.96403
Shapiro-Wilk 5% Critical Value	0.941

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-605	
MK Test Statistic	Z_{MK}	-6.78452	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0617 - cDCE

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**cDCE**		**Time**	**cDCE**		**Time**	**cDCE**
10/18/2001	3.1		1/31/2006	2.7		7/27/2011	1.36
1/30/2002	1.3		4/27/2006	2.1		1/31/2012	1.71
5/1/2002	2		8/3/2006	2.15		7/26/2012	0.59
4/22/2003	1.6		11/17/2006	0.969		2/11/2013	2.36
7/25/2003	2.6		2/28/2007	1.1		8/27/2013	1.59
10/21/2003	2.8		5/23/2007	2.82		2/19/2014	0.6
1/22/2004	2.1		8/24/2007	1.72		12/8/2014	1.88
4/21/2004	1.5		11/14/2007	2.57		1/29/2015	1.94
7/12/2004	2.6		2/19/2008	2.29		7/29/2015	1.86
11/17/2004	2.9		2/9/2009	1.31		1/25/2016	1.8
3/2/2005	2.1		7/29/2009	2.06		7/25/2016	1.08
5/24/2005	4.7		1/25/2010	0.724		2/6/2017	2.25
8/3/2005	2.3		7/30/2010	1.97		7/25/2017	2.28
11/18/2005	2.3		1/25/2011	2.2			

SUMMARY STATISTICS for cDCE								
n	41							
Min	-1.027905							
Max	0.8355796							
Range	1.8635							
Mean	0							
Median	0.1266634							
Variance	0.16736							
StdDev	0.40909							
Std Error	0.06389							
Skewness	-0.92962							
Interquartile Range	0.52025							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.028	-0.958	-0.6727	-0.263	0.1267	0.2573	0.3818	0.4687	0.8356

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
5/24/2005	4.7

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

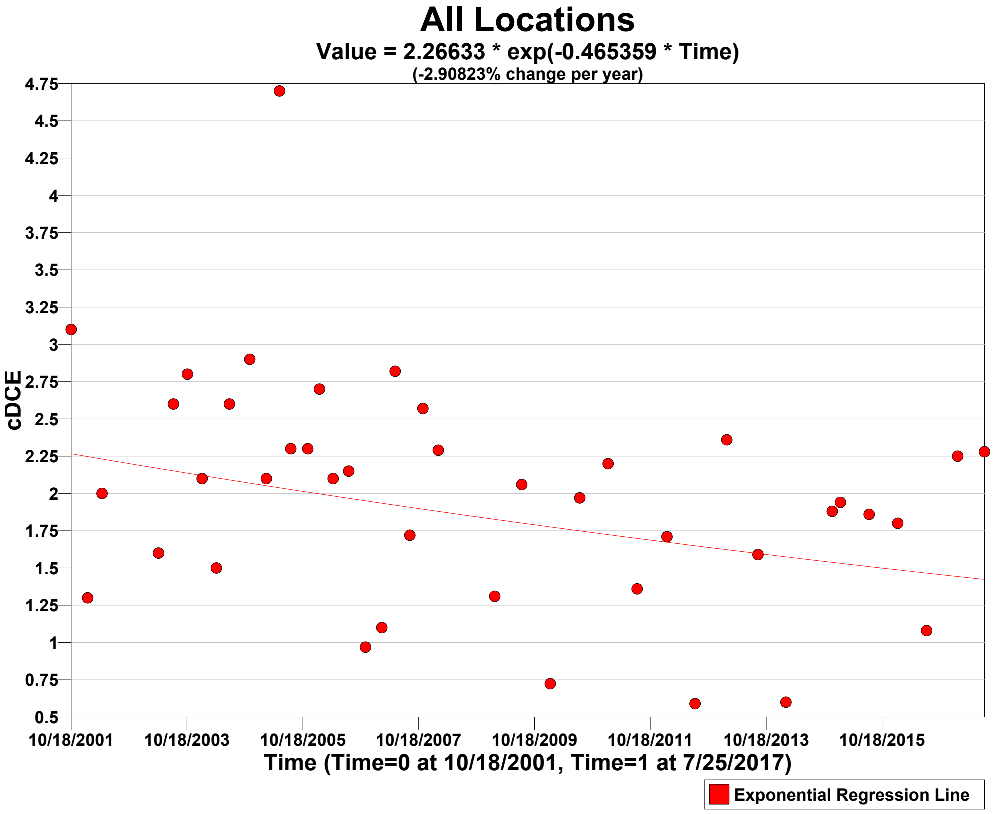
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

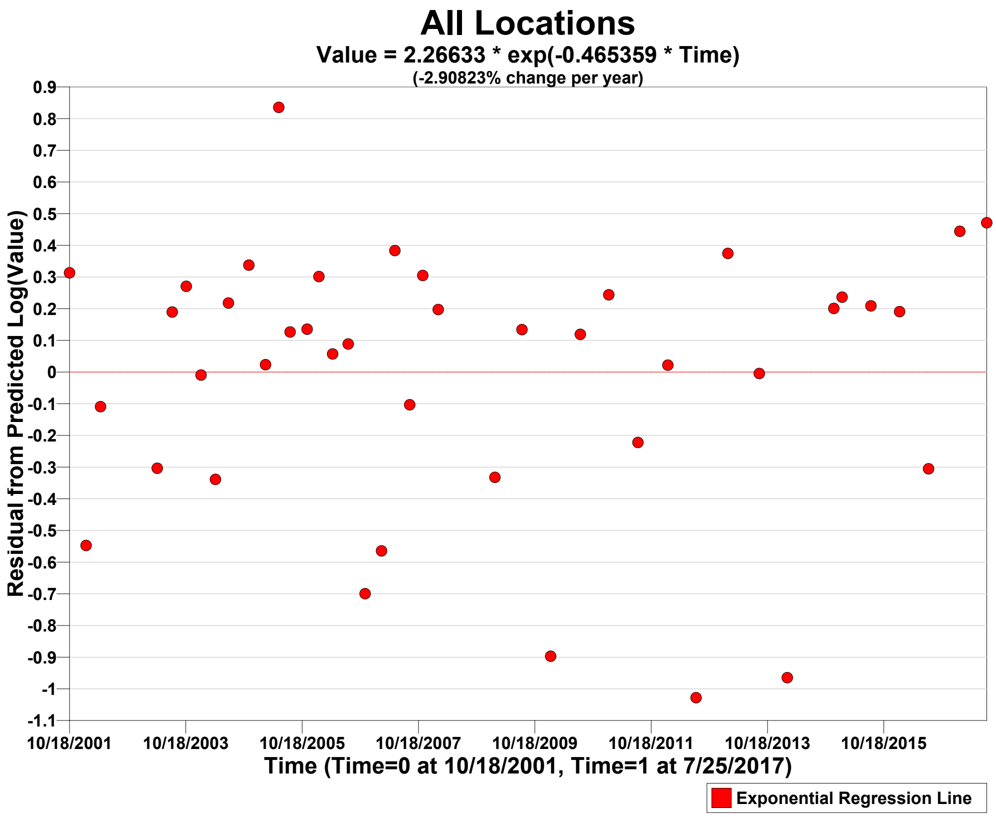
Data Plots

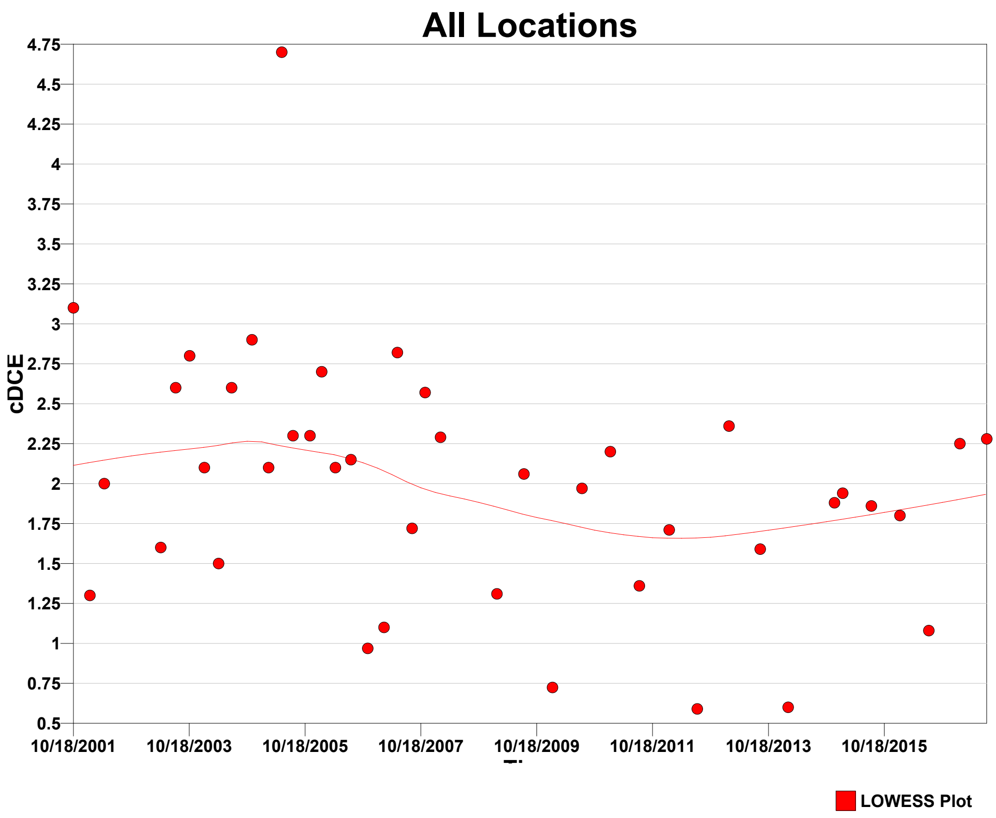
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 2.26633 * exp(-0.465359 * Time)
(-2.90823% change per year)
Residual from Predicted Log(Value)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
10/18/2001
10/18/2003
10/18/2005
10/18/2007
10/18/2009
10/18/2011
10/18/2013
10/18/2015
Time (Time=0 at 10/18/2001, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
cDCE
4.75
4.5
4.25
4
3.75
3.5
3.25
3
2.75
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
10/18/2001
10/18/2003
10/18/2005
10/18/2007
10/18/2009
10/18/2011
10/18/2013
10/18/2015
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=41) is less than 50.

Normal Distribution Test of Residuals for cDCE	
Shapiro-Wilk Test Statistic	0.91174
Shapiro-Wilk 5% Critical Value	0.941

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-199	
MK Test Statistic	Z_{MK}	-2.22472	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Seep 0617 – Trichloroethene

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
10/18/2001	12		1/31/2006	8.9		7/27/2011	6.66
1/30/2002	3.8		4/27/2006	6.2		1/31/2012	7.76
5/1/2002	7.9		8/3/2006	8.67		7/26/2012	1.84
4/22/2003	6.1		11/17/2006	3.9		2/11/2013	10.4
7/25/2003	7.4		2/28/2007	3.57		8/27/2013	6.7
10/21/2003	8.8		5/23/2007	10.4		2/19/2014	2.52
1/22/2004	7		8/24/2007	4.95		12/8/2014	8.31
4/21/2004	5.7		11/14/2007	8.5		1/29/2015	8.26
7/12/2004	9.8		2/19/2008	8.4		7/29/2015	8.05
11/17/2004	8.6		2/9/2009	4.48		1/25/2016	9.09
3/2/2005	7		7/29/2009	8.17		7/25/2016	3.53
5/24/2005	9		1/25/2010	2.89		2/6/2017	8.19
8/3/2005	6.1		7/30/2010	8.14		7/25/2017	8.17
11/18/2005	5.8		1/25/2011	9.78			

SUMMARY STATISTICS for Trichloroethene	
n	41
Min	-1.244848
Max	0.5308136
Range	1.7757
Mean	0
Median	0.1898927
Variance	0.17319
StdDev	0.41616
Std Error	0.064993
Skewness	-1.2354
Interquartile Range	0.45266

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.245	-0.9059	-0.6289	-0.1745	0.1899	0.2782	0.4065	0.487	0.5308

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

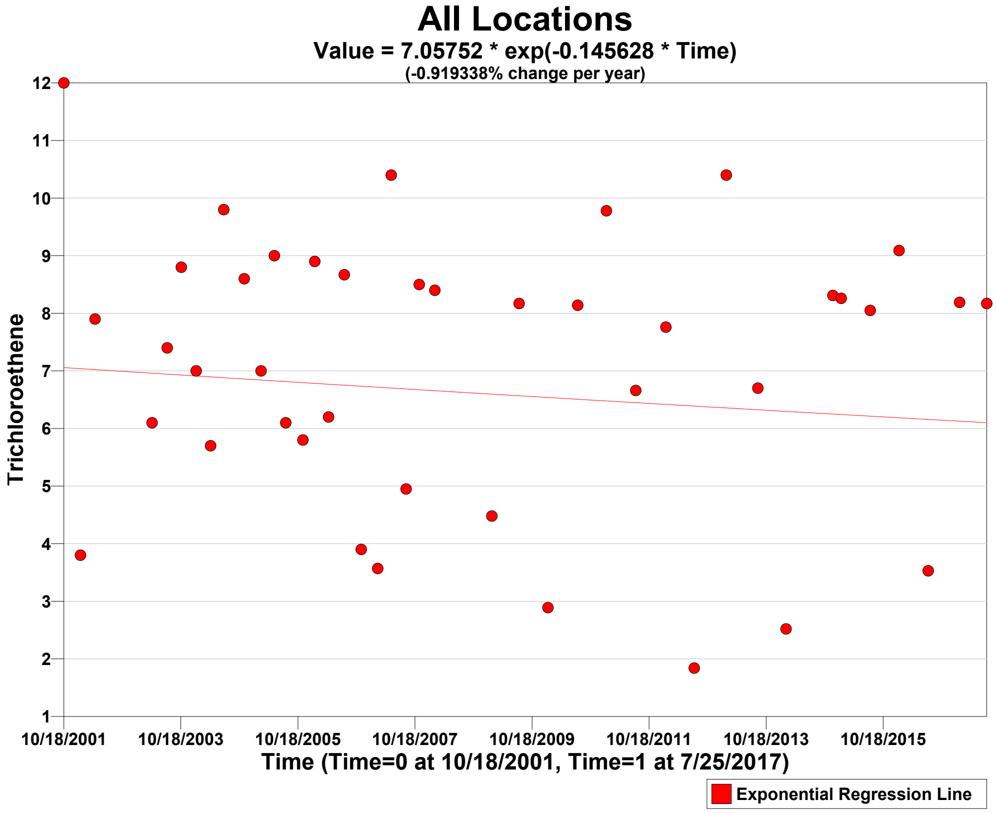
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

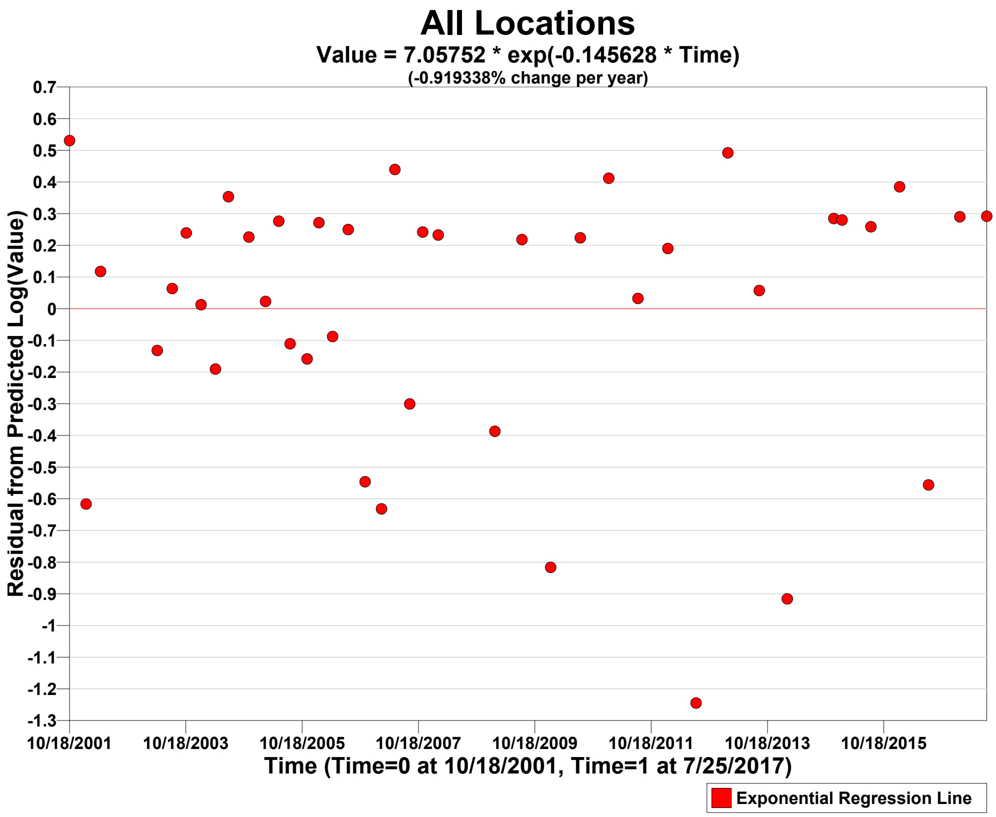
Data Plots

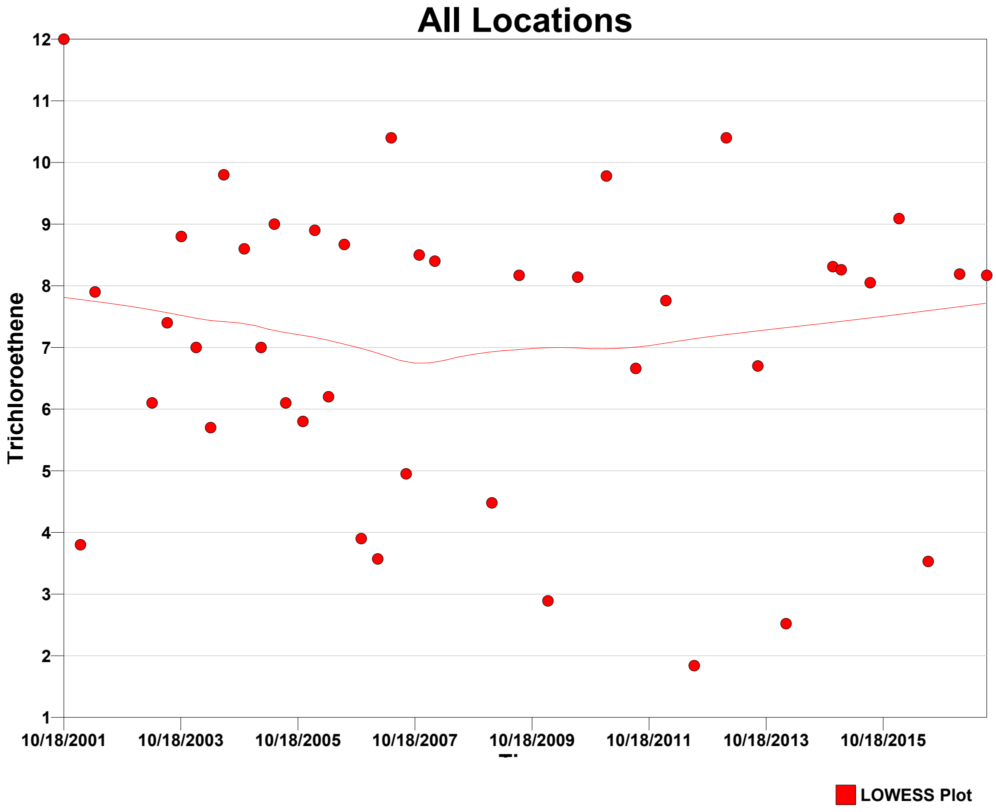
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 7.05752 * exp(-0.145628 * Time)
(-0.919338% change per year)
Residual from Predicted Log(Value)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
10/18/2001
10/18/2003
10/18/2005
10/18/2007
10/18/2009
10/18/2011
10/18/2013
10/18/2015
Time (Time=0 at 10/18/2001, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
12
11
10
9
8
7
6
5
4
3
2
1
10/18/2001
10/18/2003
10/18/2005
10/18/2007
10/18/2009
10/18/2011
10/18/2013
10/18/2015
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=41) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.87201
Shapiro-Wilk 5% Critical Value	0.941

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-44	
MK Test Statistic	Z_{MK}	-0.483095	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	-44	
MK Test Statistic	Z_{MK}	-0.483095	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

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Software and documentation available at http://vsp.pnnl.gov

* - The report contents may have been modified or reformatted by end-user of software.

Data Analysis for Well 0138 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
4/27/2005	10490		5/21/2008	3710		1/31/2012	1170
5/11/2005	8380		8/4/2008	3470		4/25/2012	1170
6/21/2005	12870		11/18/2008	1680		7/23/2012	1040
7/20/2005	13190		2/9/2009	873		2/11/2013	281
8/29/2005	14570		5/11/2009	1400		8/27/2013	1190
11/2/2005	8920		7/27/2009	2500		2/18/2014	628
1/25/2006	6680		10/26/2009	1590		8/27/2014	862
5/19/2006	14630		1/25/2010	1200		1/27/2015	430
9/25/2006	10000		5/5/2010	1570		7/28/2015	1060
12/4/2006	6910		7/26/2010	1770		1/25/2016	361
2/26/2007	7370		10/25/2010	880		7/28/2016	429
5/15/2007	6810		1/24/2011	479		2/8/2017	251
8/17/2007	4290		5/2/2011	1600		7/24/2017	858
11/29/2007	1390		7/26/2011	1600			
2/26/2008	1690		10/24/2011	914			

SUMMARY STATISTICS for Tritium	
n	43
Min	-1.185702
Max	1.264186
Range	2.4499
Mean	0
Median	0.03659005
Variance	0.30971
StdDev	0.55651
Std Error	0.084868
Skewness	-0.34433
Interquartile Range	0.7314

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.186	-1.144	-0.9205	-0.3248	0.03659	0.4066	0.6491	0.9004	1.264

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
5/11/2005	8380
8/29/2005	14570
1/25/2006	6680
5/19/2006	14630
11/29/2007	1390
2/26/2008	1690

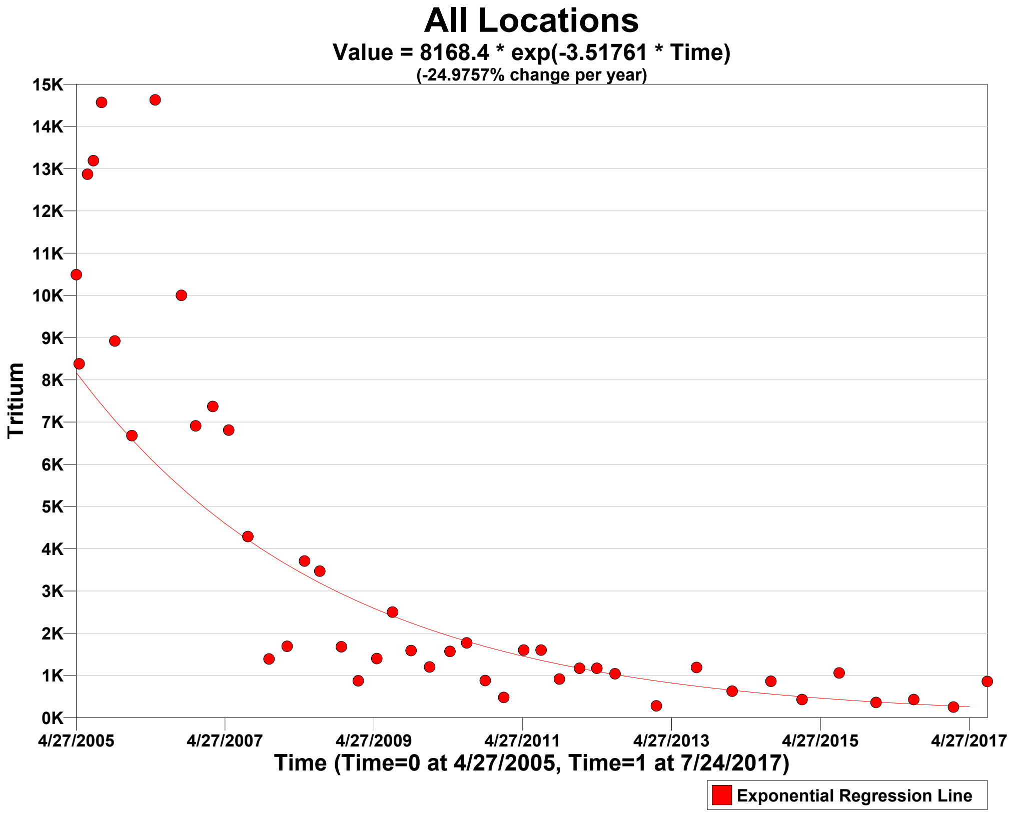
Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

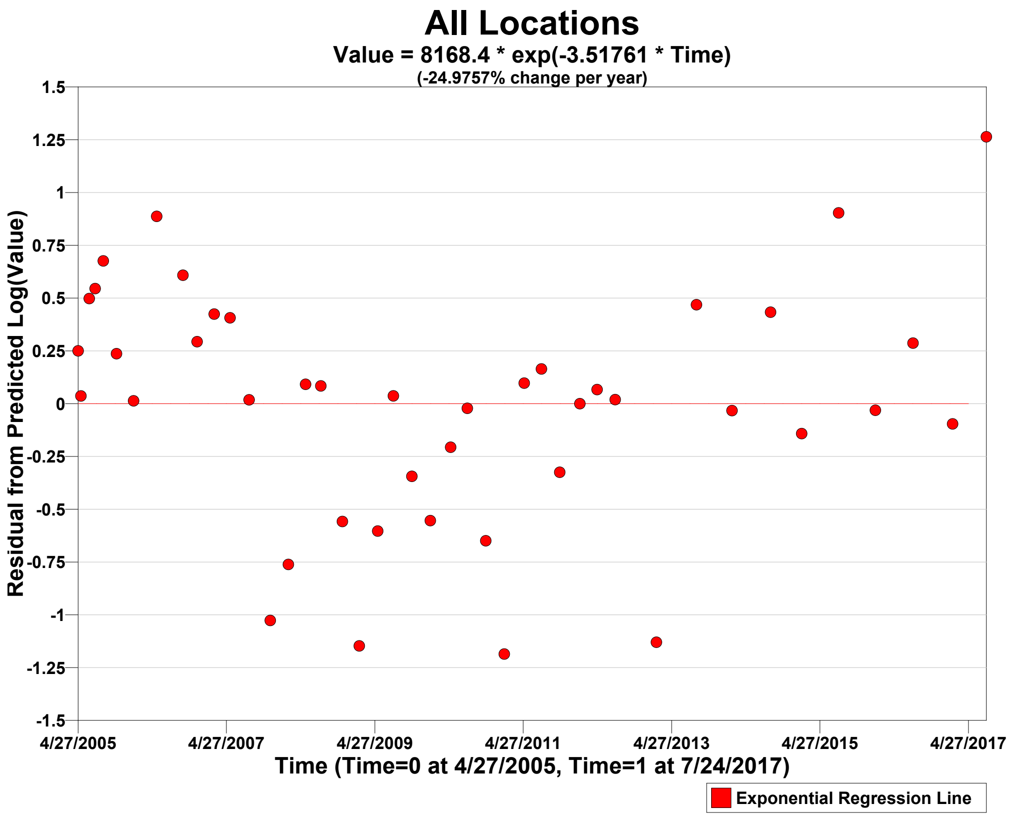
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

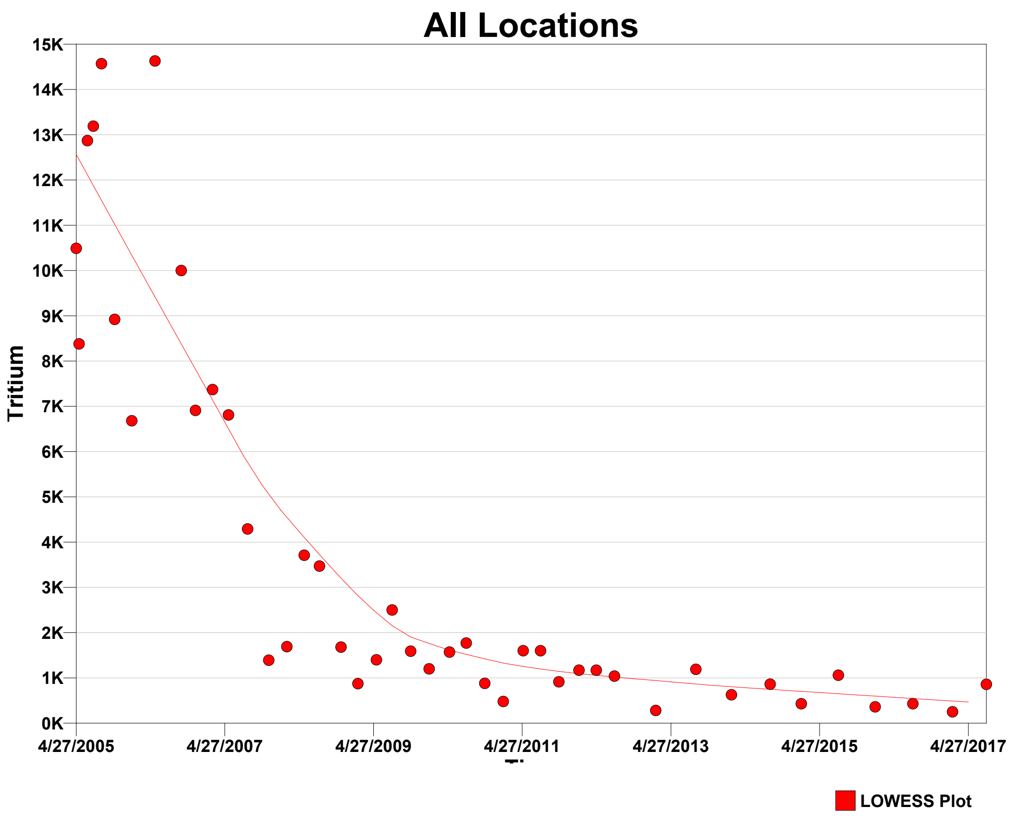
The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.





All Locations
Value = 8168.4 * exp(-3.51761 * Time)
(-24.9757% change per year)
Residual from Predicted Log(Value)
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
4/27/2005
4/27/2007
4/27/2009
4/27/2011
4/27/2013
4/27/2015
4/27/2017
Time (Time=0 at 4/27/2005, Time=1 at 7/24/2017)
🟥 Exponential Regression Line



All Locations
Tritium
15K
14K
13K
12K
11K
10K
9K
8K
7K
6K
5K
4K
3K
2K
1K
0K
4/27/2005
4/27/2007
4/27/2009
4/27/2011
4/27/2013
4/27/2015
4/27/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=43) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.96212
Shapiro-Wilk 5% Critical Value	0.943

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we cannot reject the hypothesis that the residuals are normally distributed, or in other words the residuals appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-665	
MK Test Statistic	Z_{MK}	-6.9498	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0315 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/1/2012	10.3		2/19/2014	8.7		1/25/2016	3.83
4/23/2012	12.3		5/12/2014	8.99		4/26/2016	5.67
7/25/2012	10.8		8/28/2014	10.5		7/27/2016	6.81
10/23/2012	16.6		10/27/2014	11.7		10/26/2016	7.53
2/12/2013	12.5		1/28/2015	9.62		2/7/2017	4.14
5/28/2013	7.23		4/27/2015	6.07		5/1/2017	6.98
8/26/2013	10.1		7/27/2015	6.39		7/25/2017	4.67
10/28/2013	12.9		10/28/2015	8.24		11/7/2017	6.44

SUMMARY STATISTICS for Trichloroethene								
n				24				
Min				-0.5782783				
Max				0.3611573				
Range				0.93944				
Mean				0				
Median				-0.0004139816				
Variance				0.059325				
StdDev				0.24357				
Std Error				0.049718				
Skewness				-0.52181				
Interquartile Range				0.36184				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.5783	-0.5272	-0.3531	-0.1466	-0.000414	0.2152	0.3049	0.3551	0.3612

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

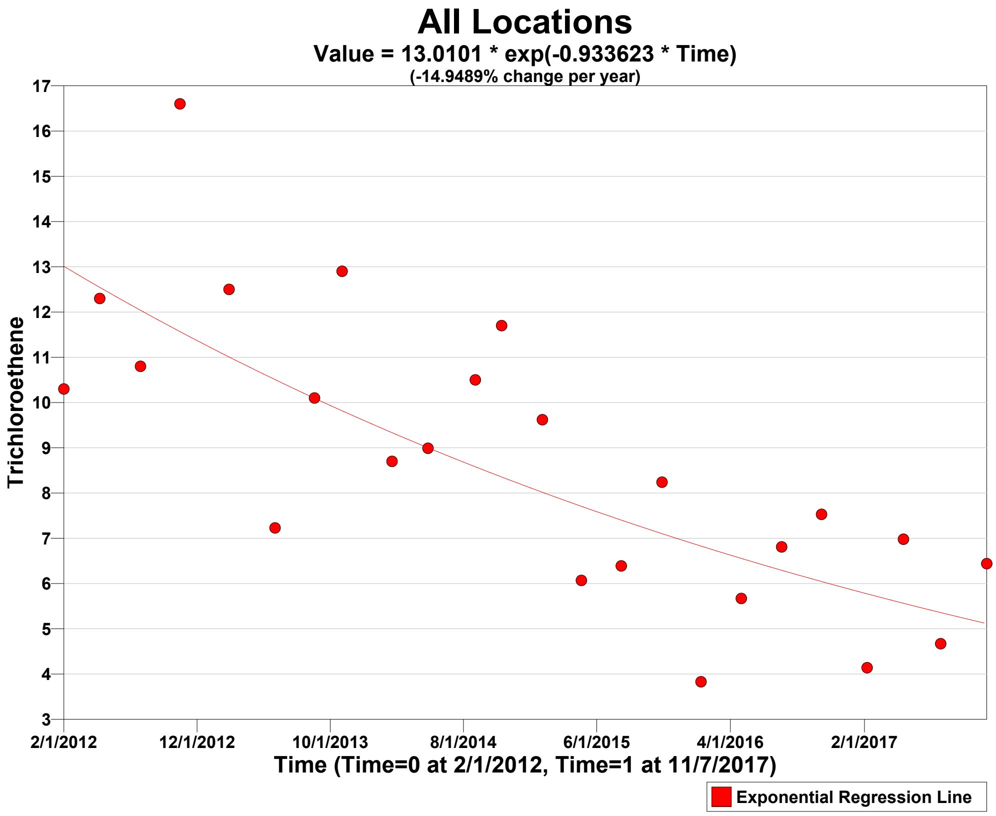
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

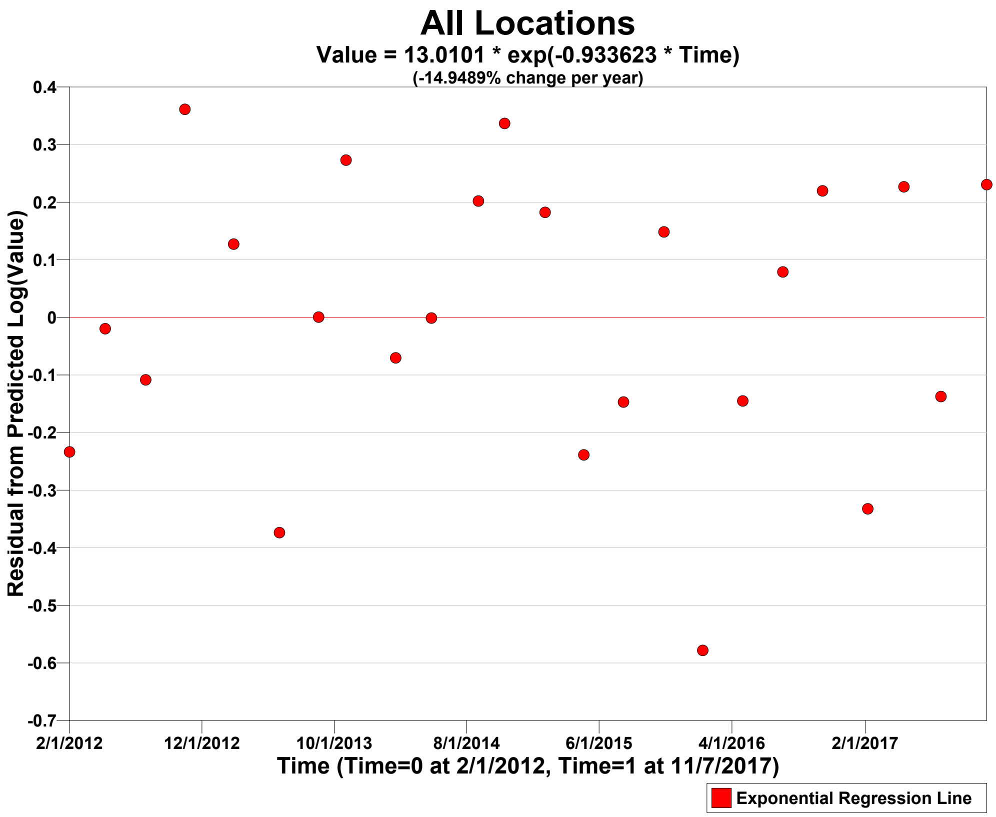
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

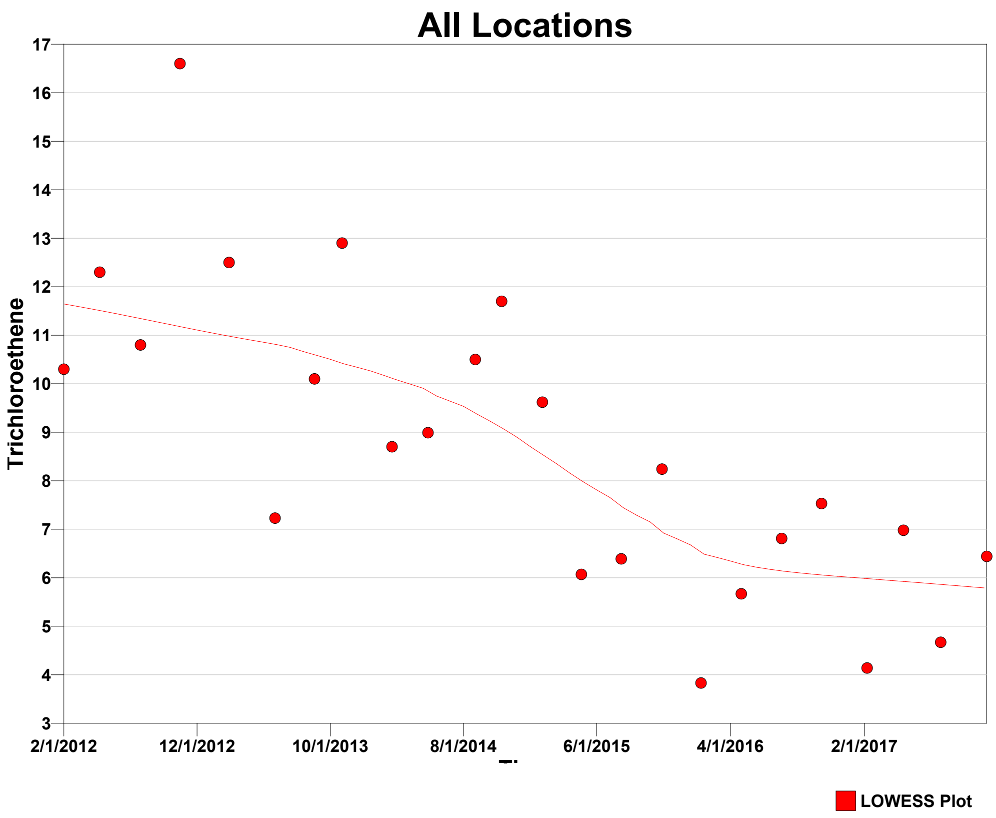
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 13.0101 * exp(-0.933623 * Time)
(-14.9489% change per year)
Residual from Predicted Log(Value)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 2/1/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=24) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.96028
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-150	
MK Test Statistic	Z_{MK}	-3.69586	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0315 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	Trichloroethene		Time	Trichloroethene		Time	Trichloroethene
3/4/2005	10		7/28/2009	11.8		10/28/2013	12.9
5/19/2005	11		10/27/2009	14.1		2/19/2014	8.7
7/22/2005	13		1/26/2010	11.8		5/12/2014	8.99
1/27/2006	5.2		5/5/2010	11.1		8/28/2014	10.5
5/17/2006	7.2		7/26/2010	9.48		10/27/2014	11.7
9/26/2006	6.3		10/25/2010	15.2		1/28/2015	9.62
12/6/2006	3.79		1/25/2011	13.6		4/27/2015	6.07
2/21/2007	11.6		5/2/2011	8.1		7/27/2015	6.39
5/16/2007	13.2		7/28/2011	6.23		10/28/2015	8.24
8/20/2007	12.2		10/24/2011	10.7		1/25/2016	3.83
11/27/2007	16.8		2/1/2012	10.3		4/26/2016	5.67
2/26/2008	9.38		4/23/2012	12.3		7/27/2016	6.81
5/21/2008	11.2		7/25/2012	10.8		10/26/2016	7.53
8/5/2008	9.65		10/23/2012	16.6		2/7/2017	4.14
11/18/2008	17.2		2/12/2013	12.5		5/1/2017	6.98
2/12/2009	11.7		5/28/2013	7.23		7/25/2017	4.67
5/5/2009	12.5		8/26/2013	10.1		11/7/2017	6.44

SUMMARY STATISTICS for Trichloroethene								
n	51							
Min	-1.070847							
Max	0.6327517							
Range	1.7036							
Mean	0							
Median	0.06881391							
Variance	0.12343							
StdDev	0.35133							
Std Error	0.049196							
Skewness	-0.87891							
Interquartile Range	0.36233							
Percentiles								
1%	5%	10%	25%	50%	75%	90%	95%	99%
-1.071	-0.7401	-0.5466	-0.1683	0.06881	0.194	0.4089	0.4874	0.6328

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

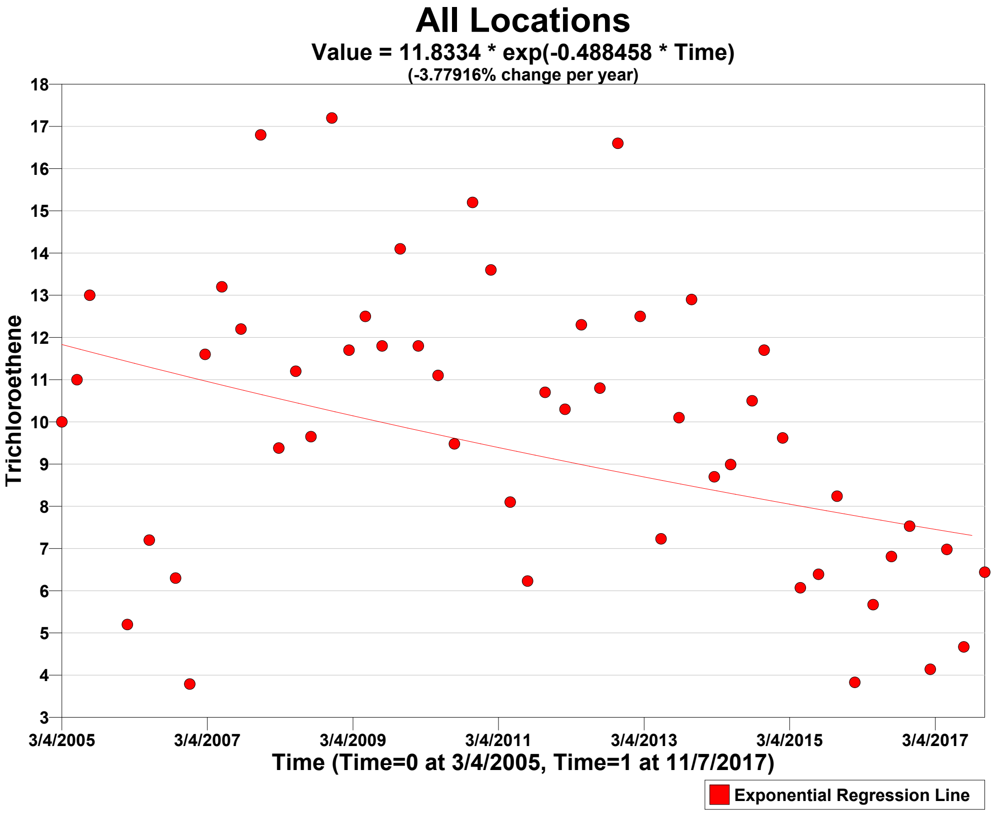
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

Data Plots

The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

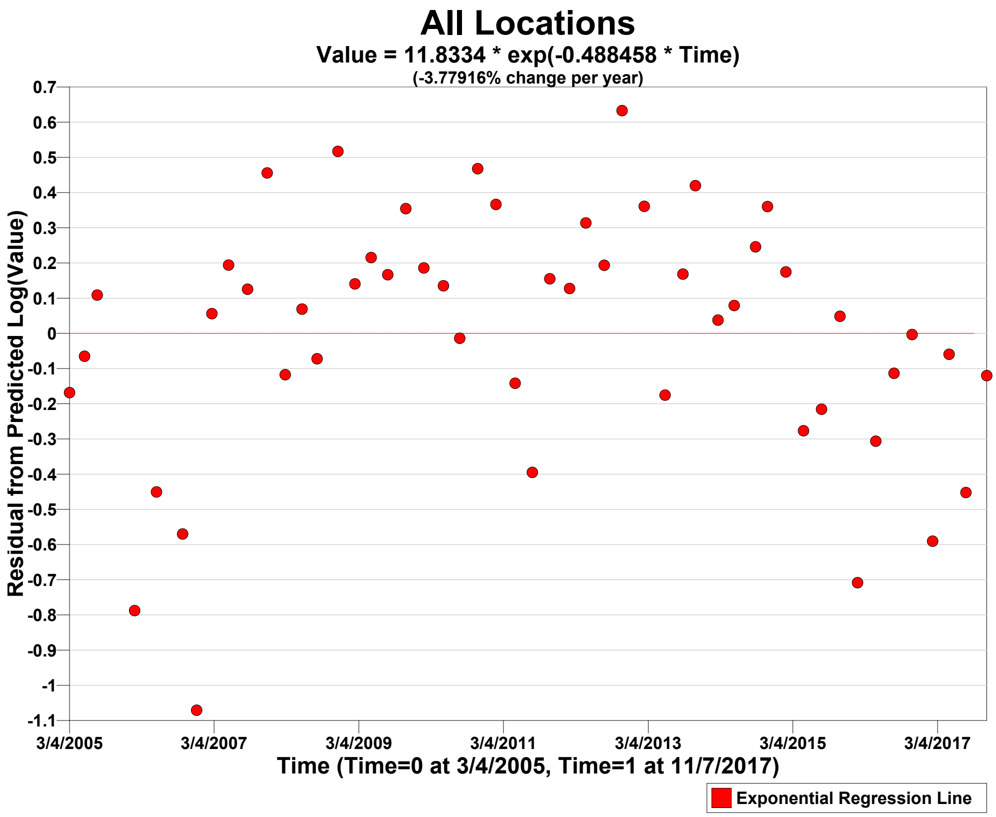
The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.

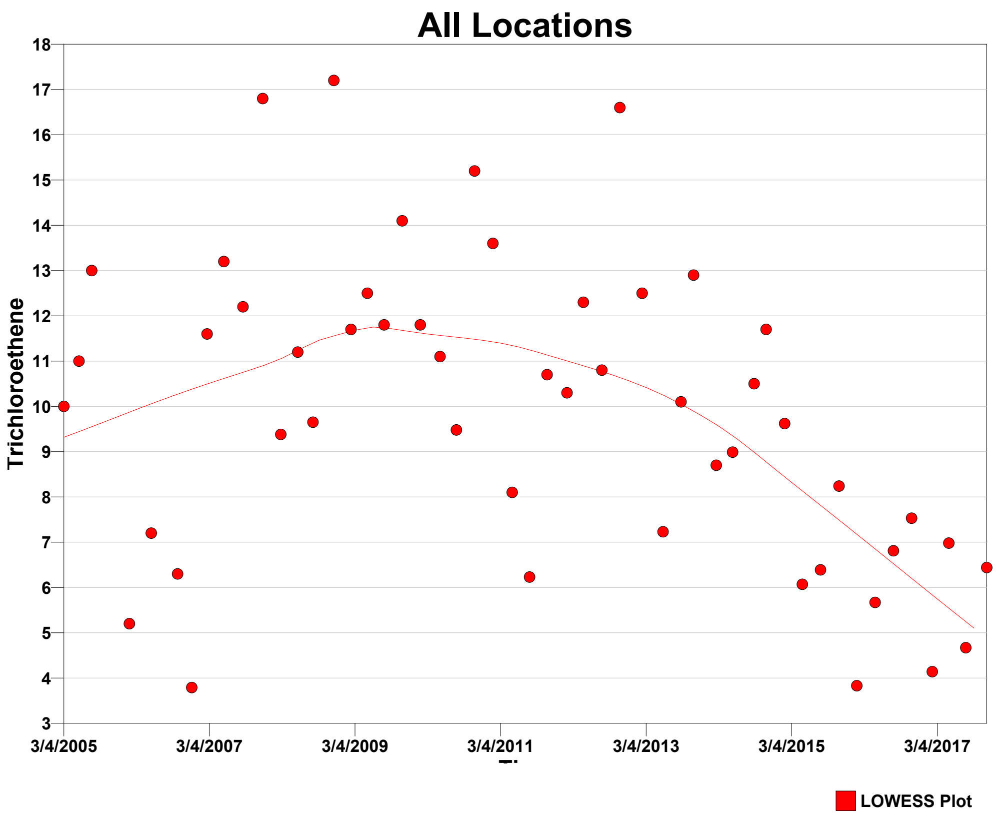


All Locations

Value = 11.8334 * exp(-0.488458 * Time)

(-3.77916% change per year)


All Locations
Value = 11.8334 * exp(-0.488458 * Time)
(-3.77916% change per year)
Residual from Predicted Log(Value)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
3/4/2005
3/4/2007
3/4/2009
3/4/2011
3/4/2013
3/4/2015
3/4/2017
Time (Time=0 at 3/4/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
3/4/2005
3/4/2007
3/4/2009
3/4/2011
3/4/2013
3/4/2015
3/4/2017
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=51) is greater than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Lilliefors Test Statistic	0.11138
Lilliefors 5% Critical Value	0.12406

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-362	
MK Test Statistic	Z_{MK}	-2.93241	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0346 – Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
3/2/2005	33770		11/28/2007	2610		7/27/2011	1470
4/19/2005	15100		2/26/2008	2090		10/24/2011	919
4/27/2005	14900		5/20/2008	2260		2/1/2012	943
5/16/2005	7850		8/5/2008	1200		4/24/2012	1050
6/21/2005	5220		11/18/2008	1830		7/25/2012	856
7/22/2005	2130		2/11/2009	1810		2/12/2013	494
11/3/2005	4460		5/5/2009	1780		8/26/2013	665
12/14/2005	4520		7/28/2009	2030		2/24/2014	196
1/25/2006	2320		10/27/2009	2000		8/28/2014	1020
5/22/2006	2050		1/26/2010	1320		1/28/2015	18.6
9/26/2006	3490		5/6/2010	1830		7/28/2015	736
12/5/2006	4750		7/27/2010	1730		1/25/2016	860
2/21/2007	2120		10/26/2010	1710		7/26/2016	566
5/16/2007	1830		1/25/2011	1280		2/7/2017	47.3
8/16/2007	1760		5/3/2011	987		7/25/2017	211

SUMMARY STATISTICS for Tritium	
n	45
Min	-2.899409
Max	1.67998
Range	4.5794
Mean	0
Median	-0.03051599
Variance	0.55142
StdDev	0.74258
Std Error	0.1107
Skewness	-1.1029
Interquartile Range	0.50731

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-2.899	-1.248	-0.7838	-0.2093	-0.03052	0.298	0.9376	1.153	1.68

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
3/2/2005	33770
4/19/2005	15100
4/27/2005	14900
5/16/2005	7850
7/22/2005	2130
1/25/2006	2320
5/22/2006	2050

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

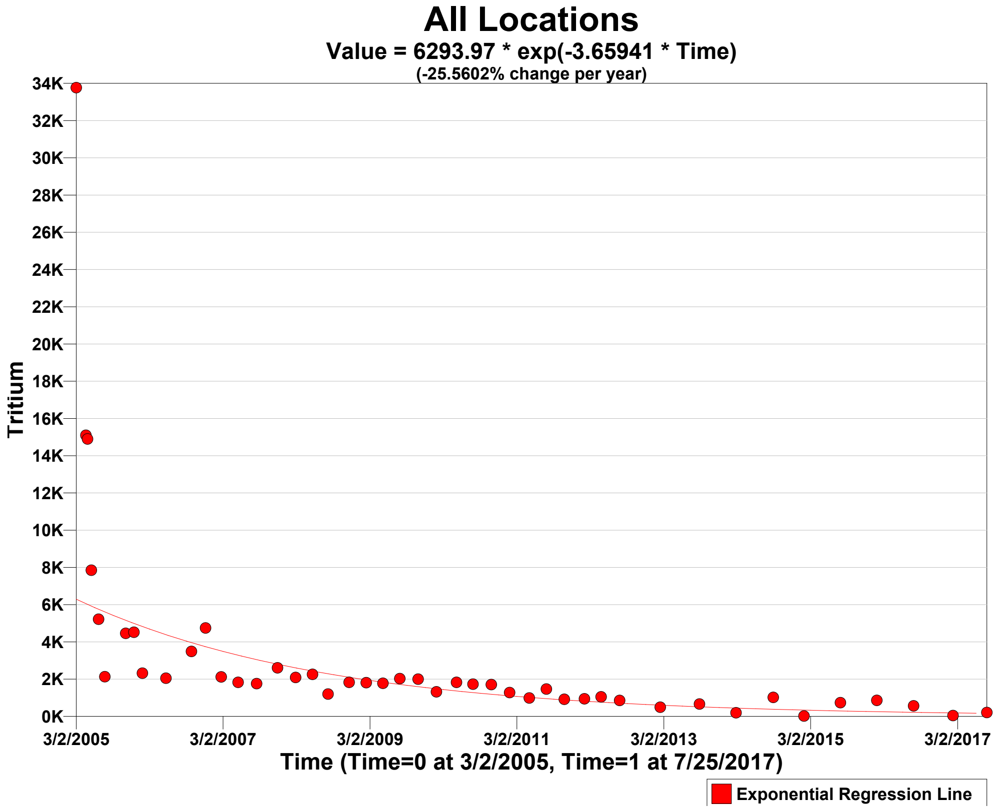
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

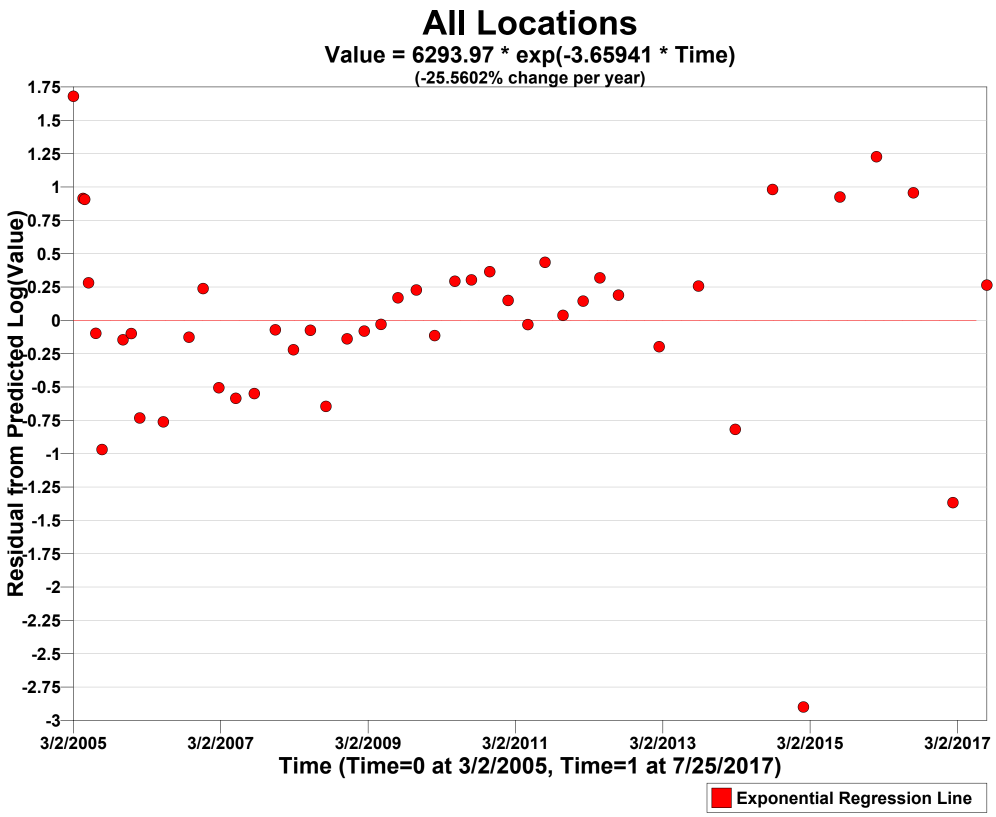
Data Plots

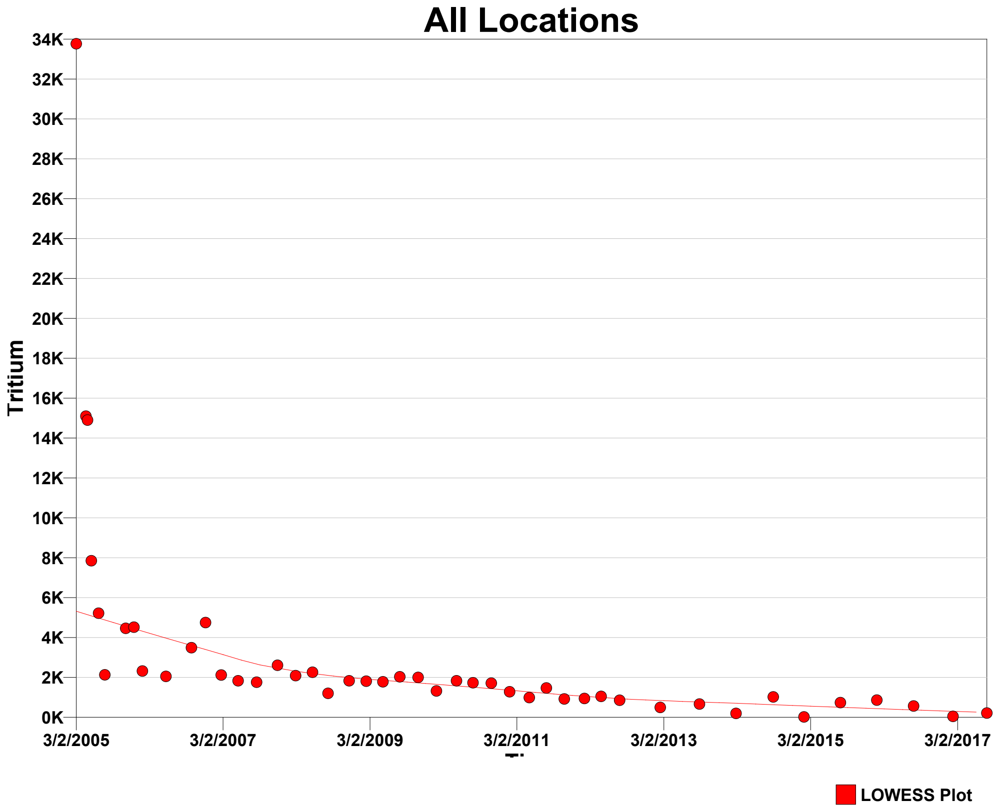
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 6293.97 * exp(-3.65941 * Time)
(-25.5602% change per year)
Residual from Predicted Log(Value)
1.75
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
-2.75
-3
3/2/2005
3/2/2007
3/2/2009
3/2/2011
3/2/2013
3/2/2015
3/2/2017
Time (Time=0 at 3/2/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Tritium
34K
32K
30K
28K
26K
24K
22K
20K
18K
16K
14K
12K
10K
8K
6K
4K
2K
0K
3/2/2005
3/2/2007
3/2/2009
3/2/2011
3/2/2013
3/2/2015
3/2/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=45) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.91888
Shapiro-Wilk 5% Critical Value	0.945

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-805	
MK Test Statistic	Z_{MK}	-7.86637	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0347 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/1/2012	28.8		2/19/2014	18.3		1/25/2016	16.6
4/23/2012	23.8		5/12/2014	23.1		4/26/2016	13.9
7/25/2012	25		8/28/2014	20.8		7/27/2016	18.2
10/24/2012	31.2		10/27/2014	23.8		10/26/2016	24.6
2/12/2013	27.5		1/28/2015	25.4		2/7/2017	20.4
5/28/2013	23.2		4/27/2015	24.5		5/1/2017	18
8/26/2013	27		7/27/2015	17.6		7/25/2017	18
10/28/2013	23.3		10/28/2015	19.6		11/7/2017	25.7

SUMMARY STATISTICS for Trichloroethene	
n	24
Min	-0.3716902
Max	0.3430993
Range	0.71479
Mean	0
Median	-0.024046
Variance	0.026103
StdDev	0.16156
Std Error	0.032979
Skewness	-0.135
Interquartile Range	0.19745

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.3717	-0.3386	-0.225	-0.08358	-0.02405	0.1139	0.2199	0.3153	0.3431

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

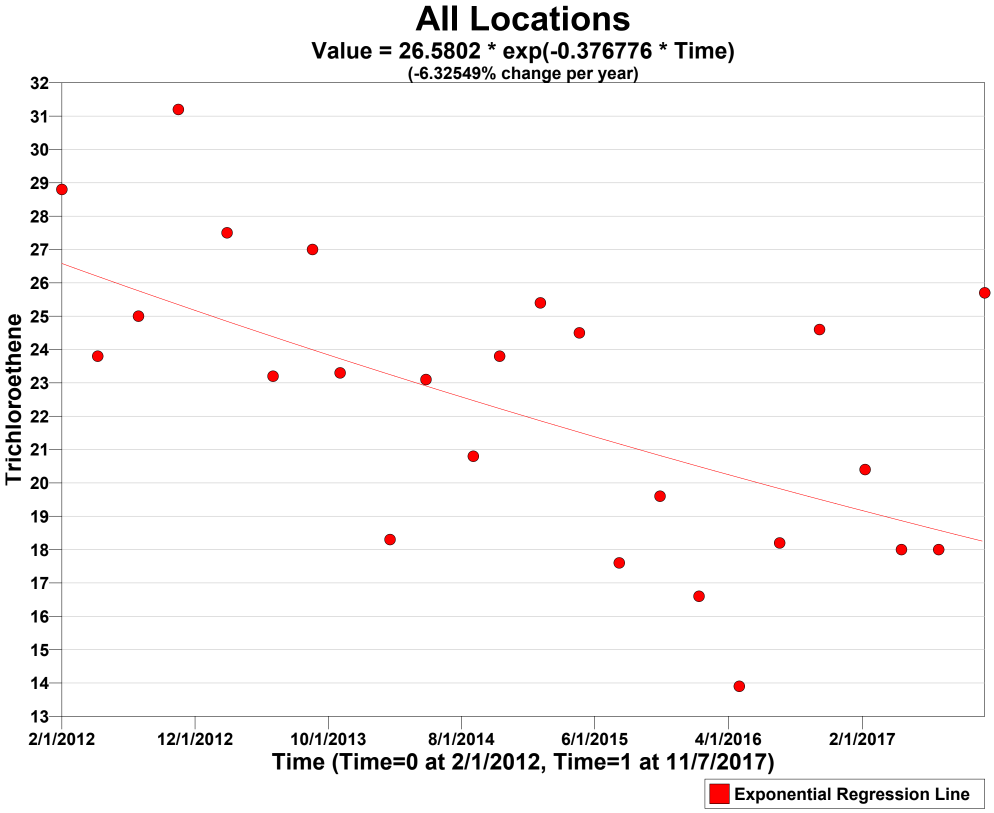
Data Plots

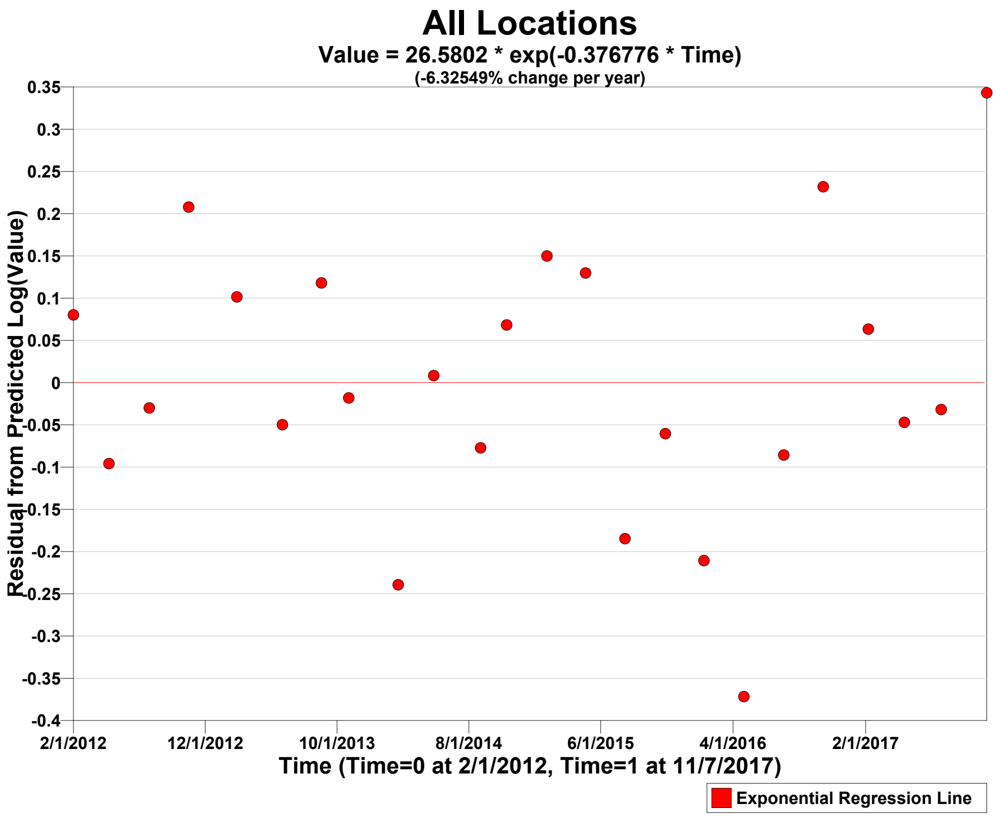
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

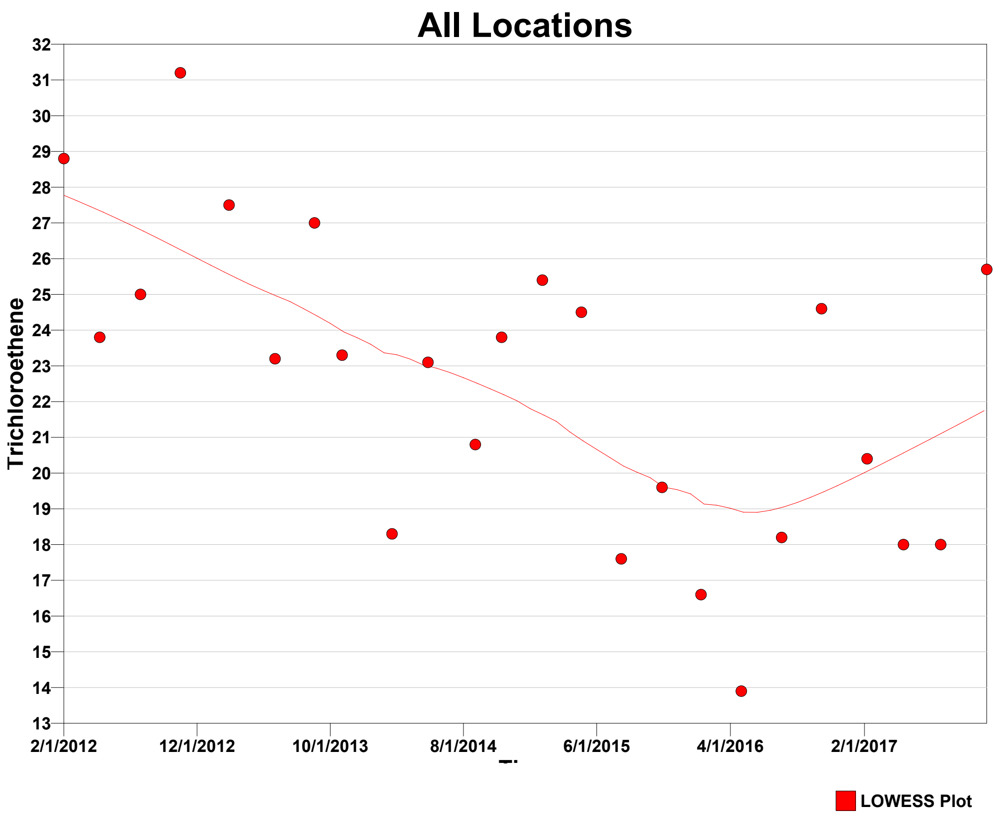
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 26.5802 * exp(-0.376776 * Time)
(-6.32549% change per year)
Residual from Predicted Log(Value)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
-0.35
-0.4
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 2/1/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=24) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.98757
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-112	
MK Test Statistic	Z_{MK}	-2.75498	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0347 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/24/2005	20		7/28/2009	23.3		10/28/2013	23.3
5/16/2005	22		10/27/2009	29.2		2/19/2014	18.3
7/22/2005	23		1/27/2010	32.3		5/12/2014	23.1
1/27/2006	21		5/5/2010	26.9		8/28/2014	20.8
5/17/2006	21		7/27/2010	18.9		10/27/2014	23.8
9/27/2006	22		10/25/2010	27.9		1/28/2015	25.4
12/5/2006	33.2		1/25/2011	23.2		4/27/2015	24.5
2/21/2007	19		5/2/2011	24.5		7/27/2015	17.6
5/16/2007	12		7/28/2011	22.1		10/28/2015	19.6
8/16/2007	26.2		10/24/2011	27.8		1/25/2016	16.6
11/27/2007	0.431		2/1/2012	28.8		4/26/2016	13.9
2/26/2008	17.9		4/23/2012	23.8		7/27/2016	18.2
5/21/2008	20.5		7/25/2012	25		10/26/2016	24.6
8/5/2008	18.3		10/24/2012	31.2		2/7/2017	20.4
11/19/2008	21.2		2/12/2013	27.5		5/1/2017	18
2/12/2009	26.1		5/28/2013	23.2		7/25/2017	18
5/5/2009	27.3		8/26/2013	27		11/7/2017	25.7

SUMMARY STATISTICS for Trichloroethene								
n	51							
Min	-3.81953							
Max	0.5395118							
Range	4.359							
Mean	0							
Median	0.08988409							
Variance	0.34453							
StdDev	0.58697							
Std Error	0.082192							
Skewness	-5.7035							
Interquartile Range	0.31213							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-3.82	-0.4782	-0.2335	-0.08146	0.08988	0.2307	0.3166	0.4185	0.5395

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
11/27/2007	0.431

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

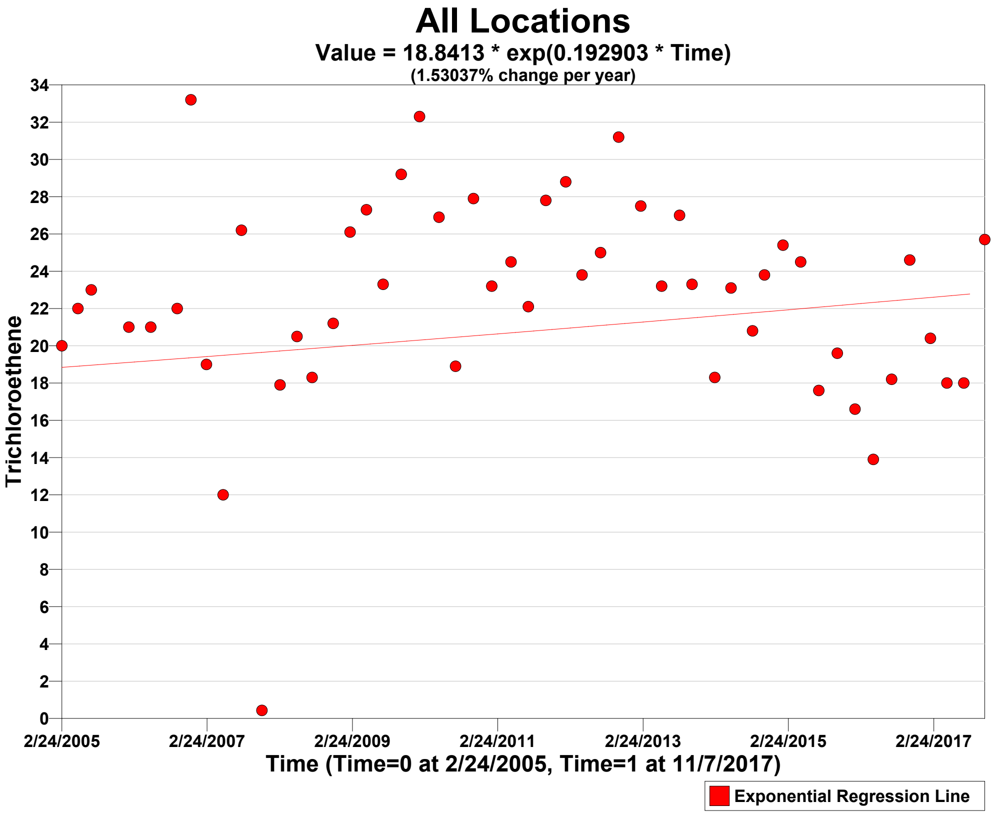
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

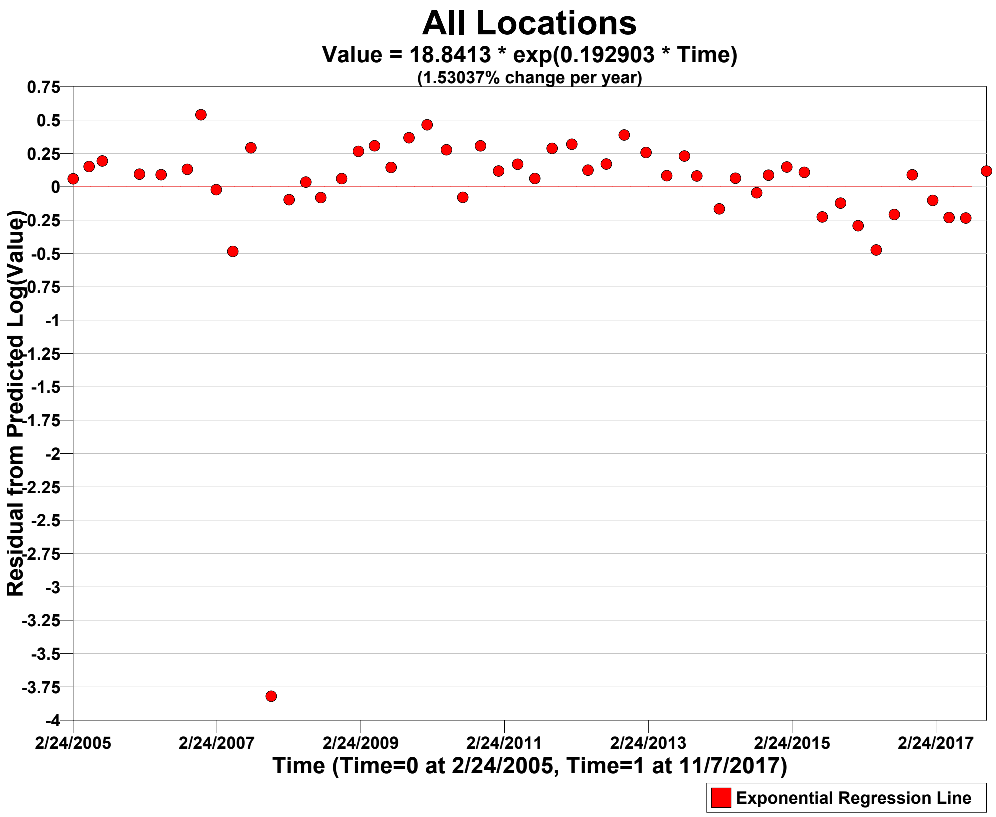
Data Plots

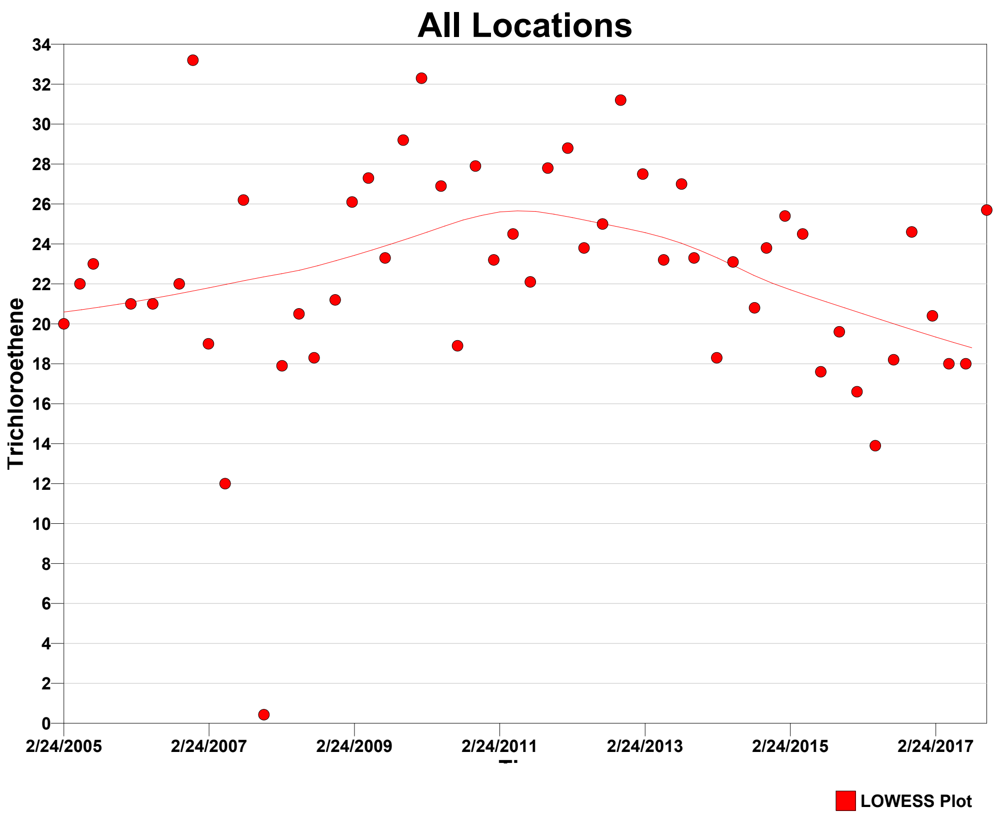
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 18.8413 * exp(0.192903 * Time)
(1.53037% change per year)
Residual from Predicted Log(Value)
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
-2.75
-3
-3.25
-3.5
-3.75
-4
2/24/2005
2/24/2007
2/24/2009
2/24/2011
2/24/2013
2/24/2015
2/24/2017
Time (Time=0 at 2/24/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
2/24/2005
2/24/2007
2/24/2009
2/24/2011
2/24/2013
2/24/2015
2/24/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=51) is greater than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Lilliefors Test Statistic	0.26651
Lilliefors 5% Critical Value	0.12406

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-63	
MK Test Statistic	Z_{MK}	-0.50371	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	-63	
MK Test Statistic	Z_{MK}	-0.50371	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

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Data Analysis for Well 0347 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
2/24/2005	2290		5/21/2008	9270		10/24/2011	5310
4/20/2005	1100		8/5/2008	5880		2/1/2012	3800
5/16/2005	1550		11/19/2008	6040		4/23/2012	4460
7/22/2005	670		2/12/2009	6570		7/25/2012	4310
11/22/2005	3740		5/5/2009	6860		2/12/2013	3420
1/27/2006	5830		7/28/2009	4590		8/26/2013	2460
5/17/2006	15420		10/27/2009	6540		2/19/2014	2290
9/27/2006	16800		1/27/2010	6530		8/28/2014	2610
12/5/2006	13000		5/5/2010	3670		1/28/2015	2820
2/21/2007	16400		7/27/2010	6710		7/27/2015	1690
5/16/2007	13100		10/25/2010	6490		1/25/2016	1430
8/16/2007	10200		1/25/2011	5730		7/27/2016	1630
11/27/2007	157		5/2/2011	3940		2/7/2017	1260
2/26/2008	6000		7/28/2011	2940		7/25/2017	1390

<table>
<tr><th colspan="9">SUMMARY STATISTICS for Tritium</th></tr>
<tr><th colspan="4">n</th><td colspan="5">42</td></tr>
<tr><th colspan="4">Min</th><td colspan="5">-3.388644</td></tr>
<tr><th colspan="4">Max</th><td colspan="5">1.201641</td></tr>
<tr><th colspan="4">Range</th><td colspan="5">4.5903</td></tr>
<tr><th colspan="4">Mean</th><td colspan="5">0</td></tr>
<tr><th colspan="4">Median</th><td colspan="5">0.1162614</td></tr>
<tr><th colspan="4">Variance</th><td colspan="5">0.78444</td></tr>
<tr><th colspan="4">StdDev</th><td colspan="5">0.88569</td></tr>
<tr><th colspan="4">Std Error</th><td colspan="5">0.13666</td></tr>
<tr><th colspan="4">Skewness</th><td colspan="5">-1.7681</td></tr>
<tr><th colspan="4">Interquartile Range</th><td colspan="5">0.87568</td></tr>
<tr><th colspan="9">Percentiles</th></tr>
<tr><th>1%</th><th>5%</th><th>10%</th><th>25%</th><th>50%</th><th>75%</th><th>90%</th><th>95%</th><th>99%</th></tr>
<tr><td>-3.389</td><td>-2.046</td><td>-1.181</td><td>-0.3753</td><td>0.1163</td><td>0.5003</td><td>0.9821</td><td>1.178</td><td>1.202</td></tr>
</table>

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
5/17/2006	15420
9/27/2006	16800
12/5/2006	13000
2/21/2007	16400
5/16/2007	13100
11/27/2007	157

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

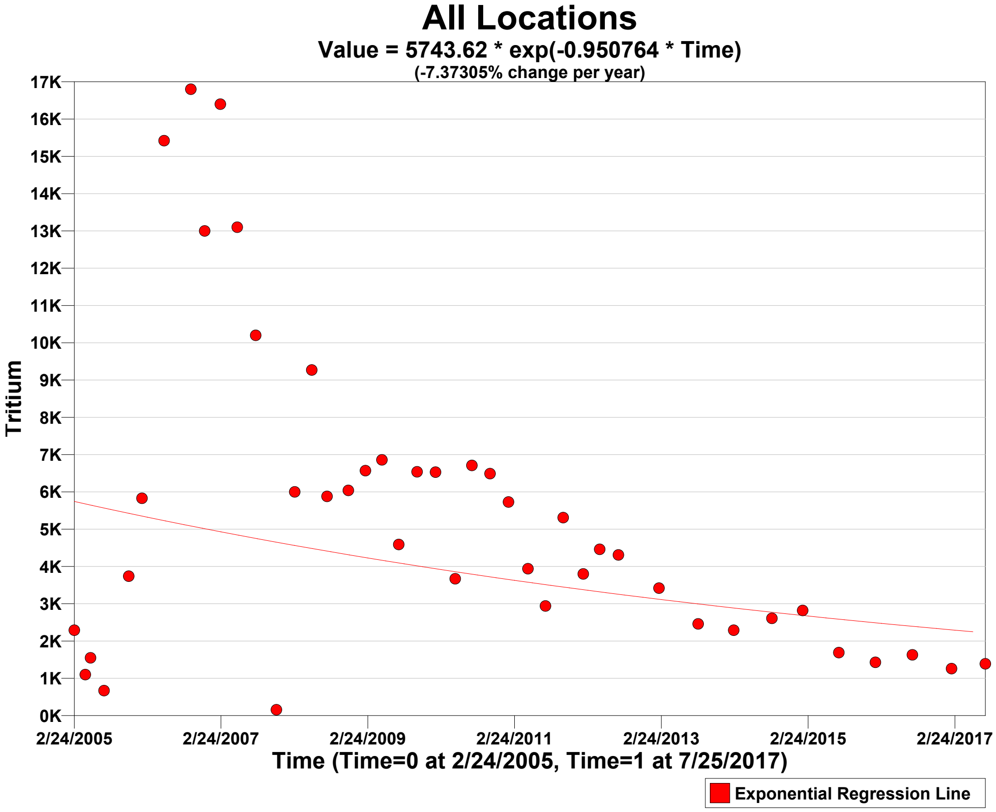
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

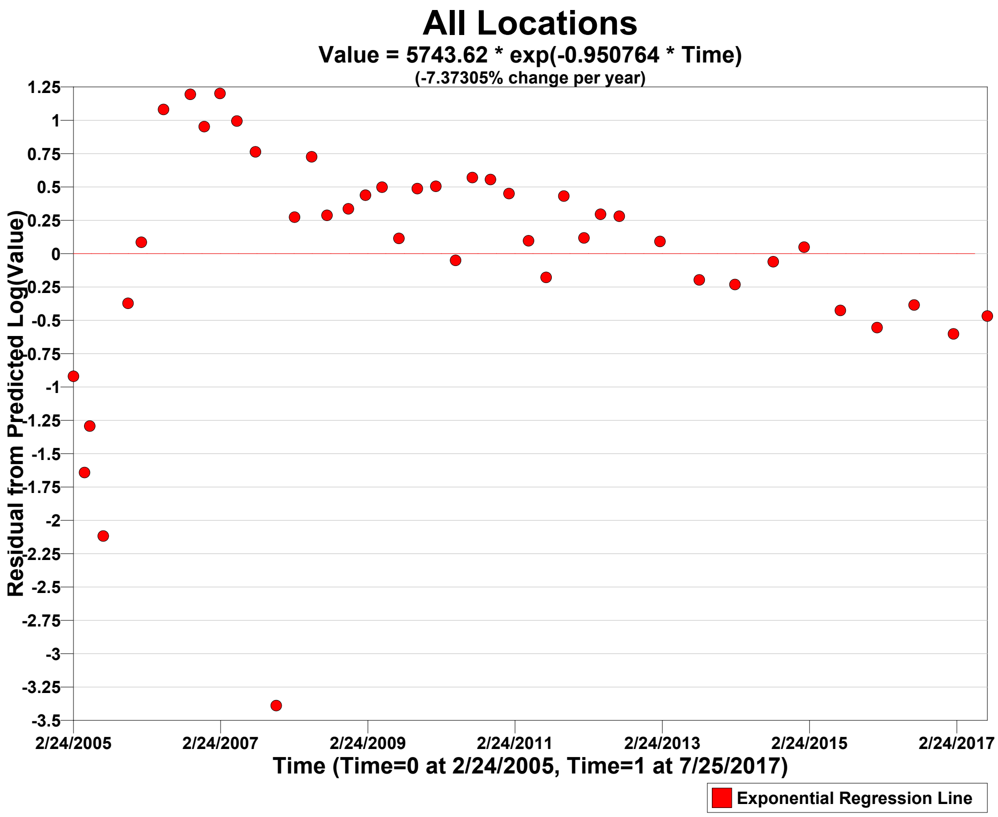
Data Plots

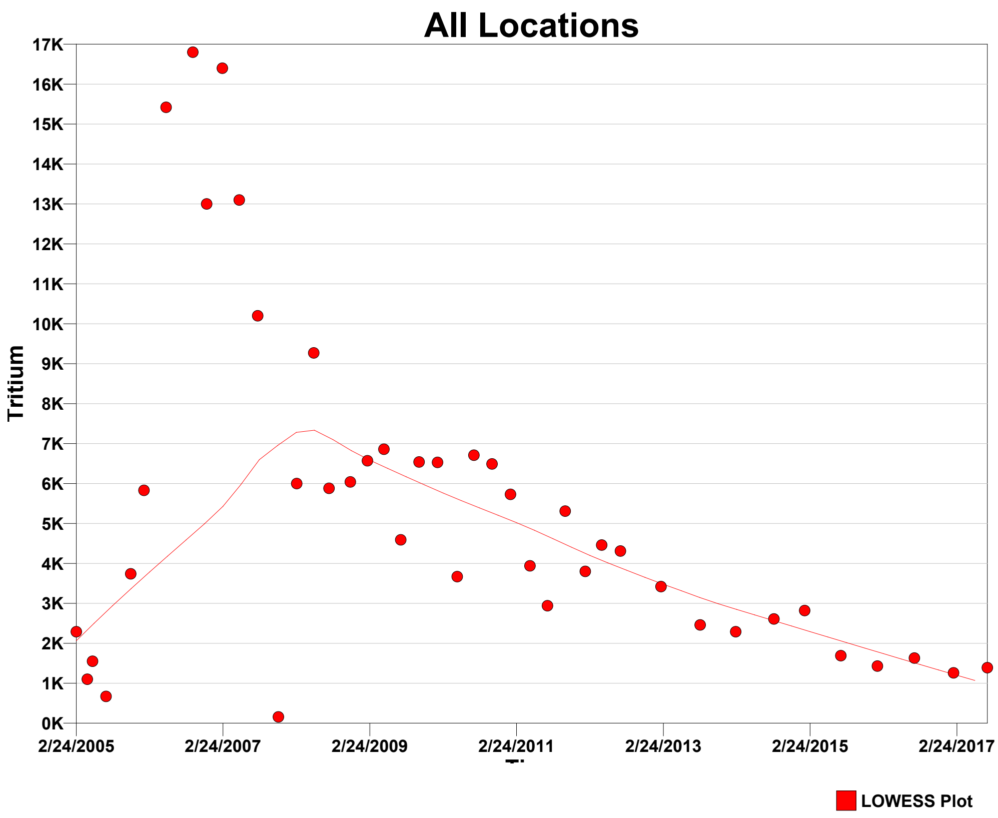
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 5743.62 * exp(-0.950764 * Time)
(-7.37305% change per year)
Residual from Predicted Log(Value)
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
-2.75
-3
-3.25
-3.5
2/24/2005
2/24/2007
2/24/2009
2/24/2011
2/24/2013
2/24/2015
2/24/2017
Time (Time=0 at 2/24/2005, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Tritium
17K
16K
15K
14K
13K
12K
11K
10K
9K
8K
7K
6K
5K
4K
3K
2K
1K
0K
2/24/2005
2/24/2007
2/24/2009
2/24/2011
2/24/2013
2/24/2015
2/24/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=42) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.83943
Shapiro-Wilk 5% Critical Value	0.942

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-322	
MK Test Statistic	Z_{MK}	-3.47901	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0379 - Tritium

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Tritium**		**Time**	**Tritium**		**Time**	**Tritium**
4/19/2005	1410		11/18/2008	1660		4/24/2012	1450
5/18/2005	750		2/12/2009	1680		7/25/2012	1550
11/1/2005	1730		5/5/2009	1530		2/11/2013	1210
1/24/2006	600		7/28/2009	1500		8/27/2013	852
5/17/2006	780		10/27/2009	1770		2/19/2014	948
9/26/2006	1640		1/26/2010	1720		8/28/2014	1200
12/5/2006	3890		5/5/2010	479		1/29/2015	1030
2/21/2007	1980		7/26/2010	1660		7/28/2015	954
5/16/2007	1950		10/25/2010	1550		1/25/2016	1230
8/16/2007	1920		1/25/2011	1420		7/26/2016	590
11/27/2007	1750		5/3/2011	1450		2/7/2017	882
2/26/2008	1980		7/27/2011	1350		7/24/2017	846
5/21/2008	1720		10/24/2011	1610			
8/6/2008	1870		2/1/2012	2010			

SUMMARY STATISTICS for Tritium								
n	40							
Min	-1.041723							
Max	0.8991481							
Range	1.9409							
Mean	0							
Median	0.09411772							
Variance	0.14422							
StdDev	0.37976							
Std Error	0.060045							
Skewness	-1.1462							
Interquartile Range	0.34906							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.042	-0.9993	-0.7147	-0.1246	0.09412	0.2244	0.2419	0.4613	0.8991

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
5/18/2005	750
1/24/2006	600
5/17/2006	780
12/5/2006	3890
5/5/2010	479

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

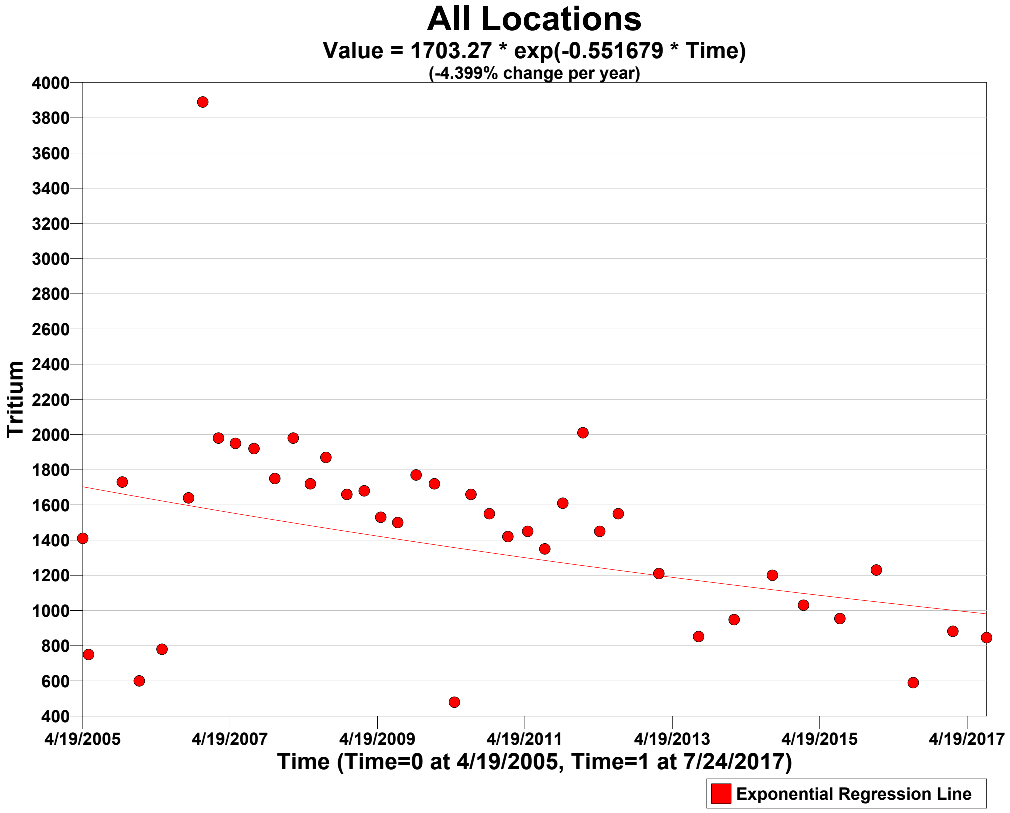
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

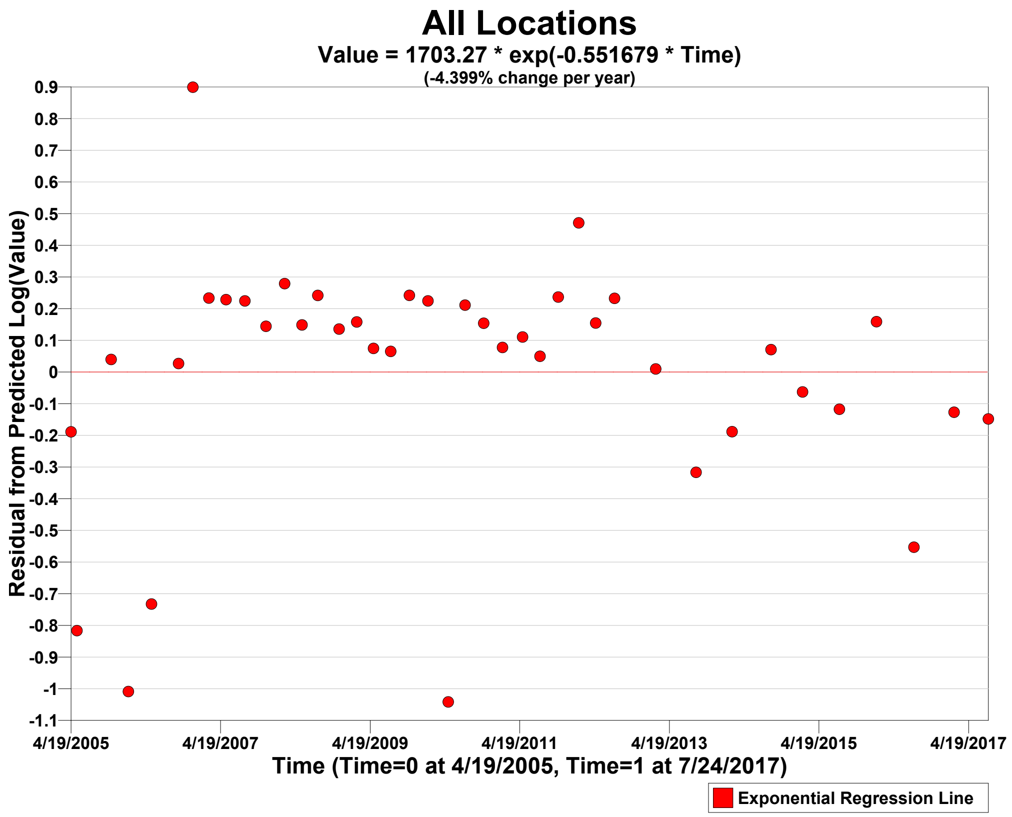
Data Plots

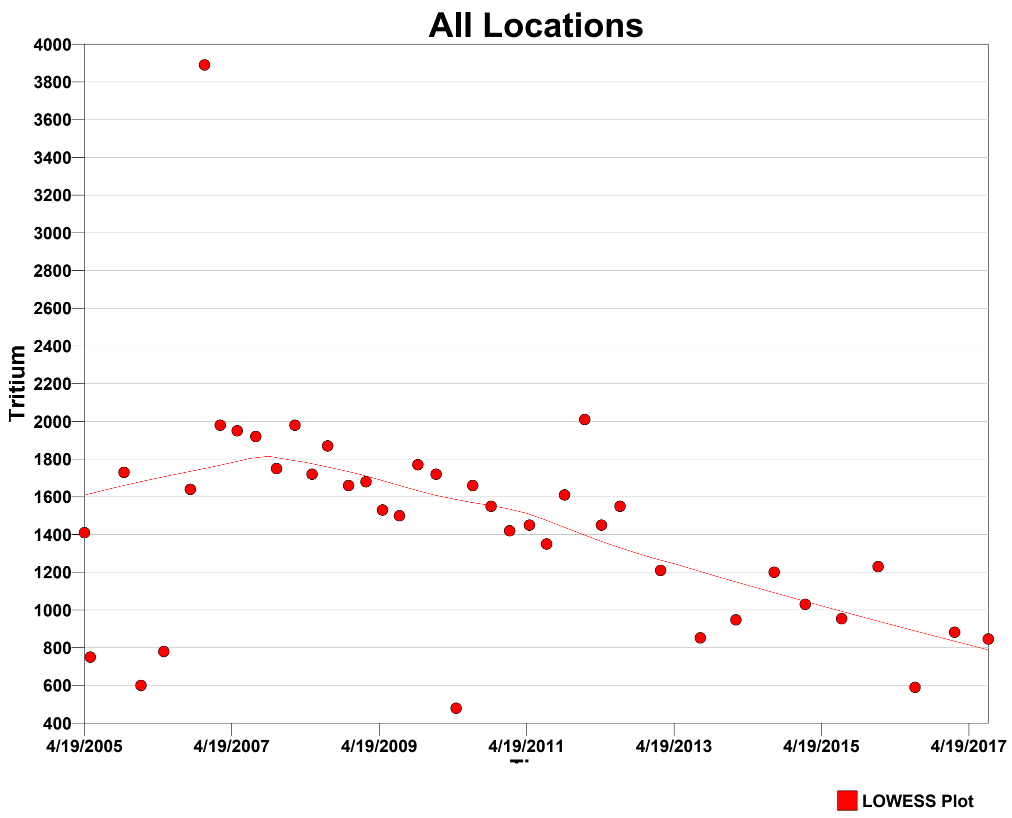
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 1703.27 * exp(-0.551679 * Time)
(-4.399% change per year)
Residual from Predicted Log(Value)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
4/19/2005
4/19/2007
4/19/2009
4/19/2011
4/19/2013
4/19/2015
4/19/2017
Time (Time=0 at 4/19/2005, Time=1 at 7/24/2017)
🟥 Exponential Regression Line


All Locations
Tritium
4000
3800
3600
3400
3200
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
4/19/2005
4/19/2007
4/19/2009
4/19/2011
4/19/2013
4/19/2015
4/19/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=40) is less than 50.

Normal Distribution Test of Residuals for Tritium	
Shapiro-Wilk Test Statistic	0.8474
Shapiro-Wilk 5% Critical Value	0.94

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-299	
MK Test Statistic	Z_{MK}	-3.47319	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0386 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/1/2012	2.65		2/19/2014	2.03		1/26/2016	2.42
4/24/2012	2.25		5/12/2014	0.97		4/25/2016	2.56
7/24/2012	2.84		8/27/2014	2.56		7/27/2016	2.38
10/24/2012	3.04		10/27/2014	2.67		10/25/2016	2.54
2/12/2013	2.82		1/28/2015	2.35		2/7/2017	1.83
5/28/2013	2.35		4/27/2015	2.11		5/2/2017	1.83
8/26/2013	2.99		7/28/2015	1.94		7/24/2017	2.22
10/28/2013	2.56		10/27/2015	2.14		11/7/2017	2.22

SUMMARY STATISTICS for Trichloroethene	
n	24
Min	-0.8836109
Max	0.2148659
Range	1.0985
Mean	0
Median	0.06680214
Variance	0.049064
StdDev	0.2215
Std Error	0.045214
Skewness	-2.9041
Interquartile Range	0.24035

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.8836	-0.7011	-0.1488	-0.1081	0.0668	0.1322	0.1863	0.211	0.2149

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
5/12/2014	0.97

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

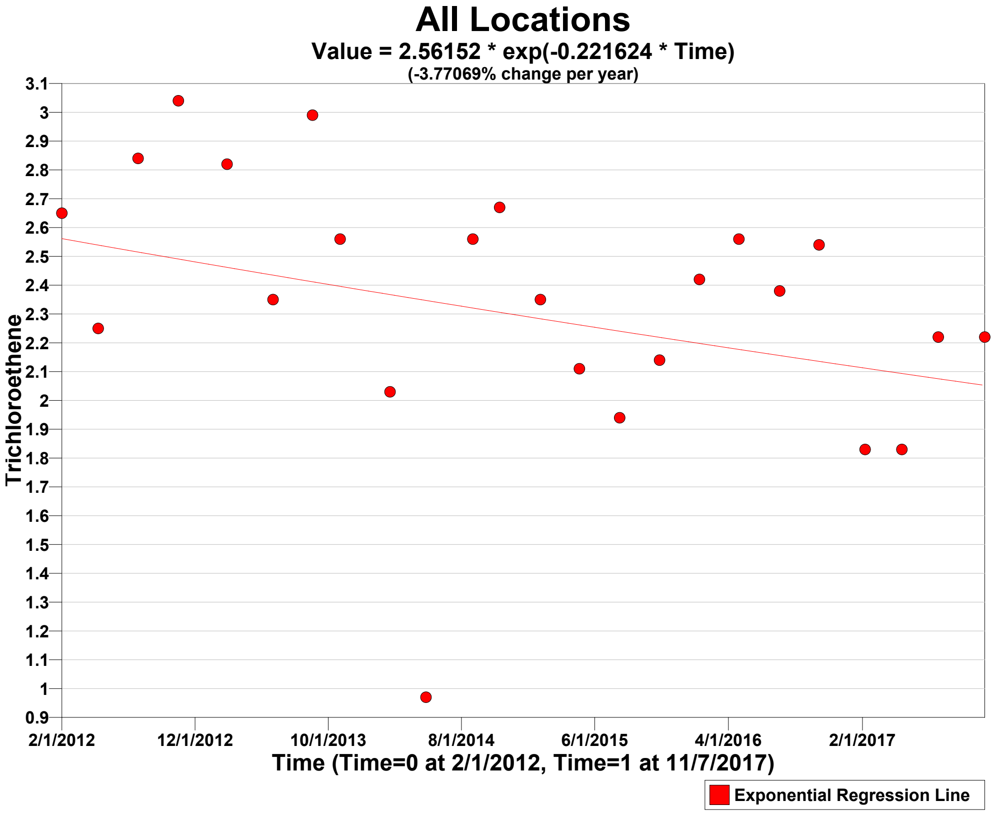
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

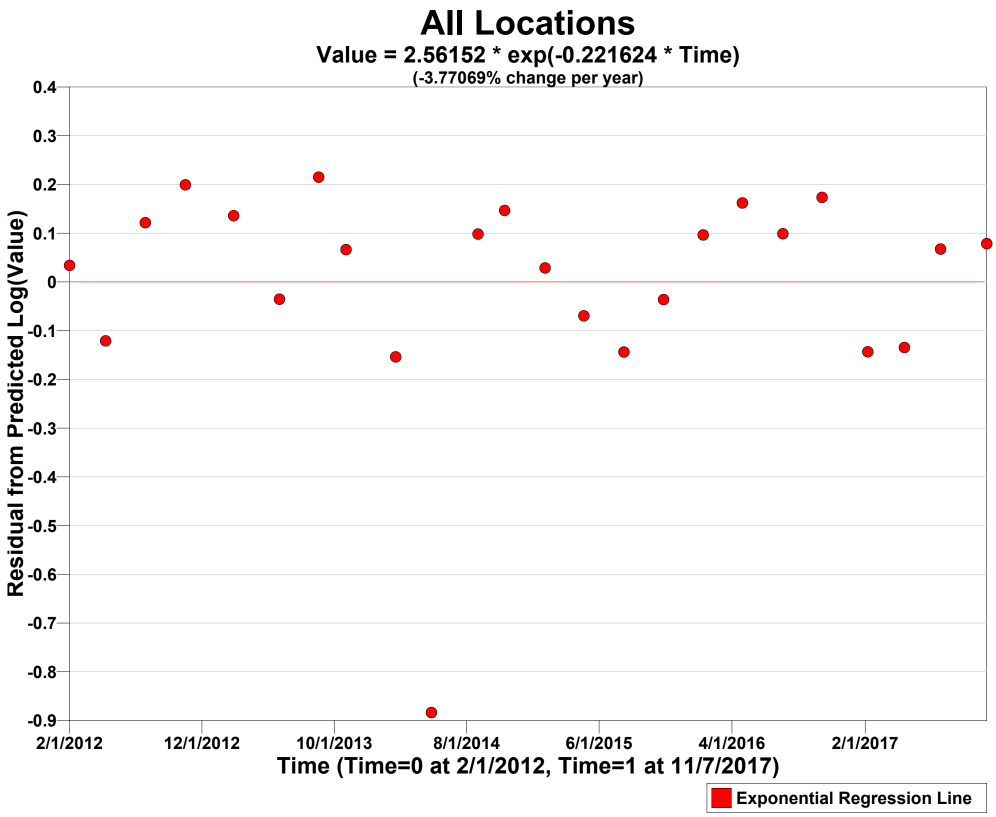
Data Plots

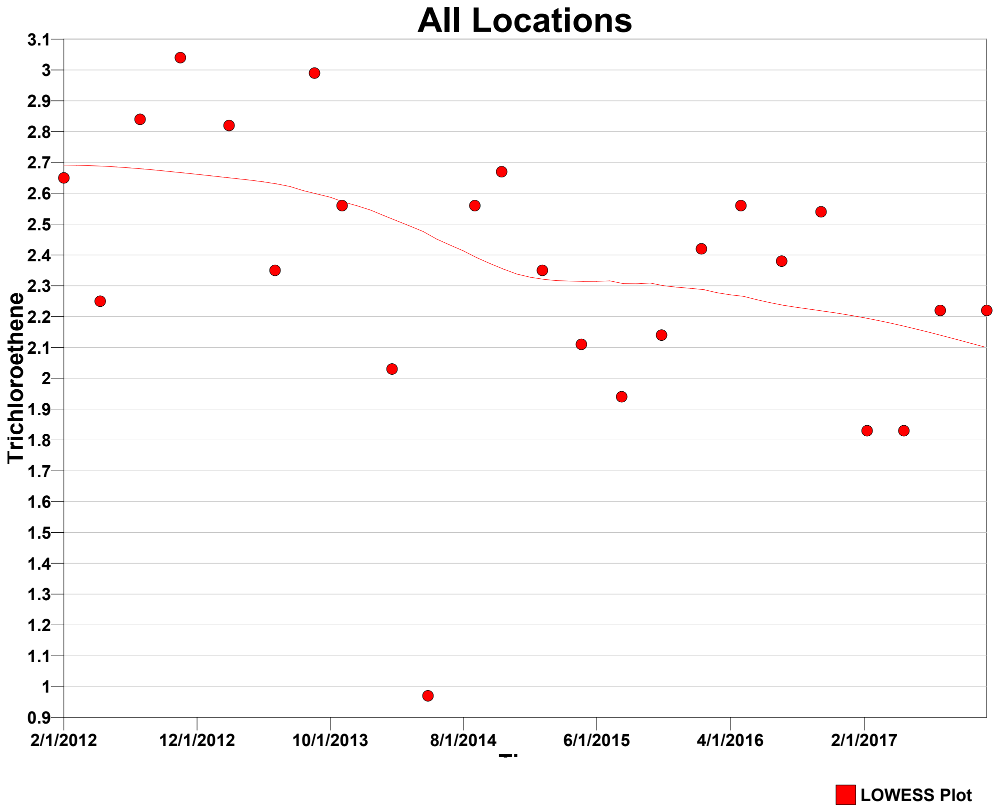
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 2.56152 * exp(-0.221624 * Time)
(-3.77069% change per year)
Residual from Predicted Log(Value)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 2/1/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=24) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.70452
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-96	
MK Test Statistic	Z_{MK}	-2.36127	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0386 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
3/7/2005	4.5		1/26/2010	0.11		5/12/2014	0.97
5/13/2005	4.1		5/6/2010	0.94		8/27/2014	2.56
7/25/2005	3.8		7/27/2010	1.9		10/27/2014	2.67
9/27/2006	2.8		10/26/2010	3.09		1/28/2015	2.35
12/6/2006	4.2		1/25/2011	2.3		4/27/2015	2.11
2/26/2007	3.76		5/3/2011	0.11		7/28/2015	1.94
5/17/2007	1.49		7/28/2011	2.25		10/27/2015	2.14
8/17/2007	3.96		10/26/2011	1.93		1/26/2016	2.42
11/27/2007	0.345		2/1/2012	2.65		4/25/2016	2.56
2/26/2008	3.24		4/24/2012	2.25		7/27/2016	2.38
5/20/2008	0.2		7/24/2012	2.84		10/25/2016	2.54
8/6/2008	3.13		10/24/2012	3.04		2/7/2017	1.83
11/19/2008	2.39		2/12/2013	2.82		5/2/2017	1.83
2/11/2009	0.11		5/28/2013	2.35		7/24/2017	2.22
5/11/2009	1.28		8/26/2013	2.99		11/7/2017	2.22
7/28/2009	2.45		10/28/2013	2.56			
10/27/2009	3.11		2/19/2014	2.03			

SUMMARY STATISTICS for Trichloroethene	
n	49
Min	-2.380372
Max	1.763028
Range	4.1434
Mean	0
Median	0.2332172
Variance	1.0529
StdDev	1.0261
Std Error	0.14658
Skewness	-0.97411
Interquartile Range	0.74653

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-2.38	-2.328	-2.221	-0.1527	0.2332	0.5939	1.147	1.474	1.763

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
11/27/2007	0.345
5/20/2008	0.2
2/11/2009	0.11
1/26/2010	0.11
5/3/2011	0.11

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

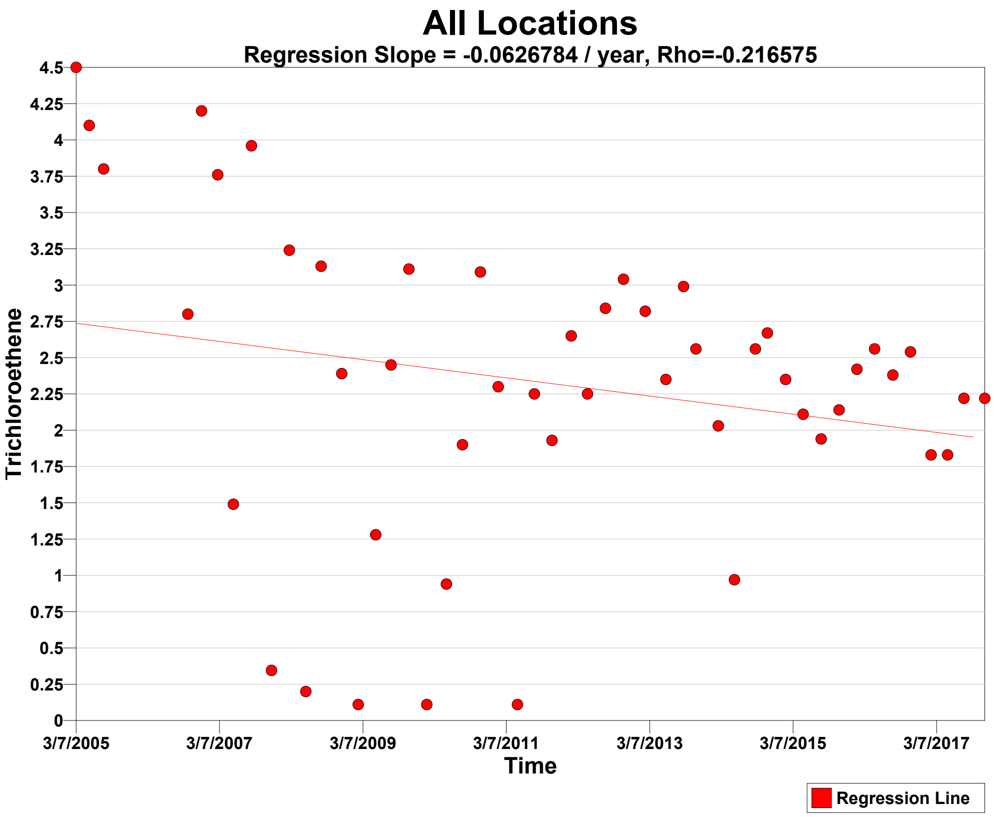
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

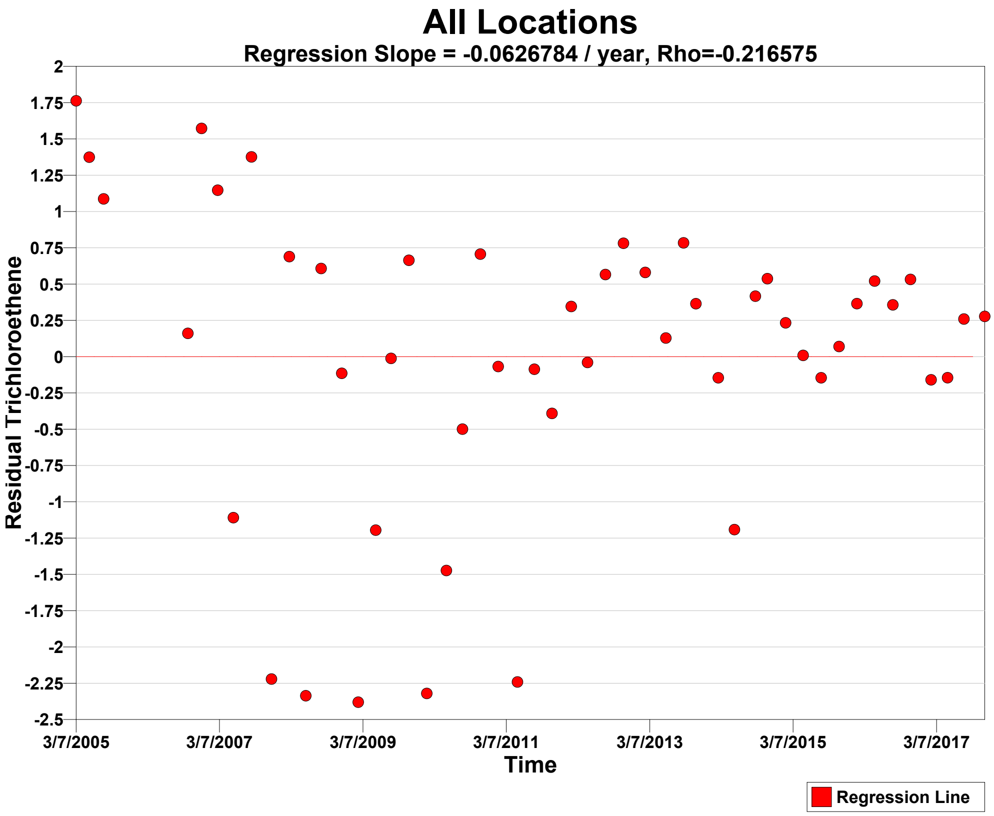
Data Plots

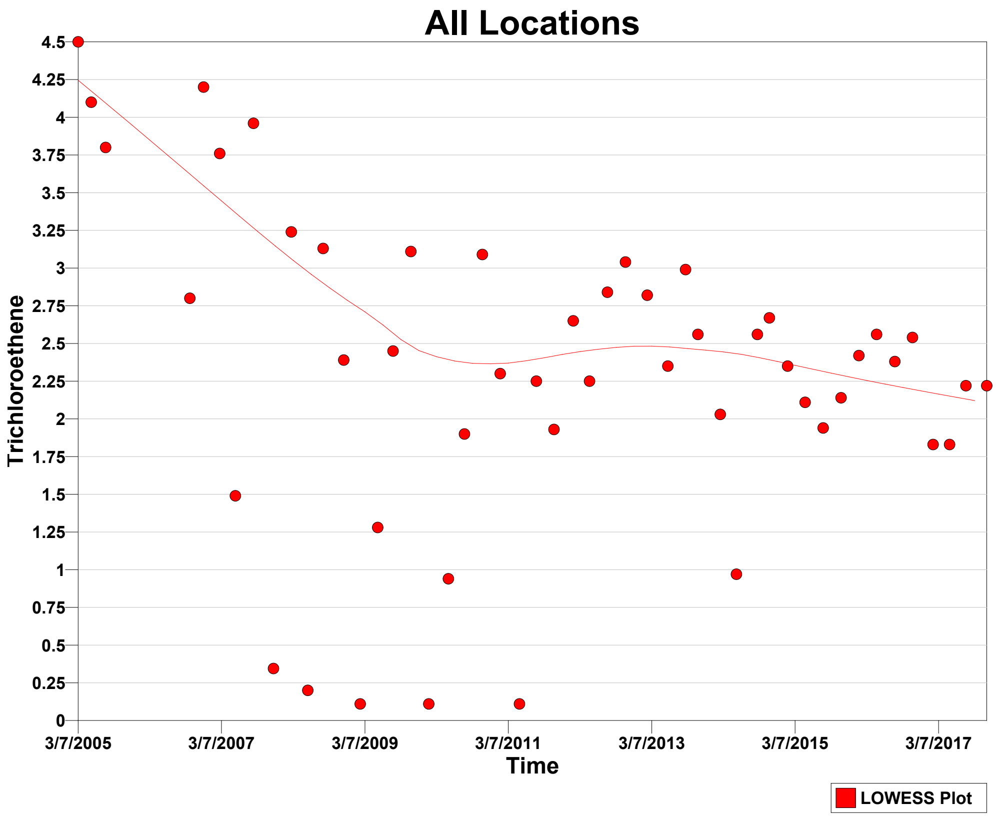
The Time vs. Measured Values Plot shows the best fitting 'least squares' linear line to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The slope of the linear line estimates the change in the data per unit time. If the linear line is a good fit to the data, then the slope of the line is an estimate of the linear trend over time in the data. If a linear line is not a good fit to the data, but an upward (or downward) tendency in the data is present, then a nonparametric estimator of monotonic change over time may be preferred to the estimated ï¿½least squaresï¿½ slope obtained assuming that a linear change over time is occurring.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the "least squares" linear line described above. The horizontal line at value zero represents a perfect fit (no difference) to the "least squares" linear line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.


All Locations
Regression Slope = -0.0626784 / year, Rho=-0.216575
Trichloroethene
4.5
4.25
4
3.75
3.5
3.25
3
2.75
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
3/7/2005
3/7/2007
3/7/2009
3/7/2011
3/7/2013
3/7/2015
3/7/2017
Time
🟥 Regression Line


All Locations
Regression Slope = -0.0626784 / year, Rho=-0.216575
Residual Trichloroethene
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
3/7/2005
3/7/2007
3/7/2009
3/7/2011
3/7/2013
3/7/2015
3/7/2017
Time
🟥 Regression Line



Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=49) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.88883
Shapiro-Wilk 5% Critical Value	0.947

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-256	
MK Test Statistic	Z_{MK}	-2.19898	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

Data Analysis for Well 0389 – Trichloroethene
Data Set: 2012 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
2/1/2012	0.31		2/19/2014	0.19		1/26/2016	0.35
4/24/2012	0.16		5/12/2014	0.16		4/25/2016	0.16
7/24/2012	0.32		8/27/2014	0.44		7/27/2016	0.8
10/24/2012	0.9		10/27/2014	0.61		10/25/2016	0.74
2/12/2013	0.53		1/28/2015	0.23		2/7/2017	0.16
5/28/2013	0.16		4/27/2015	0.16		5/2/2017	0.16
8/26/2013	0.16		7/28/2015	0.18		7/24/2017	0.16
10/28/2013	0.55		10/27/2015	0.29		11/7/2017	0.72

SUMMARY STATISTICS for Trichloroethene								
n	24							
Min	-0.6172309							
Max	1.112151							
Range	1.7294							
Mean	0							
Median	-0.1249066							
Variance	0.40022							
StdDev	0.63263							
Std Error	0.12913							
Skewness	0.50247							
Interquartile Range	1.2131							
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.6172	-0.6161	-0.612	-0.5991	-0.1249	0.614	0.9721	1.087	1.112

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

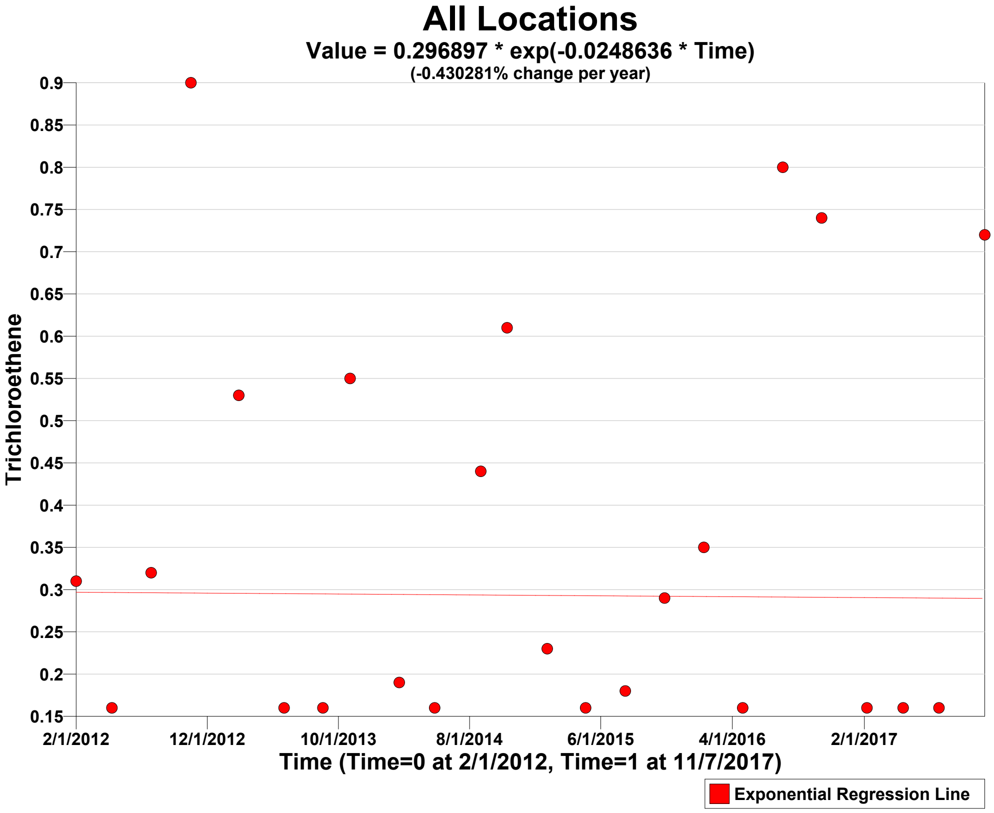
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

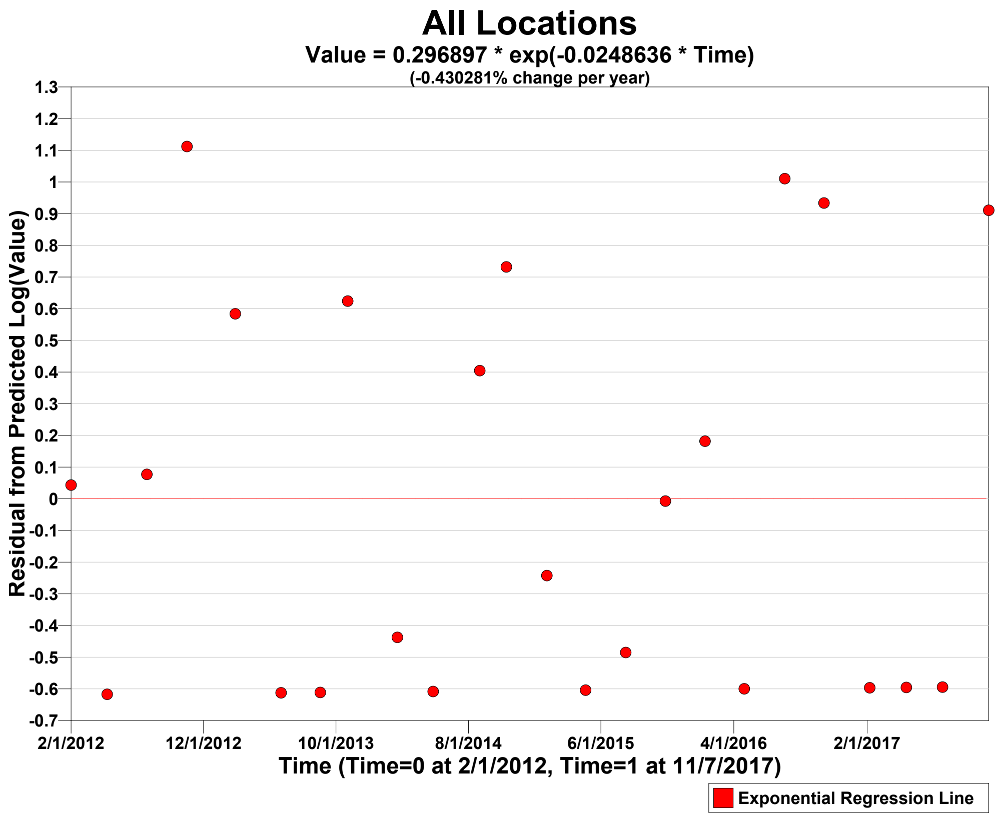
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-

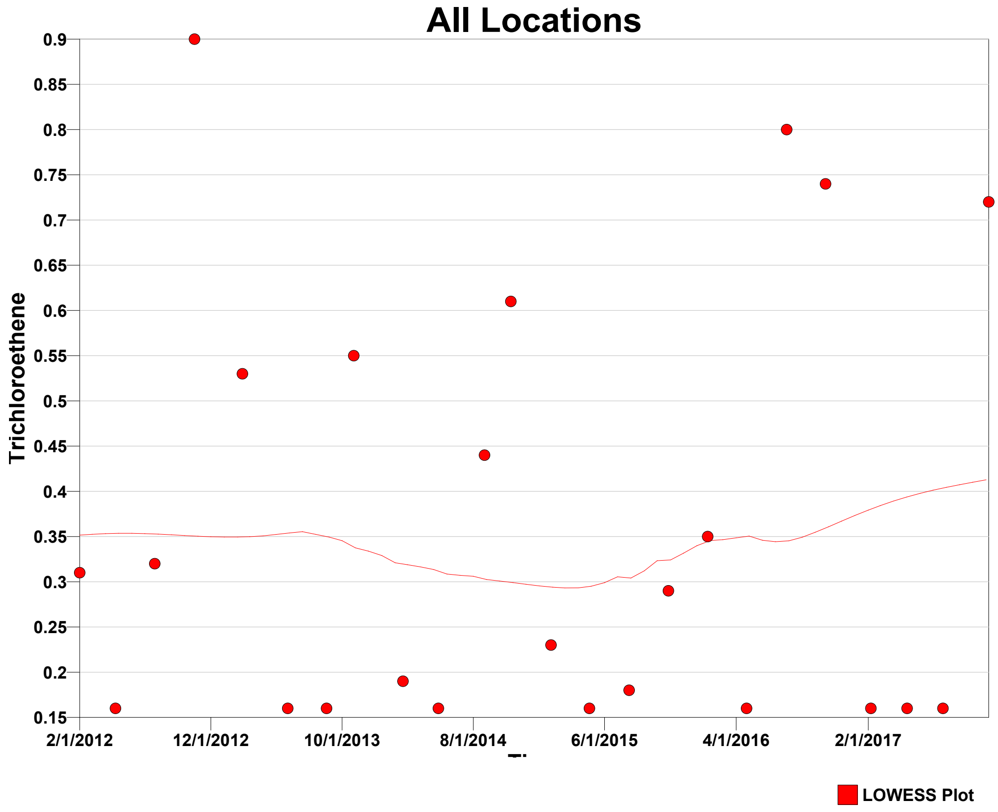
axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 0.296897 * exp(-0.0248636 * Time)
(-0.430281% change per year)
Residual from Predicted Log(Value)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
Time (Time=0 at 2/1/2012, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
2/1/2012
12/1/2012
10/1/2013
8/1/2014
6/1/2015
4/1/2016
2/1/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=24) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.84024
Shapiro-Wilk 5% Critical Value	0.916

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-6	
MK Test Statistic	Z_{MK}	-0.127688	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	-6	
MK Test Statistic	Z_{MK}	-0.127688	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

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This design was last modified 3/23/2018 4:45:22 PM.

Software and documentation available at http://vsp.pnnl.gov

Data Analysis for Well 0389 – Trichloroethene
Data Set: 2005 through 2017

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations								
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
7/25/2005	1.1		5/6/2010	0.59		5/12/2014	0.16
9/27/2006	0.98		7/27/2010	0.33		8/27/2014	0.44
12/6/2006	1.01		10/26/2010	1.39		10/27/2014	0.61
2/26/2007	1.14		1/25/2011	0.99		1/28/2015	0.23
5/17/2007	0.881		5/3/2011	0.54		4/27/2015	0.16
8/17/2007	1.22		7/28/2011	0.24		7/28/2015	0.18
11/27/2007	1.28		10/26/2011	0.72		10/27/2015	0.29
2/26/2008	0.398		2/1/2012	0.31		1/26/2016	0.35
5/20/2008	0.52		4/24/2012	0.16		4/25/2016	0.16
8/6/2008	0.408		7/24/2012	0.32		7/27/2016	0.8
11/19/2008	1.19		10/24/2012	0.9		10/25/2016	0.74
2/11/2009	1.07		2/12/2013	0.53		2/7/2017	0.16
5/11/2009	0.256		5/28/2013	0.16		5/2/2017	0.16
7/28/2009	0.894		8/26/2013	0.16		7/24/2017	0.16
10/27/2009	0.887		10/28/2013	0.55		11/7/2017	0.72
1/26/2010	1.48		2/19/2014	0.19			

SUMMARY STATISTICS for Trichloroethene	
n	47
Min	-1.035518
Max	1.204771
Range	2.2403
Mean	0
Median	0.02537138
Variance	0.35936
StdDev	0.59947
Std Error	0.087442
Skewness	0.18134
Interquartile Range	0.90616

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.036	-0.931	-0.7822	-0.5035	0.02537	0.4027	0.8984	1.122	1.205

Outliers
One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

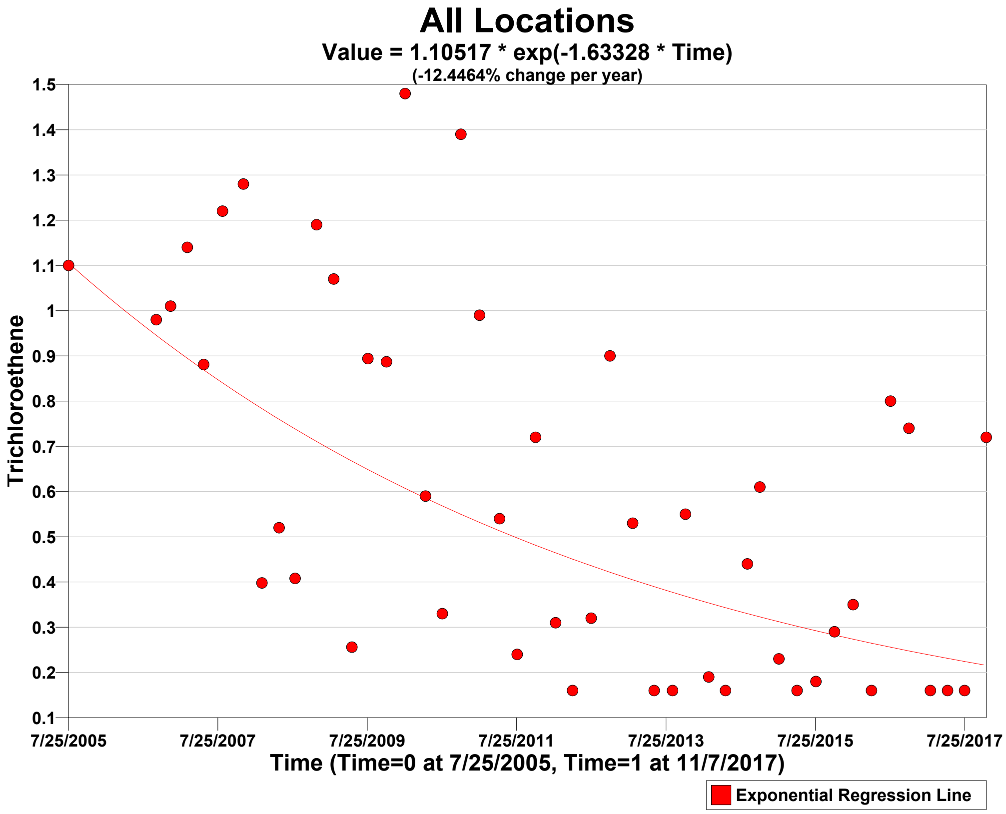
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

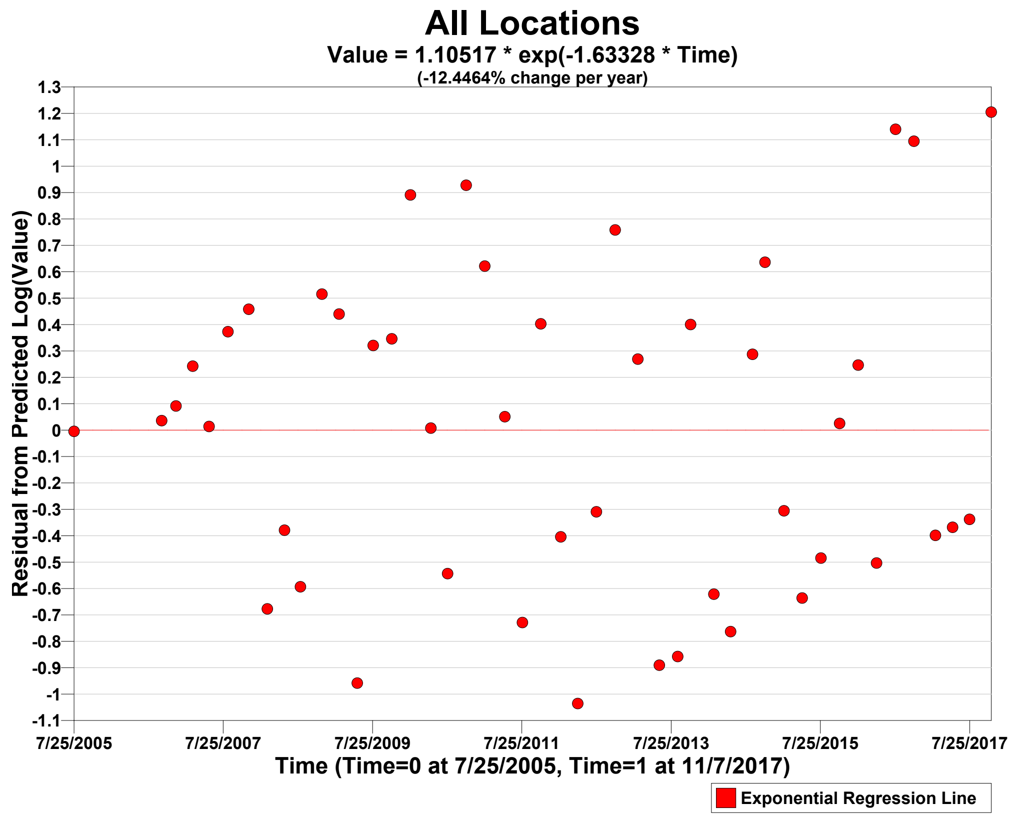
Data Plots

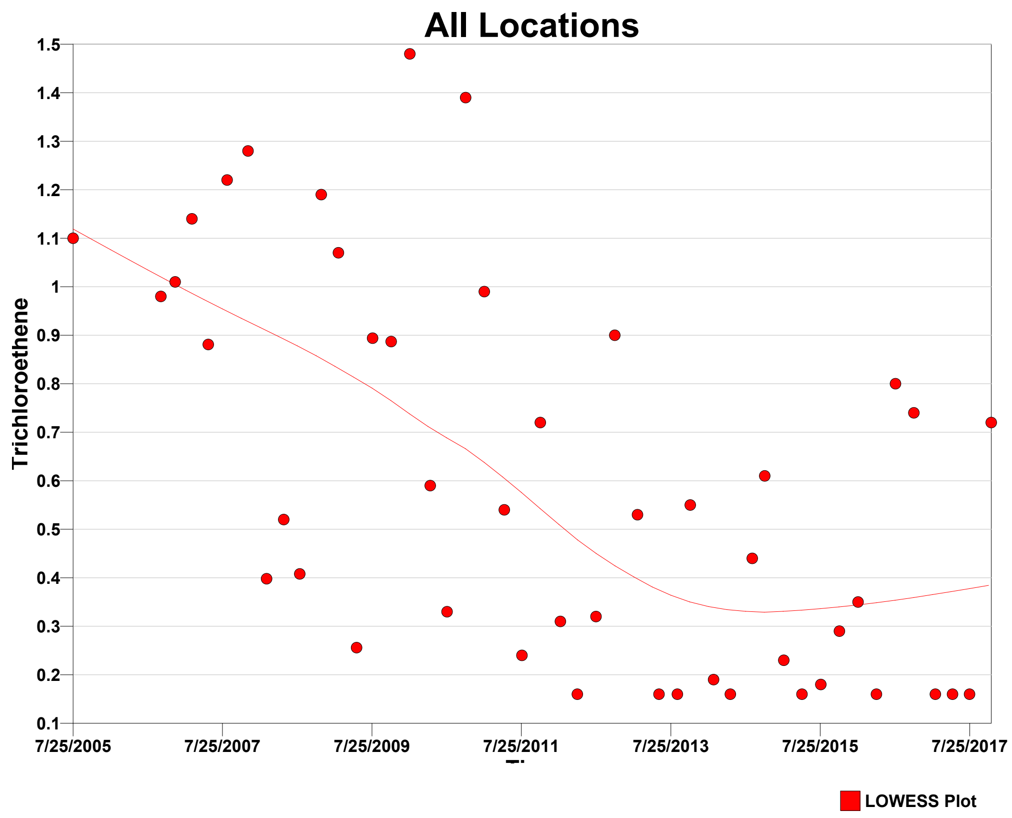
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 1.10517 * exp(-1.63328 * Time)
(-12.4464% change per year)
Residual from Predicted Log(Value)
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
7/25/2005
7/25/2007
7/25/2009
7/25/2011
7/25/2013
7/25/2015
7/25/2017
Time (Time=0 at 7/25/2005, Time=1 at 11/7/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
7/25/2005
7/25/2007
7/25/2009
7/25/2011
7/25/2013
7/25/2015
7/25/2017
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=47) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.95717
Shapiro-Wilk 5% Critical Value	0.946

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-462	
MK Test Statistic	Z_{MK}	-4.24421	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for WEll 0411 - cDCE

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**cDCE**		**Time**	**cDCE**		**Time**	**cDCE**
4/29/1999	4.8		1/22/2004	2		7/29/2009	2.89
6/21/1999	2.2		4/21/2004	1.3		1/27/2010	3.97
9/2/1999	1.8		7/12/2004	1.4		7/29/2010	2.56
2/1/2000	2.6		11/17/2004	1.3		1/26/2011	3.32
4/17/2000	2.2		2/28/2005	1		7/25/2011	2.8
7/7/2000	3		5/24/2005	1.5		1/30/2012	1.81
9/27/2000	1		8/2/2005	1.7		7/26/2012	2.17
2/9/2001	1.6		11/1/2005	2.4		2/14/2013	4.71
4/26/2001	1.5		1/31/2006	3.7		8/28/2013	3.57
7/20/2001	2.4		4/26/2006	2.9		2/24/2014	2.33
10/18/2001	1.9		8/4/2006	1.95		8/26/2014	2.28
1/29/2002	1.9		11/17/2006	2.76		1/27/2015	3.34
5/6/2002	2.8		2/28/2007	1.7		7/29/2015	1.69
7/24/2002	3.5		5/23/2007	1.56		1/25/2016	0.65
11/8/2002	1.4		8/22/2007	2.73		7/25/2016	0.94
1/28/2003	2		11/13/2007	2.74		2/6/2017	1.17
4/22/2003	1.8		2/19/2008	2.21		7/25/2017	1.34
7/25/2003	1.6		8/11/2008	1.33			
10/22/2003	1.6		2/10/2009	3.36			

SUMMARY STATISTICS for cDCE	
n	55
Min	-1.109604
Max	0.8580523
Range	1.9677
Mean	0
Median	-0.03795734
Variance	0.17571
StdDev	0.41918
Std Error	0.056522
Skewness	-0.16335
Interquartile Range	0.57034

Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-1.11	-0.7399	-0.4875	-0.2739	-0.03796	0.2964	0.547	0.7025	0.8581

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
4/29/1999	4.8
2/14/2013	4.71

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

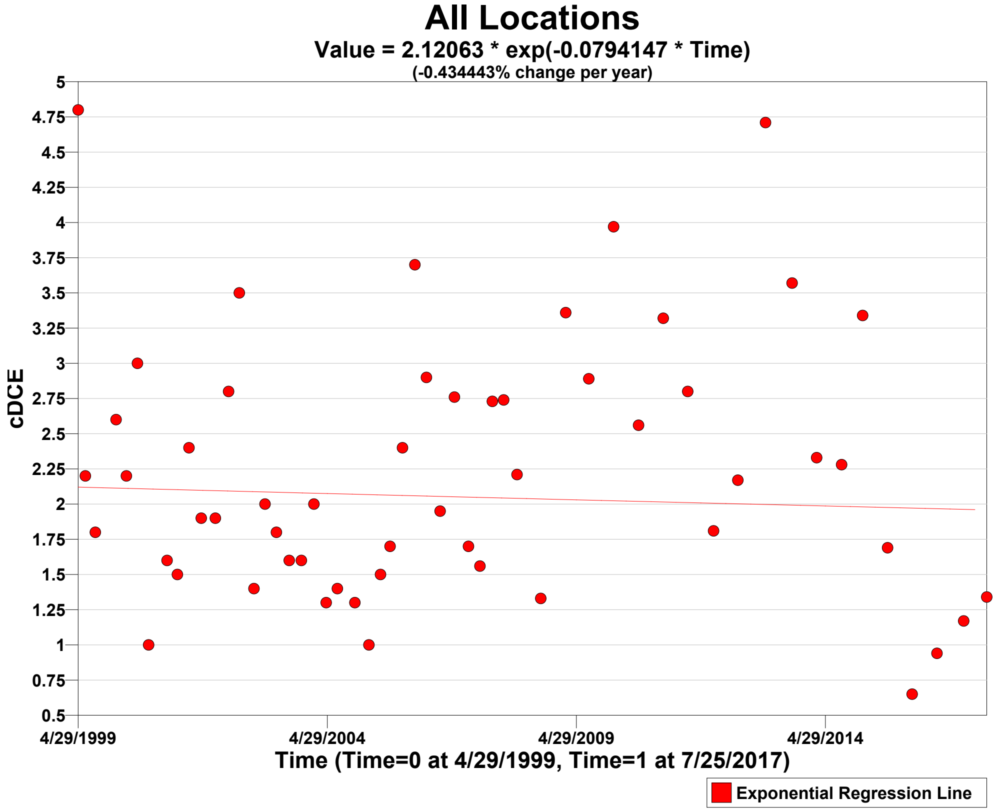
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

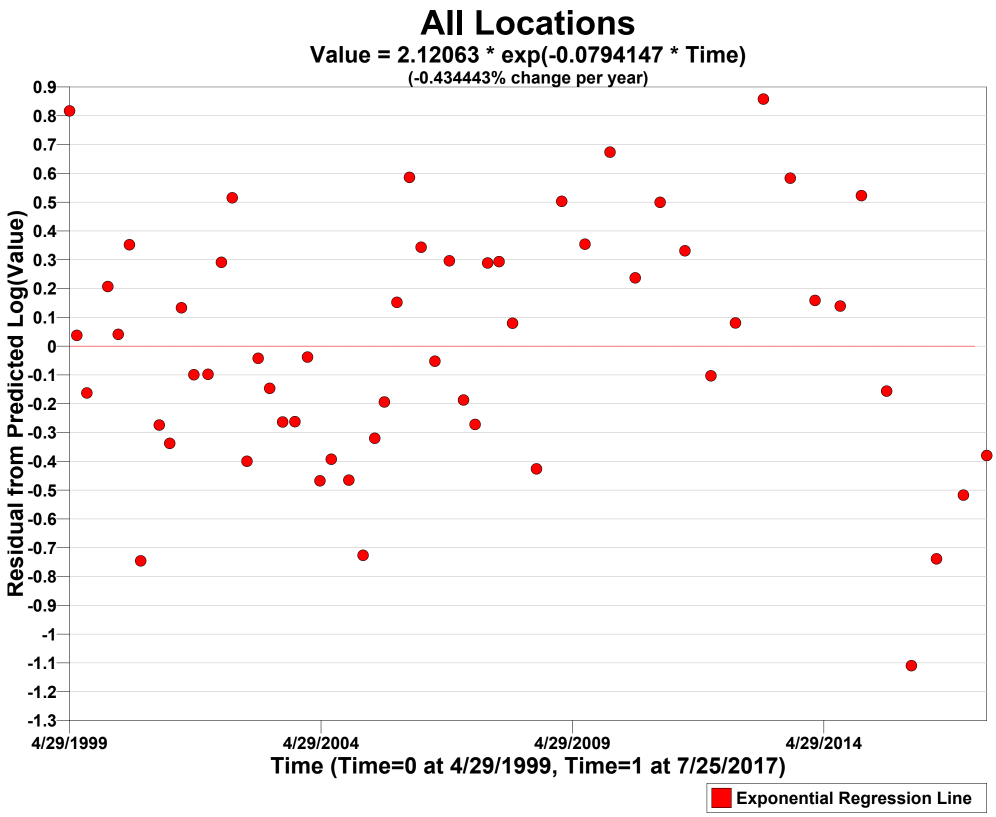
Data Plots

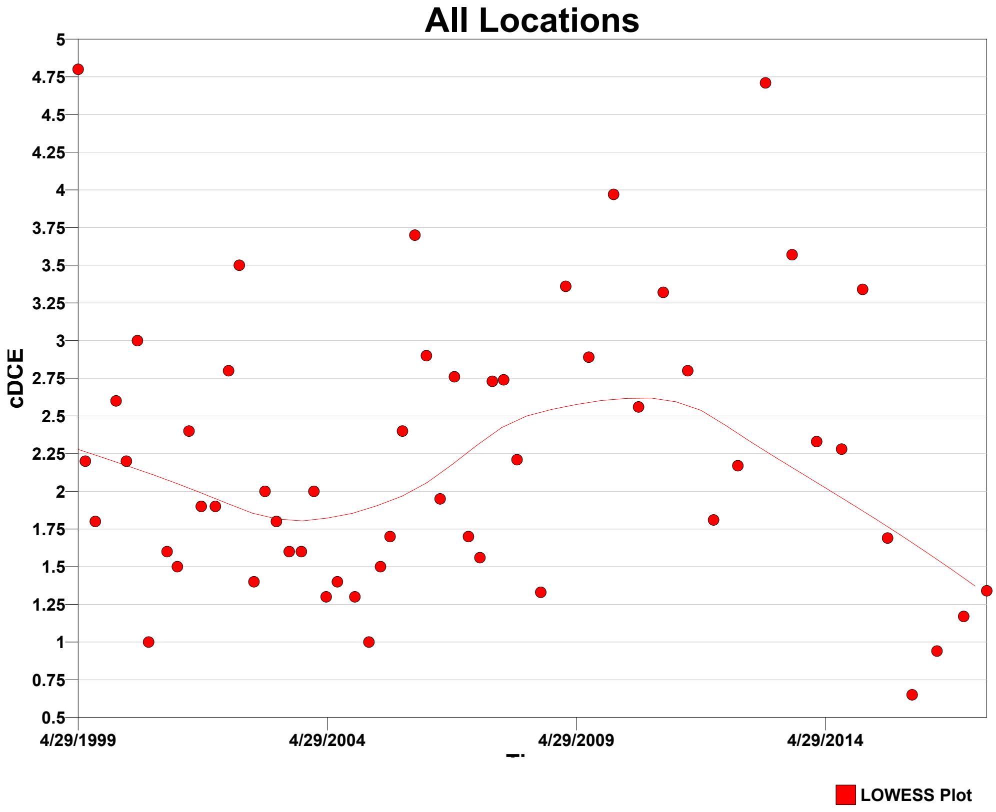
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 2.12063 * exp(-0.0794147 * Time)
(-0.434443% change per year)
Residual from Predicted Log(Value)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
4/29/1999
4/29/2004
4/29/2009
4/29/2014
Time (Time=0 at 4/29/1999, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
cDCE
5
4.75
4.5
4.25
4
3.75
3.5
3.25
3
2.75
2.5
2.25
2
1.75
1.5
1.25
1
0.75
0.5
4/29/1999
4/29/2004
4/29/2009
4/29/2014
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=55) is greater than 50.

Normal Distribution Test of Residuals for cDCE	
Lilliefors Test Statistic	0.06366
Lilliefors 5% Critical Value	0.11947

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	29	
MK Test Statistic	Z_{MK}	0.203346	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	29	
MK Test Statistic	Z_{MK}	0.203346	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

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Data Analysis for Well 0411 – Trichloroethene

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**Trichloroethene**		**Time**	**Trichloroethene**		**Time**	**Trichloroethene**
4/29/1999	21		1/22/2004	10		7/29/2009	11.2
6/21/1999	18		4/21/2004	9		1/27/2010	10.1
9/2/1999	21		7/12/2004	10		7/29/2010	9.62
2/1/2000	22		11/17/2004	9		1/26/2011	10.6
4/17/2000	13		2/28/2005	11		7/25/2011	9.42
7/7/2000	16		5/24/2005	11		1/30/2012	13.4
9/27/2000	14		8/2/2005	11		7/26/2012	12.7
2/9/2001	14		11/1/2005	14		2/14/2013	12.5
4/26/2001	12		1/31/2006	11		8/28/2013	13.3
7/20/2001	13		4/26/2006	9.2		2/24/2014	12
10/18/2001	14		8/4/2006	14.4		8/26/2014	10.6
1/29/2002	8.4		11/17/2006	12.2		1/27/2015	10.8
5/6/2002	16		2/28/2007	12.7		7/29/2015	10.3
7/24/2002	13		5/23/2007	12.1		1/25/2016	11.9
11/8/2002	12		8/22/2007	15.2		7/25/2016	11.7
1/28/2003	13		11/13/2007	12.3		2/6/2017	10.5
4/22/2003	12		2/19/2008	12.2		7/25/2017	10.3
7/25/2003	11		8/11/2008	14.1			
10/22/2003	11		2/10/2009	12.7			

<table>
<tr><th colspan="9">SUMMARY STATISTICS for Trichloroethene</th></tr>
<tr><th colspan="4">n</th><td colspan="5">55</td></tr>
<tr><th colspan="4">Min</th><td colspan="5">-0.4586374</td></tr>
<tr><th colspan="4">Max</th><td colspan="5">0.4705929</td></tr>
<tr><th colspan="4">Range</th><td colspan="5">0.92923</td></tr>
<tr><th colspan="4">Mean</th><td colspan="5">0</td></tr>
<tr><th colspan="4">Median</th><td colspan="5">-0.004177112</td></tr>
<tr><th colspan="4">Variance</th><td colspan="5">0.034716</td></tr>
<tr><th colspan="4">StdDev</th><td colspan="5">0.18632</td></tr>
<tr><th colspan="4">Std Error</th><td colspan="5">0.025124</td></tr>
<tr><th colspan="4">Skewness</th><td colspan="5">0.14036</td></tr>
<tr><th colspan="4">Interquartile Range</th><td colspan="5">0.25482</td></tr>
<tr><th colspan="9">Percentiles</th></tr>
<tr><th>1%</th><th>5%</th><th>10%</th><th>25%</th><th>50%</th><th>75%</th><th>90%</th><th>95%</th><th>99%</th></tr>
<tr><td>-0.4586</td><td>-0.3444</td><td>-0.2462</td><td>-0.1299</td><td>-0.004177</td><td>0.1249</td><td>0.2088</td><td>0.4124</td><td>0.4706</td></tr>
</table>

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
2/1/2000	22
1/29/2002	8.4

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

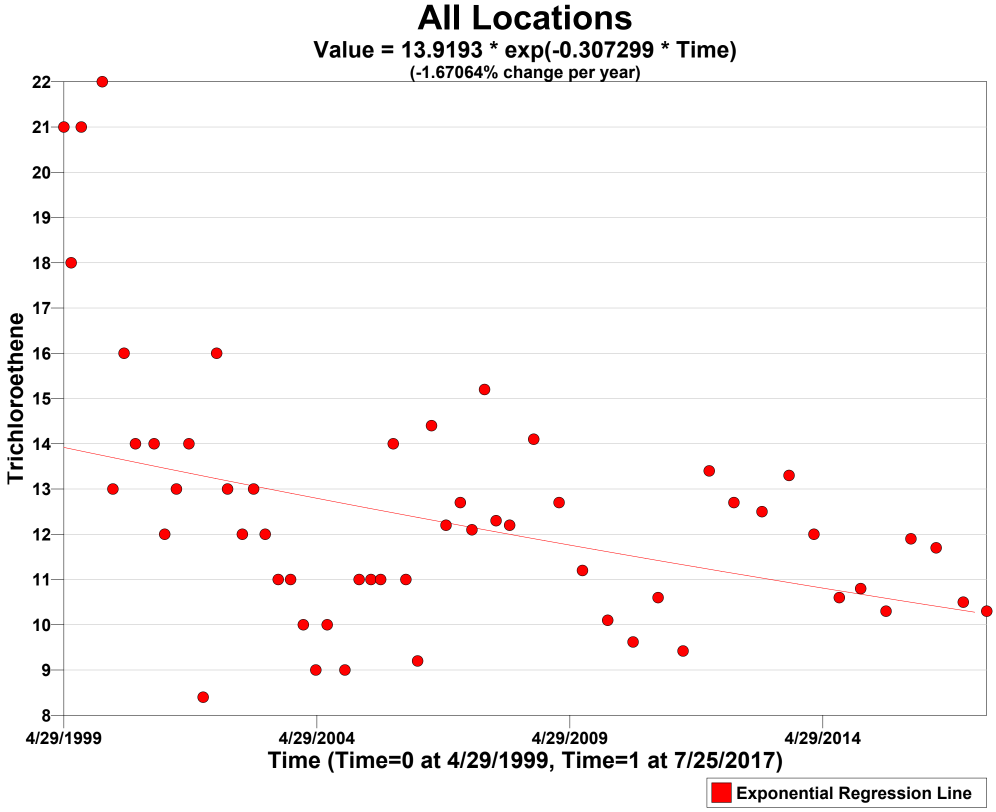
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

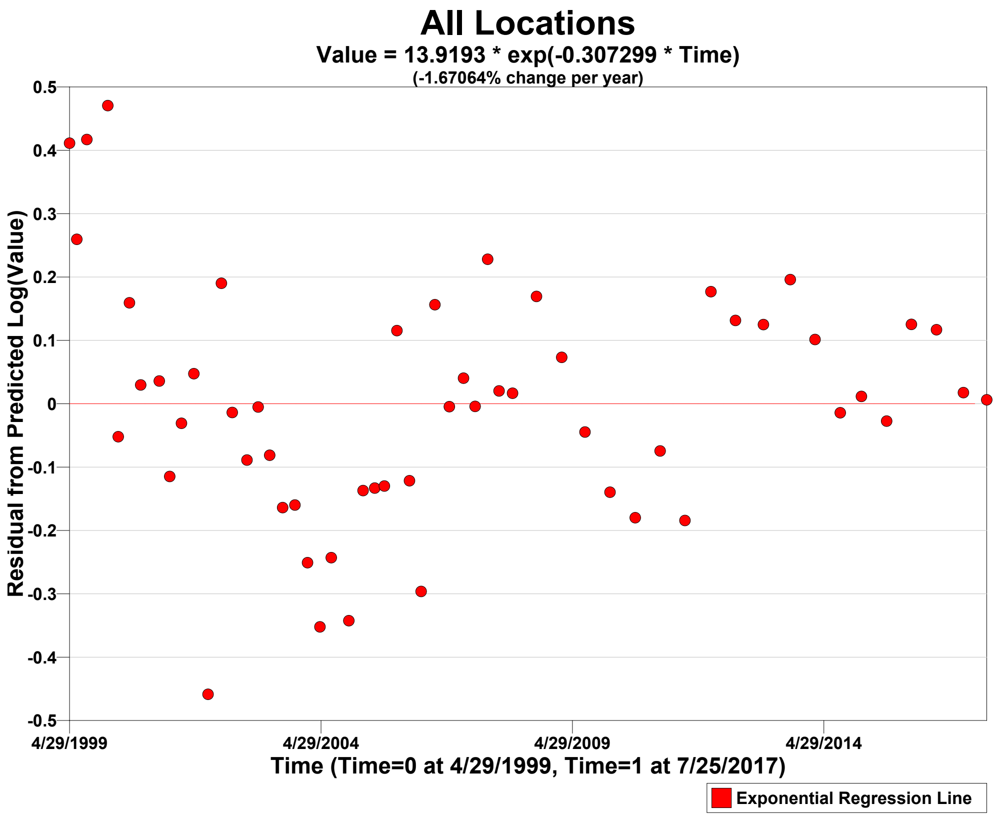
Data Plots

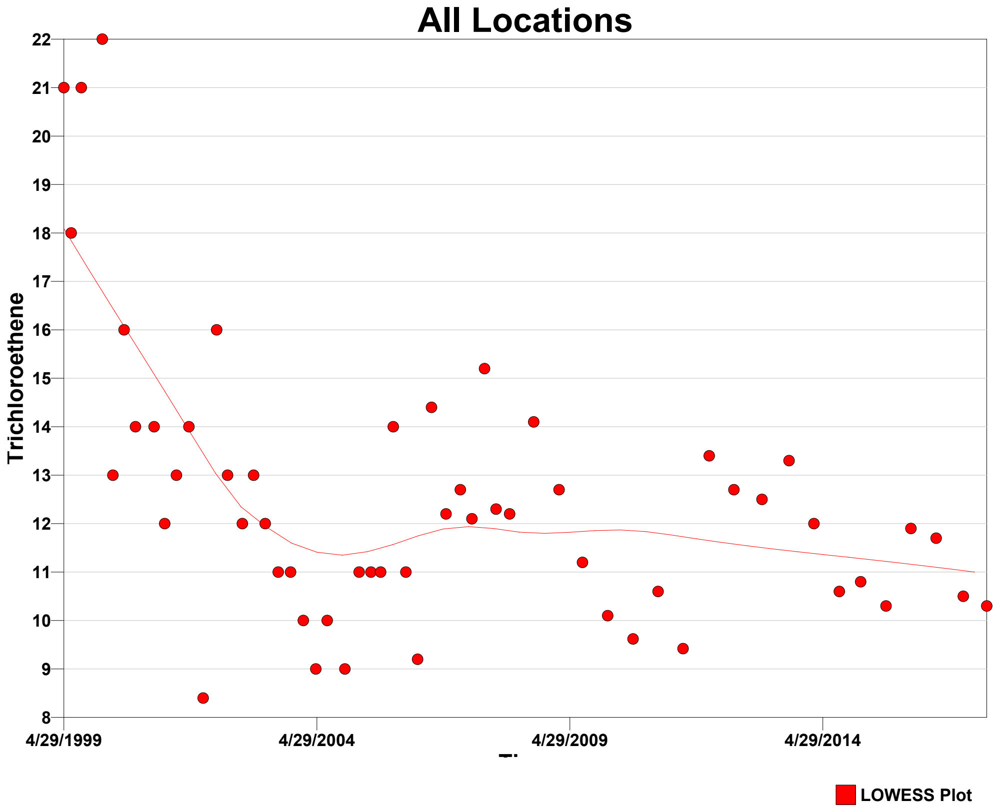
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 13.9193 * exp(-0.307299 * Time)
(-1.67064% change per year)
Residual from Predicted Log(Value)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
4/29/1999
4/29/2004
4/29/2009
4/29/2014
Time (Time=0 at 4/29/1999, Time=1 at 7/25/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
4/29/1999
4/29/2004
4/29/2009
4/29/2014
🟥 LOWESS Plot

Tests
A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Lilliefors test was determined most appropriate for this VSP application because the size of the data set (n=55) is greater than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Lilliefors Test Statistic	0.072244
Lilliefors 5% Critical Value	0.11947

The calculated test statistic exceeds the 5% Lilliefors critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test
The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-448	
MK Test Statistic	Z_{MK}	-3.25059	
Alpha	α	0.05	
Critical Value	$-Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Data Analysis for Well 0443 - cDCE

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

All Locations							
Time	**cDCE**		**Time**	**cDCE**		**Time**	**cDCE**
5/6/2002	1		1/31/2006	1.9		7/25/2011	0.22
7/26/2002	1		4/26/2006	1		1/30/2012	0.75
11/8/2002	1		8/4/2006	0.341		7/26/2012	0.27
1/28/2003	1		11/17/2006	0.438		2/14/2013	0.57
4/22/2003	1		2/28/2007	0.919		8/28/2013	0.38
7/25/2003	1		5/23/2007	5		2/24/2014	0.54
10/22/2003	1		8/22/2007	0.708		8/26/2014	0.36
1/22/2004	1		11/13/2007	0.872		1/27/2015	0.27
4/21/2004	1		2/19/2008	0.83		7/29/2015	0.33
7/12/2004	1		12/30/2008	1.04		1/25/2016	0.23
11/18/2004	0.97		2/10/2009	0.762		7/25/2016	0.33
3/2/2005	1		7/30/2009	0.32		2/6/2017	0.35
5/24/2005	1		1/27/2010	0.451		7/26/2017	0.55
8/3/2005	1		7/29/2010	0.28			
11/16/2005	1.1		1/26/2011	0.49			

SUMMARY STATISTICS for cDCE								
n				43				
Min				-0.8706157				
Max				1.89006				
Range				2.7607				
Mean				0				
Median				-0.03348607				
Variance				0.21229				
StdDev				0.46074				
Std Error				0.070263				
Skewness				1.3931				
Interquartile Range				0.34862				
Percentiles								
1%	**5%**	**10%**	**25%**	**50%**	**75%**	**90%**	**95%**	**99%**
-0.8706	-0.8106	-0.6288	-0.1742	-0.03349	0.1745	0.4568	0.7679	1.89

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. These values with low weights can be considered possible outliers and are listed in the table below.

SUSPECTED OUTLIERS	
Date/Time	**Value**
1/31/2006	1.9
8/4/2006	0.341
11/17/2006	0.438
5/23/2007	5
12/30/2008	1.04
7/30/2009	0.32
7/29/2010	0.28

7/25/2011	0.22
1/30/2012	0.75

Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

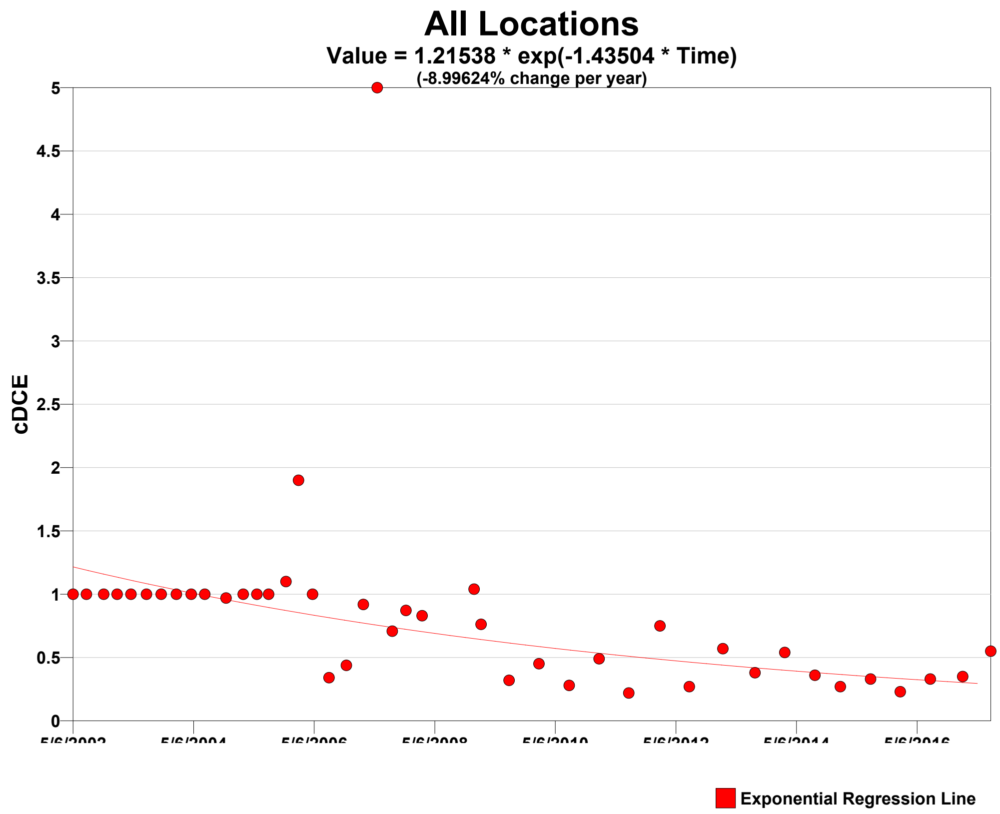
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

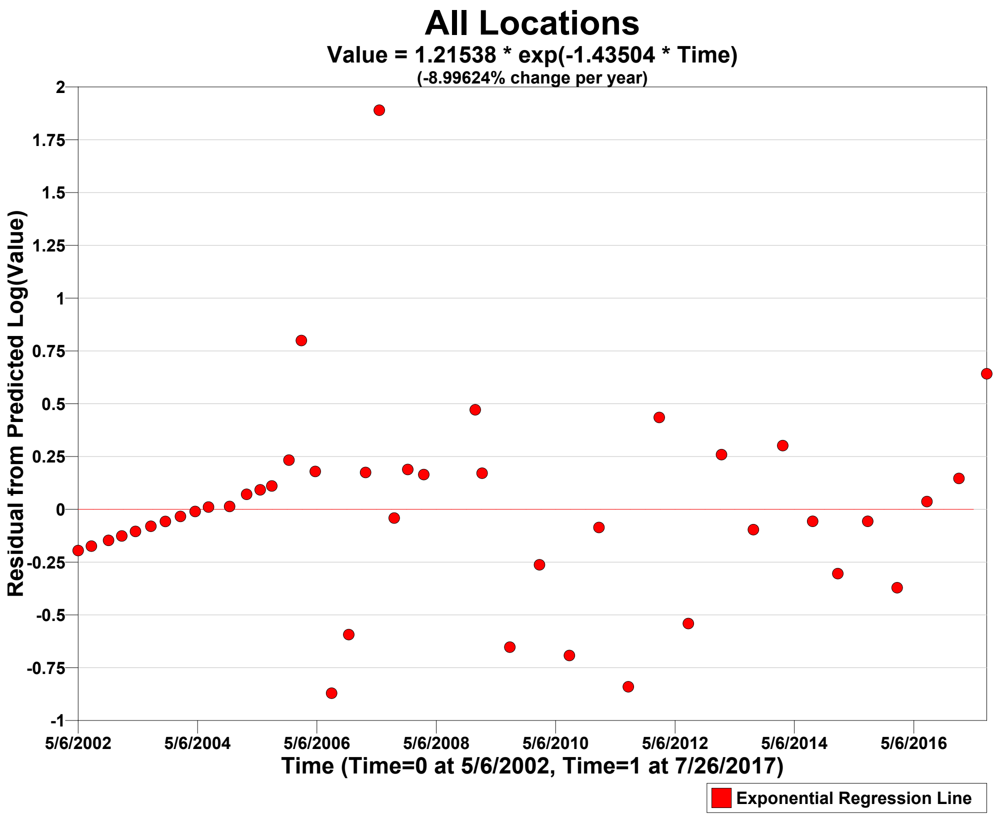
Data Plots

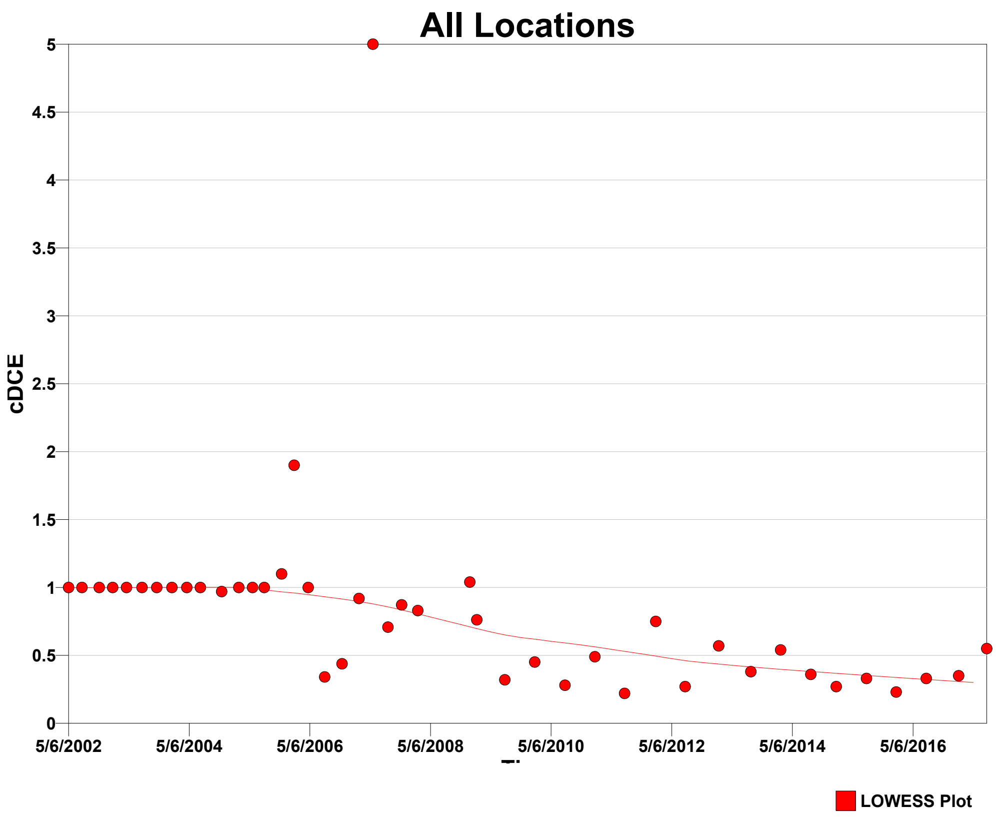
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 1.21538 * exp(-1.43504 * Time)
(-8.99624% change per year)
Residual from Predicted Log(Value)
2
1.75
1.5
1.25
1
0.75
0.5
0.25
0
-0.25
-0.5
-0.75
-1
5/6/2002
5/6/2004
5/6/2006
5/6/2008
5/6/2010
5/6/2012
5/6/2014
5/6/2016
Time (Time=0 at 5/6/2002, Time=1 at 7/26/2017)
🟥 Exponential Regression Line


All Locations
cDCE
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
5/6/2002
5/6/2004
5/6/2006
5/6/2008
5/6/2010
5/6/2012
5/6/2014
5/6/2016
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=43) is less than 50.

Normal Distribution Test of Residuals for cDCE	
Shapiro-Wilk Test Statistic	0.88723
Shapiro-Wilk 5% Critical Value	0.943

The calculated test statistic does not exceed the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	-470	
MK Test Statistic	Z_{MK}	-5.00107	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	Reject
Alternative Hypothesis	H_a	A downward monotonic trend exists	**Accept**
Conclude with 95% confidence that a downward monotonic trend exists.			

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Software and documentation available at http://vsp.pnnl.gov

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Data Analysis for Well 0443 - Trichloroethene

Analysis was performed on the entire set of data that was entered by the user. The following table lists the data points that were used in the analysis.

<table>
<tr><th colspan="8">All Locations</th></tr>
<tr><th>Time</th><th>Trichloroethene</th><th></th><th>Time</th><th>Trichloroethene</th><th></th><th>Time</th><th>Trichloroethene</th></tr>
<tr><td>5/6/2002</td><td>9.2</td><td></td><td>1/31/2006</td><td>9.3</td><td></td><td>7/25/2011</td><td>5.73</td></tr>
<tr><td>7/26/2002</td><td>3.5</td><td></td><td>4/26/2006</td><td>7.9</td><td></td><td>1/30/2012</td><td>14</td></tr>
<tr><td>11/8/2002</td><td>6.6</td><td></td><td>8/4/2006</td><td>6.34</td><td></td><td>7/26/2012</td><td>5.32</td></tr>
<tr><td>1/28/2003</td><td>5.4</td><td></td><td>11/17/2006</td><td>7.33</td><td></td><td>2/14/2013</td><td>7.25</td></tr>
<tr><td>4/22/2003</td><td>7.8</td><td></td><td>2/28/2007</td><td>12.3</td><td></td><td>8/28/2013</td><td>8.85</td></tr>
<tr><td>7/25/2003</td><td>2.8</td><td></td><td>5/23/2007</td><td>3.06</td><td></td><td>2/24/2014</td><td>11.2</td></tr>
<tr><td>10/22/2003</td><td>7.2</td><td></td><td>8/22/2007</td><td>11.7</td><td></td><td>8/26/2014</td><td>7.45</td></tr>
<tr><td>1/22/2004</td><td>6.3</td><td></td><td>11/13/2007</td><td>12.1</td><td></td><td>1/27/2015</td><td>6.03</td></tr>
<tr><td>4/21/2004</td><td>6.5</td><td></td><td>2/19/2008</td><td>11.2</td><td></td><td>7/29/2015</td><td>5.87</td></tr>
<tr><td>7/12/2004</td><td>3.2</td><td></td><td>12/30/2008</td><td>11</td><td></td><td>1/25/2016</td><td>7.53</td></tr>
<tr><td>11/18/2004</td><td>10</td><td></td><td>2/10/2009</td><td>8.36</td><td></td><td>7/25/2016</td><td>7.27</td></tr>
<tr><td>3/2/2005</td><td>11</td><td></td><td>7/30/2009</td><td>3.99</td><td></td><td>2/6/2017</td><td>5.88</td></tr>
<tr><td>5/24/2005</td><td>2.2</td><td></td><td>1/27/2010</td><td>7.47</td><td></td><td>7/26/2017</td><td>6.02</td></tr>
<tr><td>8/3/2005</td><td>6.6</td><td></td><td>7/29/2010</td><td>5.3</td><td></td><td></td><td></td></tr>
<tr><td>11/16/2005</td><td>12</td><td></td><td>1/26/2011</td><td>7.47</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th colspan="9">SUMMARY STATISTICS for Trichloroethene</th></tr>
<tr><td colspan="4">n</td><td colspan="5">43</td></tr>
<tr><td colspan="4">Min</td><td colspan="5">-1.110942</td></tr>
<tr><td colspan="4">Max</td><td colspan="5">0.6613251</td></tr>
<tr><td colspan="4">Range</td><td colspan="5">1.7723</td></tr>
<tr><td colspan="4">Mean</td><td colspan="5">0</td></tr>
<tr><td colspan="4">Median</td><td colspan="5">0.0003609895</td></tr>
<tr><td colspan="4">Variance</td><td colspan="5">0.1779</td></tr>
<tr><td colspan="4">StdDev</td><td colspan="5">0.42179</td></tr>
<tr><td colspan="4">Std Error</td><td colspan="5">0.064322</td></tr>
<tr><td colspan="4">Skewness</td><td colspan="5">-0.60951</td></tr>
<tr><td colspan="4">Interquartile Range</td><td colspan="5">0.60247</td></tr>
<tr><th colspan="9">Percentiles</th></tr>
<tr><th>1%</th><th>5%</th><th>10%</th><th>25%</th><th>50%</th><th>75%</th><th>90%</th><th>95%</th><th>99%</th></tr>
<tr><td>-1.111</td><td>-0.8395</td><td>-0.6811</td><td>-0.2469</td><td>0.000361</td><td>0.3555</td><td>0.5525</td><td>0.5876</td><td>0.6613</td></tr>
</table>

Outliers

One of the trend data plots in VSP uses the LOWESS method to fit a non-linear trend line through the data while giving little weight to values that appear to be out of place and that donï¿½t follow the trend. The LOWESS method did not detect any outliers for the current data set.

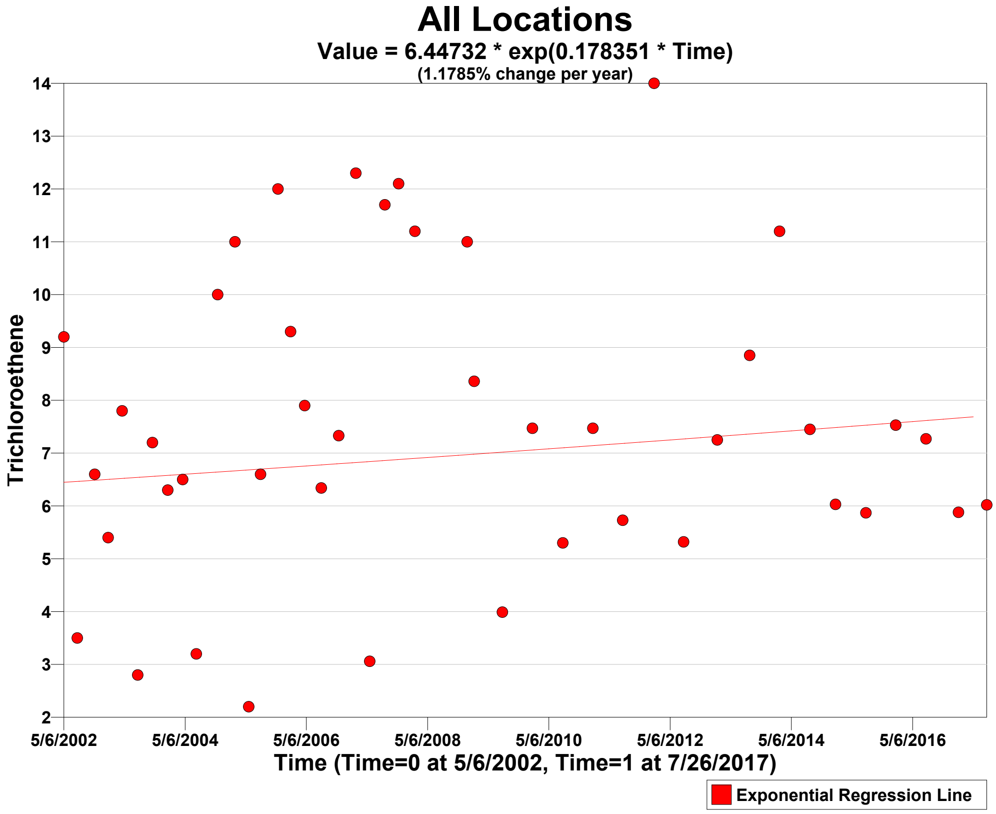
Data should not be excluded from analysis solely on the basis of the results of this method or any other outlier detection method. If any values are flagged as possible outliers, further investigation is recommended to determine whether there is a plausible explanation that justifies removing or replacing them. Additionally, the default LOWESS parameters are robust for most datasets, but in some extreme cases some additional points besides the obvious outliers may be flagged as outliers while appearing to fit the fitted line rather well.

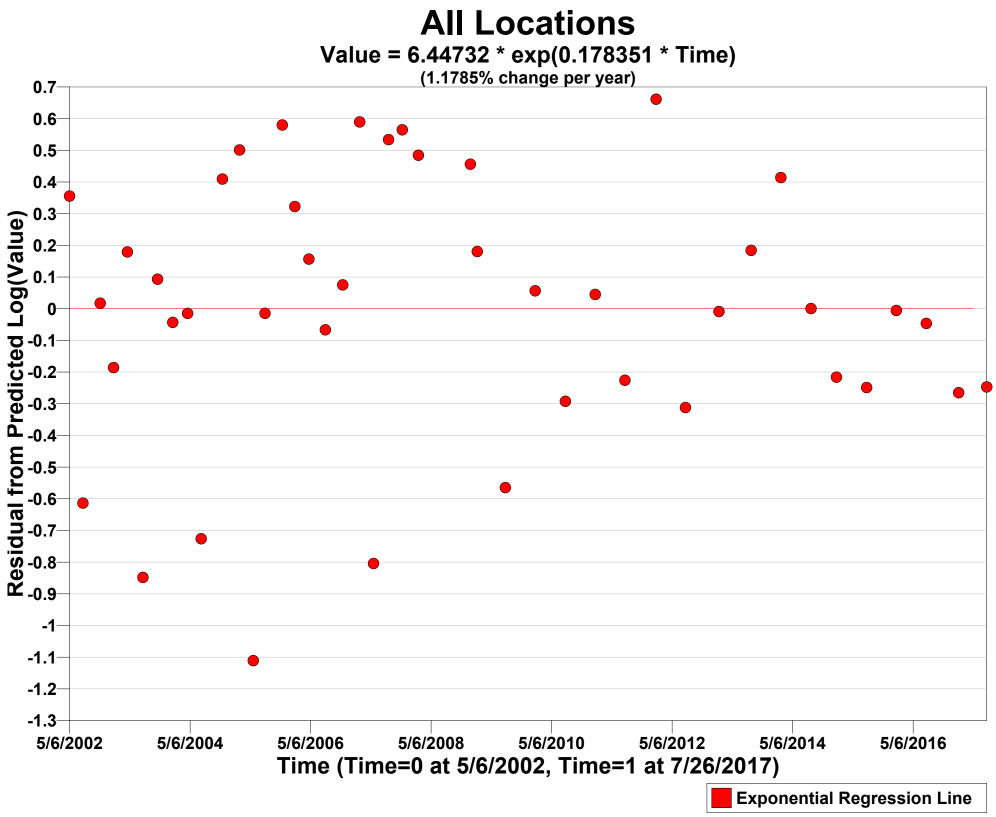
It is also recommended that the trend data plots be studied in depth to identify potential outliers and that the raw data be checked by an expert. No outlier detection method can replace a thorough and diligent examination by someone familiar with the data. Ideally, data plots are examined and the obvious erroneous values are addressed before relying on an outlier test.

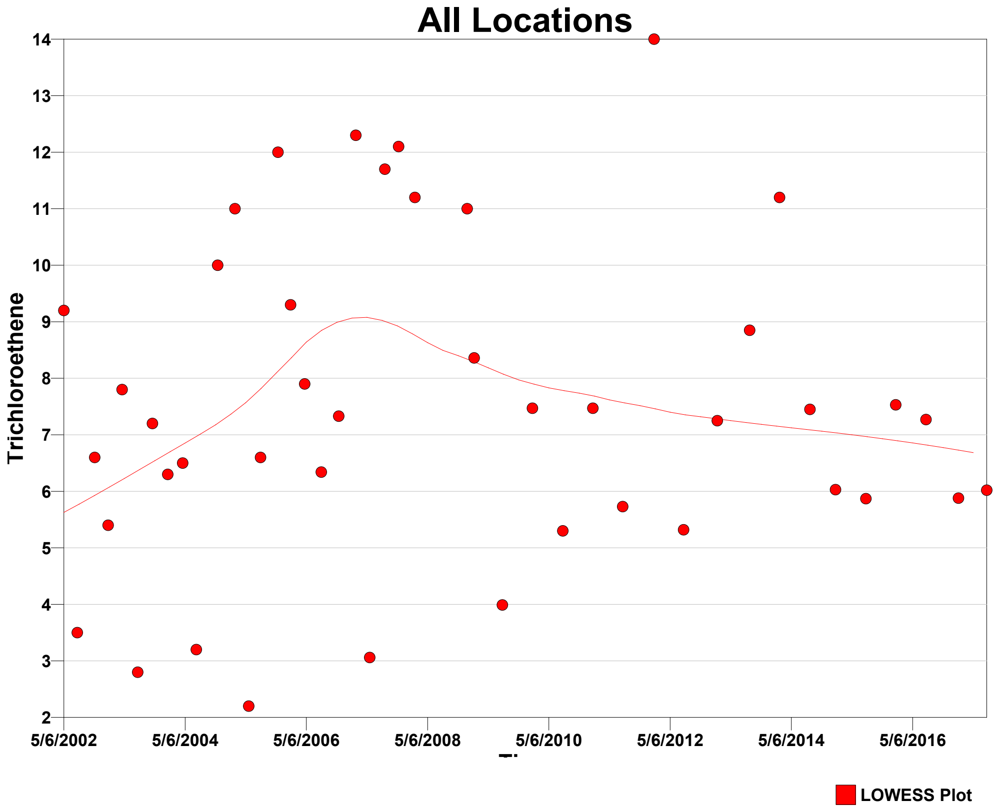
Data Plots
The Time vs. Measured Values Plot shows the best fitting exponential curve (shown as the red line) to the observed n data values plotted against time. The x-axis is the time when data were collected and the y-axis is the value of each datum. The exponential increase or decrease function is shown in the title. The curve is also expressed as a percent change per time period.

The Time vs. Residual Values Plot shows the deviation (difference) of each observed value from the log of the predicted value on the curve. The horizontal line at value zero represents a perfect fit (no difference) to the exponential curve line.

The last plot is a Locally Weighted Smoothed Scatterplot (LOWESS Plot) developed by William S. Cleveland that shows a fitted line through the data that tends to eliminate the distortion that comes from deviant points.




All Locations
Value = 6.44732 * exp(0.178351 * Time)
(1.1785% change per year)
Residual from Predicted Log(Value)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1
-1.1
-1.2
-1.3
5/6/2002
5/6/2004
5/6/2006
5/6/2008
5/6/2010
5/6/2012
5/6/2014
5/6/2016
Time (Time=0 at 5/6/2002, Time=1 at 7/26/2017)
🟥 Exponential Regression Line


All Locations
Trichloroethene
14
13
12
11
10
9
8
7
6
5
4
3
2
5/6/2002
5/6/2004
5/6/2006
5/6/2008
5/6/2010
5/6/2012
5/6/2014
5/6/2016
🟥 LOWESS Plot

Tests

A goodness-of-fit test was performed to test whether the residuals (deviations from the linear regression line described and displayed above) are normally distributed. The Shapiro-Wilk test was determined most appropriate for this VSP application because the size of the data set (n=43) is less than 50.

Normal Distribution Test of Residuals for Trichloroethene	
Shapiro-Wilk Test Statistic	0.95078
Shapiro-Wilk 5% Critical Value	0.943

The calculated test statistic exceeds the 5% Shapiro-Wilk critical value, so we can reject the hypothesis that the residuals are normally distributed, or in other words the residuals do not appear to follow a normal distribution at the 5% level of significance. A Q-Q plot of residual values (displayed above) should be used to further assess the normality of the data.

Mann-Kendall Test

The Mann-Kendall Test for trend was performed on the data as outlined in the *Calculations to Determine Whether a Trend Exists* section above. The results are as follows:

Mann-Kendall Test			
Sum of Signs	S	39	
MK Test Statistic	Z_{MK}	0.397773	
Alpha	α	0.05	
Critical Value	$- Z_{1-\alpha}$	-1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	A downward monotonic trend exists	Reject
Conclude with 95% confidence that a downward monotonic trend does not exist.			

Mann-Kendall Test			
Sum of Signs	S	39	
MK Test Statistic	Z_{MK}	0.397773	
Alpha	α	0.05	
Critical Value	$Z_{1-\alpha}$	1.64485	
Null Hypothesis	H_o	No trend exists	**Accept**
Alternative Hypothesis	H_a	An upward monotonic trend exists	Reject
Conclude with 95% confidence that an upward monotonic trend does not exist.			

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* - The report contents may have been modified or reformatted by end-user of software.

Appendix C

2017 Groundwater Elevations

Table C-1. Phase I Groundwater Elevations

Well ID	Date	Elevation of Top of Casing (ft MSL)	Depth from Top of Casing (ft)	Groundwater Elevation (ft MSL)
0353	2/6/2017	745.33	3.8	741.53
	7/25/2017	745.33	2.06	743.27
0400	1/17/2017	705.11	24.3	680.81
	2/6/2017	705.11	23.8	681.31
	3/9/2017	705.11	23.26	681.85
	4/10/2017	705.11	22.71	682.4
	5/3/2017	705.11	23.23	681.88
	6/14/2017	705.11	23.86	681.25
	7/19/2017	705.11	22.7	682.41
	7/25/2017	705.11	22.96	682.15
	8/8/2017	705.11	24.06	681.05
	8/24/2017	705.11	25.2	679.91
	9/7/2017	705.11	25.6	679.51
	10/9/2017	705.11	25.92	679.19
	11/8/2017	705.11	22.68	682.43
	11/21/2017	705.11	22.11	683
	11/28/2017	705.11	22.3	682.81
	12/5/2017	705.11	23.77	681.34
	12/12/2017	705.11	24.97	680.14
	12/19/2017	705.11	25.6	679.51
	12/26/2017	705.11	25.4	679.71
0402	1/17/2017	704.02	23.12	680.9
	2/6/2017	704.02	22.64	681.38
	2/13/2017	704.02	22.74	681.28
	3/9/2017	704.02	22.08	681.94
	4/10/2017	704.02	21.59	682.43
	4/24/2017	704.02	22.46	681.56
	5/3/2017	704.02	22.1	681.92
	6/14/2017	704.02	22.73	681.29
	7/19/2017	704.02	21.55	682.47
	7/25/2017	704.02	21.79	682.23
	7/31/2017	704.02	22.18	681.84
	8/8/2017	704.02	22.9	681.12
	8/24/2017	704.02	24.03	679.99
	9/7/2017	704.02	24.41	679.61
	10/9/2017	704.02	24.66	679.36
	10/30/2017	704.02	24.42	679.6
	11/8/2017	704.02	21.38	682.64
	11/21/2017	704.02	20.82	683.2

Table C-1. Phase I Groundwater Elevations (continued)

Well ID	Date	Elevation of Top of Casing (ft MSL)	Depth from Top of Casing (ft)	Groundwater Elevation (ft MSL)
0402 (continued)	11/28/2017	704.02	21.14	682.88
	12/5/2017	704.02	22.66	681.36
	12/12/2017	704.02	23.92	680.1
	12/19/2017	704.02	24.47	679.55
	12/26/2017	704.02	24.25	679.77
0411	2/6/2017	836.57	18.4	818.17
	7/25/2017	836.57	18.21	818.36
0443	2/6/2017	858.78	32.85	825.93
	7/26/2017	858.78	33.35	825.43
0444	7/26/2017	773	21.97	751.03
0445	2/6/2017	743.43	19.85	723.58
	2/16/2017	743.43	16.75	726.68
	7/26/2017	743.43	14.7	728.73
P033	1/17/2017	705.83	25.03	680.8
	2/6/2017	705.83	24.52	681.31
	2/6/2017	705.83	24.52	681.31
	3/9/2017	705.83	24.02	681.81
	4/10/2017	705.83	23.46	682.37
	5/3/2017	705.83	23.98	681.85
	6/14/2017	705.83	24.59	681.24
	7/19/2017	705.83	23.44	682.39
	7/26/2017	705.83	23.7	682.13
	8/8/2017	705.83	24.8	681.03
	8/24/2017	705.83	25.94	679.89
	9/7/2017	705.83	26.32	679.51
	10/9/2017	705.83	26.63	679.2
	11/8/2017	705.83	23.37	682.46
	11/21/2017	705.83	22.79	683.04
	11/28/2017	705.83	23.05	682.78
	12/5/2017	705.83	24.57	681.26
	12/12/2017	705.83	25.75	680.08
	12/19/2017	705.83	26.34	679.49
P064	11/8/2017	729.98	49.95	680.03
	11/21/2017	729.98	47.34	682.64
	11/28/2017	729.98	47.35	682.63
	12/5/2017	729.98	48.8	681.18
	12/12/2017	729.98	49.96	680.02
	12/19/2017	729.98	50.65	679.33

Table C-2. Parcels 6, 7, and 8 Groundwater Elevations

Location	Date	Elevation of Top of Casing (ft MSL)	Depth from Top of Casing (ft)	Groundwater Elevation (ft MSL)
0118	2/8/2017	704.86	22.75	682.11
	5/1/2017	704.86	22.01	682.85
	7/24/2017	704.86	21.43	683.43
	11/6/2017	704.86	22.29	682.57
0124	2/8/2017	705.12	23.46	681.66
	5/1/2017	705.12	23.15	681.97
	7/24/2017	705.12	22.63	682.49
	11/6/2017	705.12	23.77	681.35
0126	1/17/2017	705.54	24.37	681.17
	2/6/2017	705.54	23.9	681.64
	2/8/2017	705.54	23.88	681.66
	3/9/2017	705.54	23.37	682.17
	4/10/2017	705.54	22.92	682.62
	5/1/2017	705.54	23.6	681.94
	5/3/2017	705.54	23.31	682.23
	6/14/2017	705.54	23.97	681.57
	7/19/2017	705.54	22.91	682.63
	7/24/2017	705.54	23.07	682.47
	8/8/2017	705.54	24.24	681.3
	8/24/2017	705.54	25.34	680.2
	9/7/2017	705.54	25.66	679.88
	10/9/2017	705.54	25.84	679.7
	11/6/2017	705.54	24.32	681.22
	11/8/2017	705.54	22.26	683.28
	11/21/2017	705.54	21.63	683.91
	11/28/2017	705.54	22.43	683.11
	12/5/2017	705.54	24.35	681.19
	12/12/2017	705.54	25.66	679.88
	12/19/2017	705.54	25.93	679.61
	12/26/2017	705.54	25.58	679.96
0138	2/8/2017	697.76	25.86	671.9
	5/2/2017	697.76	24.78	672.98
	7/24/2017	697.76	24.68	673.08
	11/6/2017	697.76	25.03	672.73
0315	2/7/2017	723.99	42.32	681.67
	5/1/2017	723.99	42.08	681.91
	7/25/2017	723.99	41.58	682.41
	11/7/2017	723.99	41.44	682.55

Table C-2. Parcels 6, 7, and 8 Groundwater Elevations (continued)

Location	Date	Elevation of Top of Casing (ft MSL)	Depth from Top of Casing (ft)	Groundwater Elevation (ft MSL)
0346	2/7/2017	742.97	14.22	728.75
	5/2/2017	742.97	13.33	729.64
	7/25/2017	742.97	13.4	729.57
	11/8/2017	742.97	14.75	728.22
0347	2/7/2017	725.2	43.53	681.67
	5/1/2017	725.2	43.28	681.92
	7/25/2017	725.2	42.8	682.4
	11/7/2017	725.2	42.61	682.59
0378	1/17/2017	682.81	18.78	664.03
	2/6/2017	682.81	18.33	664.48
	3/9/2017	682.81	17.8	665.01
	4/10/2017	682.81	17.32	665.49
	5/3/2017	682.81	17.69	665.12
	6/14/2017	682.81	18.28	664.53
	7/19/2017	682.81	17.3	665.51
	8/8/2017	682.81	18.66	664.15
	8/24/2017	682.81	19.76	663.05
	9/7/2017	682.81	20.1	662.71
	10/9/2017	682.81	20.23	662.58
	11/8/2017	682.81	16.75	666.06
	11/21/2017	682.81	16.18	666.63
	11/28/2017	682.81	16.9	665.91
	12/5/2017	682.81	18.64	664.17
	12/12/2017	682.81	19.91	662.9
	12/19/2017	682.81	20.24	662.57
	12/26/2017	682.81	19.97	662.84
0379	1/17/2017	716.11	34.99	681.12
	2/6/2017	716.11	34.49	681.62
	2/7/2017	716.11	34.45	681.66
	2/13/2017	716.11	34.64	681.47
	3/9/2017	716.11	33.96	682.15
	4/10/2017	716.11	33.47	682.64
	4/24/2017	716.11	34.31	681.8
	5/1/2017	716.11	34.25	681.86
	5/3/2017	716.11	33.91	682.2
	6/14/2017	716.11	34.6	681.51
	7/19/2017	716.11	33.44	682.67
	7/24/2017	716.11	33.66	682.45
	7/31/2017	716.11	34.07	682.04

Table C-2. Parcels 6, 7, and 8 Groundwater Elevations (continued)

Location	Date	Elevation of Top of Casing (ft MSL)	Depth from Top of Casing (ft)	Groundwater Elevation (ft MSL)
0379	8/8/2017	716.11	34.79	681.32
	8/24/2017	716.11	35.89	680.22
	9/7/2017	716.11	36.23	679.88
	10/9/2017	716.11	36.44	679.67
	10/30/2017	716.11	36.23	679.88
	11/6/2017	716.11	35.2	680.91
	11/8/2017	716.11	32.92	683.19
	11/21/2017	716.11	32.65	683.46
	11/28/2017	716.11	32.98	683.13
	12/5/2017	716.11	34.84	681.27
	12/12/2017	716.11	36.18	679.93
	12/19/2017	716.11	36.55	679.56
	12/26/2017	716.11	36.15	679.96
0386	2/7/2017	724.79	43.15	681.64
	5/2/2017	724.79	42.7	682.09
	7/24/2017	724.79	42.28	682.51
	11/7/2017	724.79	42.28	682.51
0387	2/7/2017	720.89	39.28	681.61
	5/2/2017	720.89	38.83	682.06
	7/24/2017	720.89	38.42	682.47
	11/7/2017	720.89	38.45	682.44
0389	2/7/2017	724.65	43	681.65
	5/2/2017	724.65	42.56	682.09
	7/24/2017	724.65	42.1	682.55
	11/7/2017	724.65	44.14	680.51
0392	2/7/2017	720.84	39.2	681.64
	5/2/2017	720.84	38.65	682.19
	7/24/2017	720.84	38.25	682.59
	11/7/2017	720.84	38.3	682.54

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Appendix D

2017 Groundwater and Seep Data Tables

Table D-1. Phase I Groundwater Data

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0353	*cis*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0353		7/25/2017	0.16	0.16	U	QF	µg/L	F
0353	Dissolved oxygen	2/6/2017	6.79				mg/L	F
0353		7/25/2017	1.63			QF	mg/L	F
0353	Oxidation reduction potential	2/6/2017	78.7				mV	F
0353		7/25/2017	1.9			QF	mV	F
0353	pH	2/6/2017	7.28				s.u.	F
0353		7/25/2017	7.1			QF	s.u.	F
0353	Specific conductance	2/6/2017	1360				µmho/cm	F
0353		7/25/2017	1380			QF	µmho/cm	F
0353	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0353		7/25/2017	0.16	0.16	U	QF	µg/L	F
0353	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0353		7/25/2017	0.16	0.16	U	QF	µg/L	F
0353	Trichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0353		7/25/2017	0.16	0.16	U	QF	µg/L	F
0353	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0353		7/25/2017	0.16	0.16	U	QF	µg/L	F
0400	*cis*-1,2-Dichloroethene	2/6/2017	0.59	0.16	J		µg/L	F
0400		7/25/2017	0.16	0.16	U	F	µg/L	F
0400	Dissolved oxygen	2/6/2017	1.49				mg/L	F
0400		7/25/2017	1.08			F	mg/L	F
0400	Oxidation reduction potential	2/6/2017	55.7				mV	F
0400		7/25/2017	68.3			F	mV	F

Table D-1. Phase I Groundwater Data (continued)

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0400	pH	2/6/2017	7.03				s.u.	F
0400		7/25/2017	7.15			F	s.u.	F
0400	Specific conductance	2/6/2017	1390				µmho/cm	F
0400		7/25/2017	1420			F	µmho/cm	F
0400	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0400		7/25/2017	0.16	0.16	U	F	µg/L	F
0400	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0400		7/25/2017	0.16	0.16	U	F	µg/L	F
0400	Trichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0400		7/25/2017	0.16	0.16	U	F	µg/L	F
0400	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0400		7/25/2017	0.16	0.16	U	F	µg/L	F
0402	*cis*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0402		7/25/2017	0.16	0.16	U	F	µg/L	F
0402	Dissolved oxygen	2/6/2017	3.76				mg/L	F
0402		7/25/2017	3.47			F	mg/L	F
0402		7/31/2017	3.3			F	mg/L	F
0402	Oxidation reduction potential	2/6/2017	120.4				mV	F
0402		7/25/2017	152.1			F	mV	F
0402		7/31/2017	143.1			F	mV	F
0402	pH	2/6/2017	6.9				s.u.	F
0402		7/25/2017	7.1			F	s.u.	F
0402		7/31/2017	6.81			F	s.u.	F
0402	Specific conductance	2/6/2017	1300				µmho/cm	F
0402		7/25/2017	1170			F	µmho/cm	F
0402		7/31/2017	1170			F	µmho/cm	F

Table D-1. Phase I Groundwater Data (continued)

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0402	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0402		7/25/2017	0.16	0.16	U	F	µg/L	F
0402		7/31/2017	0.333	0.333	U	F	µg/L	F
0402	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0402		7/25/2017	0.16	0.16	U	F	µg/L	F
0402		7/31/2017	0.333	0.333	U	F	µg/L	F
0402	Trichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0402		7/25/2017	0.16	0.16	U	F	µg/L	F
0402	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0402		7/25/2017	0.16	0.16	U	F	µg/L	F
0402		7/31/2017	0.333	0.333	U	F	µg/L	F
0411	*cis*-1,2-Dichloroethene	2/6/2017	1.17	0.16			µg/L	F
0411		2/6/2017	1.22	0.16			µg/L	D
0411		7/25/2017	1.34	0.16		F	µg/L	F
0411	Dissolved oxygen	2/6/2017	0.39				mg/L	F
0411		7/25/2017	0.25			F	mg/L	F
0411	Oxidation reduction potential	2/6/2017	16.2				mV	F
0411		7/25/2017	-1.4			F	mV	F
0411	pH	2/6/2017	7.12				s.u.	F
0411		7/25/2017	7.2			F	s.u.	F
0411	Specific conductance	2/6/2017	1440				µmho/cm	F
0411		7/25/2017	1400			F	µmho/cm	F
0411	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0411		2/6/2017	0.16	0.16	U		µg/L	D
0411		7/25/2017	0.16	0.16	U	F	µg/L	F

Table D-1. Phase I Groundwater Data (continued)

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0411	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0411		2/6/2017	0.16	0.16	U		µg/L	D
0411		7/25/2017	0.16	0.16	U	F	µg/L	F
0411	Trichloroethene	2/6/2017	10.5	0.16			µg/L	F
0411		2/6/2017	10.7	0.16			µg/L	D
0411		7/25/2017	10.3	0.16		F	µg/L	F
0411	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0411		2/6/2017	0.16	0.16	U		µg/L	D
0411		7/25/2017	0.16	0.16	U	F	µg/L	F
0443	*cis*-1,2-Dichloroethene	2/6/2017	0.35	0.16	J		µg/L	F
0443		7/26/2017	0.55	0.16	J	F	µg/L	F
0443		7/26/2017	0.58	0.16	J	F	µg/L	D
0443	Dissolved oxygen	2/6/2017	2.58				mg/L	F
0443		7/26/2017	2.2			F	mg/L	F
0443	Oxidation reduction potential	2/6/2017	85.7				mV	F
0443		7/26/2017	54.9			F	mV	F
0443	pH	2/6/2017	7.14				s.u.	F
0443		7/26/2017	7.26			F	s.u.	F
0443	Specific conductance	2/6/2017	1320				µmho/cm	F
0443		7/26/2017	1270			F	µmho/cm	F
0443	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0443		7/26/2017	0.16	0.16	U	F	µg/L	F
0443		7/26/2017	0.16	0.16	U	F	µg/L	D
0443	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0443		7/26/2017	0.16	0.16	U	F	µg/L	F
0443		7/26/2017	0.16	0.16	U	F	µg/L	D

Table D-1. Phase I Groundwater Data (continued)

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0443	Trichloroethene	2/6/2017	5.88	0.16			µg/L	F
0443		7/26/2017	6.02	0.16		F	µg/L	F
0443		7/26/2017	6	0.16		F	µg/L	D
0443	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0443		7/26/2017	0.16	0.16	U	F	µg/L	F
0443		7/26/2017	0.16	0.16	U	F	µg/L	D
0444	*cis*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0444		7/26/2017	0.16	0.16	U	QF	µg/L	F
0444	Dissolved oxygen	2/6/2017	1.24				mg/L	F
0444		7/26/2017	1.11			QF	mg/L	F
0444	Oxidation reduction potential	2/6/2017	59.6				mV	F
0444		7/26/2017	36.2			QF	mV	F
0444	pH	2/6/2017	7.18				s.u.	F
0444		7/26/2017	7.28			QF	s.u.	F
0444	Specific conductance	2/6/2017	1320				µmho/cm	F
0444		7/26/2017	1310			QF	µmho/cm	F
0444	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0444		7/26/2017	0.16	0.16	U	QF	µg/L	F
0444	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0444		7/26/2017	0.16	0.16	U	QF	µg/L	F
0444	Trichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0444		7/26/2017	0.16	0.16	U	QF	µg/L	F
0444	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0444		7/26/2017	0.16	0.16	U	QF	µg/L	F

Table D-1. Phase I Groundwater Data (continued)

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0445	*cis*-1,2-Dichloroethene	7/26/2017	0.16	0.16	U	QF	µg/L	F
0445	Dissolved oxygen	7/26/2017	0.26			QF	mg/L	F
0445	Oxidation reduction potential	7/26/2017	-107.8			QF	mV	F
0445	pH	7/26/2017	7.3			QF	s.u.	F
0445	Specific conductance	7/26/2017	12830			QF	µmho/cm	F
0445	Tetrachloroethene	7/26/2017	0.16	0.16	U	QF	µg/L	F
0445	*trans*-1,2-Dichloroethene	7/26/2017	0.16	0.16	U	QF	µg/L	F
0445	Trichloroethene	7/26/2017	0.16	0.16	U	QF	µg/L	F
0445	Vinyl chloride	7/26/2017	0.16	0.16	U	QF	µg/L	F
P033	*cis*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
P033		7/26/2017	0.16	0.16	U	F	µg/L	F
P033	Dissolved oxygen	2/6/2017	3.47				mg/L	F
P033		7/26/2017	3.91			F	mg/L	F
P033	Oxidation reduction potential	2/6/2017	78.7				mV	F
P033		7/26/2017	95			F	mV	F
P033	pH	2/6/2017	6.92				s.u.	F
P033		7/26/2017	7.18			F	s.u.	F
P033	Specific conductance	2/6/2017	1710				µmho/cm	F
P033		7/26/2017	1710			F	µmho/cm	F
P033	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
P033		7/26/2017	0.16	0.16	U	F	µg/L	F
P033	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
P033		7/26/2017	0.16	0.16	U	F	µg/L	F
P033	Trichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
P033		7/26/2017	0.16	0.16	U	F	µg/L	F

Table D-1. Phase I Groundwater Data (continued)

Location ID	Analyte	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
P033	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
P033		7/26/2017	0.16	0.16	U	F	µg/L	F
P064	*cis*-1,2-Dichloroethene	11/8/2017	2.52	0.16		F	µg/L	D
P064		11/8/2017	2.43	0.16		F	µg/L	F
P064	Dissolved oxygen	11/8/2017	0.81			F	mg/L	F
P064	Oxidation reduction potential	11/8/2017	110.1			F	mV	F
P064	pH	11/8/2017	6.89			F	s.u.	F
P064	Specific conductance	11/8/2017	1370			F	µmho/cm	F
P064	Tetrachloroethene	11/8/2017	0.75	0.16	J	F	µg/L	D
P064		11/8/2017	0.71	0.16	J	F	µg/L	F
P064	*trans*-1,2-Dichloroethene	11/8/2017	0.16	0.16	U	F	µg/L	D
P064		11/8/2017	0.16	0.16	U	F	µg/L	F
P064	Trichloroethene	11/8/2017	1.54	0.16		F	µg/L	D
P064		11/8/2017	1.44	0.16		F	µg/L	F
P064	Vinyl chloride	11/8/2017	0.16	0.16	U	F	µg/L	D
P064		11/8/2017	0.16	0.16	U	F	µg/L	F

Abbreviations:
D = analyte determined in diluted sample
F = low flow sampling method used
J = estimated value
µg/L = micrograms per liter
µmho/cm = micromhos per centimeter
mg/L = milligrams per liter
mV = millivolts
pCi/L = picocuries per liter
Q = quantitative result due to sampling technique
s.u. = standard unit
U = analytical result below detection limit

Table D-2. Parcels 6, 7, and 8 Groundwater Data

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0118	*cis*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0118		5/1/2017	0.16	0.16	U	F	µg/L	F
0118		7/24/2017	0.16	0.16	U	F	µg/L	F
0118		11/6/2017	0.16	0.16	U	F	µg/L	F
0118	Dissolved oxygen	2/8/2017	5.42				mg/L	F
0118		5/1/2017	5.27			F	mg/L	F
0118		7/24/2017	5.51			F	mg/L	F
0118		11/6/2017	5.59			F	mg/L	F
0118	Oxidation reduction potential	2/8/2017	106.2				mV	F
0118		5/1/2017	169.8			F	mV	F
0118		7/24/2017	116.3			F	mV	F
0118		11/6/2017	126.3			F	mV	F
0118	pH	2/8/2017	7.2				s.u.	F
0118		5/1/2017	7.16			F	s.u.	F
0118		7/24/2017	7.58			F	s.u.	F
0118		11/6/2017	7.08			F	s.u.	F
0118	Specific conductance	2/8/2017	1180				µmho/cm	F
0118		5/1/2017	1180			F	µmho/cm	F
0118		7/24/2017	1180			F	µmho/cm	F
0118		11/6/2017	1120			F	µmho/cm	F
0118	Tetrachloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0118		5/1/2017	0.16	0.16	U	F	µg/L	F
0118		7/24/2017	0.16	0.16	U	F	µg/L	F
0118		11/6/2017	0.16	0.16	U	F	µg/L	F
0118	*trans*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0118		5/1/2017	0.16	0.16	U	F	µg/L	F
0118		7/24/2017	0.16	0.16	U	F	µg/L	F
0118		11/6/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0118	Trichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0118		5/1/2017	0.16	0.16	U	F	µg/L	F
0118		7/24/2017	0.16	0.16	U	F	µg/L	F
0118		11/6/2017	0.16	0.16	U	F	µg/L	F
0118	Tritium	2/8/2017	-0.834	350	U		pCi/L	F
0118		7/24/2017	216	307	U	F	pCi/L	F
0118	Vinyl chloride	2/8/2017	0.16	0.16	U		µg/L	F
0118		5/1/2017	0.16	0.16	U	F	µg/L	F
0118		7/24/2017	0.16	0.16	U	F	µg/L	F
0118		11/6/2017	0.16	0.16	U	F	µg/L	F
0124	*cis*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0124		5/1/2017	0.16	0.16	U	F	µg/L	F
0124		7/24/2017	0.16	0.16	U	F	µg/L	F
0124		11/6/2017	0.16	0.16	U	F	µg/L	F
0124	Dissolved oxygen	2/8/2017	0.25				mg/L	F
0124		5/1/2017	2.96			F	mg/L	F
0124		7/24/2017	3.63			F	mg/L	F
0124		11/6/2017	1.7			F	mg/L	F
0124	Oxidation reduction potential	2/8/2017	99.8				mV	F
0124		5/1/2017	168.1			F	mV	F
0124		7/24/2017	56.5			F	mV	F
0124		11/6/2017	76.8			F	mV	F
0124	pH	2/8/2017	7.03				s.u.	F
0124		5/1/2017	6.99			F	s.u.	F
0124		7/24/2017	7.42			F	s.u.	F
0124		11/6/2017	6.87			F	s.u.	F
0124	Specific conductance	2/8/2017	1370				µmho/cm	F
0124		5/1/2017	1220			F	µmho/cm	F
0124		7/24/2017	1170			F	µmho/cm	F
0124		11/6/2017	1210			F	µmho/cm	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0124	Tetrachloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0124		5/1/2017	0.16	0.16	U	F	µg/L	F
0124		7/24/2017	0.16	0.16	U	F	µg/L	F
0124		11/6/2017	0.16	0.16	U	F	µg/L	F
0124	*trans*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0124		5/1/2017	0.16	0.16	U	F	µg/L	F
0124		7/24/2017	0.16	0.16	U	F	µg/L	F
0124		11/6/2017	0.16	0.16	U	F	µg/L	F
0124	Trichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0124		5/1/2017	0.16	0.16	U	F	µg/L	F
0124		7/24/2017	0.16	0.16	U	F	µg/L	F
0124		11/6/2017	0.16	0.16	U	F	µg/L	F
0124	Vinyl chloride	2/8/2017	0.16	0.16	U		µg/L	F
0124		5/1/2017	0.16	0.16	U	F	µg/L	F
0124		7/24/2017	0.16	0.16	U	F	µg/L	F
0124		11/6/2017	0.16	0.16	U	F	µg/L	F
0126	*cis*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0126		5/1/2017	0.16	0.16	U	F	µg/L	F
0126		7/24/2017	0.16	0.16	U	F	µg/L	F
0126		11/6/2017	0.16	0.16	U	F	µg/L	F
0126	Dissolved oxygen	2/8/2017	0.23				mg/L	F
0126		5/1/2017	0.12			F	mg/L	F
0126		7/24/2017	0.29			F	mg/L	F
0126		11/6/2017	1.79			F	mg/L	F
0126	Oxidation reduction potential	2/8/2017	125				mV	F
0126		5/1/2017	138.6			F	mV	F
0126		7/24/2017	70.4			F	mV	F
0126		11/6/2017	114.9			F	mV	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0126	pH	2/8/2017	7.01				s.u.	F
0126		5/1/2017	7			F	s.u.	F
0126		7/24/2017	8.07			F	s.u.	F
0126		11/6/2017	6.89			F	s.u.	F
0126	Specific conductance	2/8/2017	1240				µmho/cm	F
0126		5/1/2017	1250			F	µmho/cm	F
0126		7/24/2017	1230			F	µmho/cm	F
0126		11/6/2017	1200			F	µmho/cm	F
0126	Tetrachloroethene	2/8/2017	0.69	0.16	J		µg/L	F
0126		5/1/2017	0.85	0.16	J	F	µg/L	F
0126		7/24/2017	0.81	0.16	J	F	µg/L	F
0126		11/6/2017	0.79	0.16	J	F	µg/L	F
0126	*trans*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0126		5/1/2017	0.16	0.16	U	F	µg/L	F
0126		7/24/2017	0.16	0.16	U	F	µg/L	F
0126		11/6/2017	0.16	0.16	U	F	µg/L	F
0126	Trichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0126		5/1/2017	0.16	0.16	U	F	µg/L	F
0126		7/24/2017	0.16	0.16	U	F	µg/L	F
0126		11/6/2017	0.16	0.16	U	F	µg/L	F
0126	Vinyl chloride	2/8/2017	0.16	0.16	U		µg/L	F
0126		5/1/2017	0.16	0.16	U	F	µg/L	F
0126		7/24/2017	0.16	0.16	U	F	µg/L	F
0126		11/6/2017	0.16	0.16	U	F	µg/L	F
0138	*cis*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0138		5/2/2017	0.16	0.16	U	F	µg/L	F
0138		7/24/2017	0.16	0.16	U	F	µg/L	F
0138		11/6/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0138	Dissolved oxygen	2/8/2017	3.48				mg/L	F
0138		5/2/2017	2.69			F	mg/L	F
0138		7/24/2017	2.29			F	mg/L	F
0138		11/6/2017	3.29			F	mg/L	F
0138	Oxidation reduction potential	2/8/2017	85.3				mV	F
0138		5/2/2017	20.2			F	mV	F
0138		7/24/2017	92			F	mV	F
0138		11/6/2017	128.7			F	mV	F
0138	pH	2/8/2017	6.93				s.u.	F
0138		5/2/2017	7.14			F	s.u.	F
0138		7/24/2017	7.36			F	s.u.	F
0138		11/6/2017	7.04			F	s.u.	F
0138	Specific conductance	2/8/2017	1240				µmho/cm	F
0138		5/2/2017	1260			F	µmho/cm	F
0138		7/24/2017	1260			F	µmho/cm	F
0138		11/6/2017	1180			F	µmho/cm	F
0138	Tetrachloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0138		5/2/2017	0.16	0.16	U	F	µg/L	F
0138		7/24/2017	0.16	0.16	U	F	µg/L	F
0138		11/6/2017	0.16	0.16	U	F	µg/L	F
0138	*trans*-1,2-Dichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0138		5/2/2017	0.16	0.16	U	F	µg/L	F
0138		7/24/2017	0.16	0.16	U	F	µg/L	F
0138		11/6/2017	0.16	0.16	U	F	µg/L	F
0138	Trichloroethene	2/8/2017	0.16	0.16	U		µg/L	F
0138		5/2/2017	0.16	0.16	U	F	µg/L	F
0138		7/24/2017	0.16	0.16	U	F	µg/L	F
0138		11/6/2017	0.16	0.16	U	F	µg/L	F
0138	Tritium	2/8/2017	251	352	U		pCi/L	F
0138		7/24/2017	858	303		JF	pCi/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0138	Vinyl chloride	2/8/2017	0.16	0.16	U		µg/L	F
0138		5/2/2017	0.16	0.16	U	F	µg/L	F
0138		7/24/2017	0.16	0.16	U	F	µg/L	F
0138		11/6/2017	0.16	0.16	U	F	µg/L	F
0315	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	D
0315		7/25/2017	0.16	0.16	U	F	µg/L	F
0315		11/7/2017	0.16	0.16	U	F	µg/L	F
0315	Dissolved oxygen	2/7/2017	0.62				mg/L	F
0315		5/1/2017	1.6			F	mg/L	F
0315		7/25/2017	1.06			F	mg/L	F
0315		11/7/2017	0.66			F	mg/L	F
0315	Oxidation reduction potential	2/7/2017	-6.6				mV	F
0315		5/1/2017	19.3			F	mV	F
0315		7/25/2017	-1.9			F	mV	F
0315		11/7/2017	11			F	mV	F
0315	pH	2/7/2017	7.1				s.u.	F
0315		5/1/2017	7.12			F	s.u.	F
0315		7/25/2017	7.31			F	s.u.	F
0315		11/7/2017	6.99			F	s.u.	F
0315	Specific conductance	2/7/2017	1650				µmho/cm	F
0315		5/1/2017	1690			F	µmho/cm	F
0315		7/25/2017	1700			F	µmho/cm	F
0315		11/7/2017	1530			F	µmho/cm	F
0315	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	D
0315		7/25/2017	0.16	0.16	U	F	µg/L	F
0315		11/7/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0315	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	D
0315		7/25/2017	0.16	0.16	U	F	µg/L	F
0315		11/7/2017	0.16	0.16	U	F	µg/L	F
0315	Trichloroethene	2/7/2017	4.14	0.16			µg/L	F
0315		5/1/2017	6.98	0.16		F	µg/L	F
0315		5/1/2017	6.9	0.16		F	µg/L	D
0315		7/25/2017	4.67	0.16		F	µg/L	F
0315		11/7/2017	6.44	0.16		F	µg/L	F
0315	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	F
0315		5/1/2017	0.16	0.16	U	F	µg/L	D
0315		7/25/2017	0.16	0.16	U	F	µg/L	F
0315		11/7/2017	0.16	0.16	U	F	µg/L	F
0346	*cis*-1,2-Dichloroethenef	2/7/2017	0.16	0.16	U		µg/L	F
0346		5/2/2017	0.16	0.16	U	F	µg/L	F
0346		7/25/2017	0.16	0.16	U	F	µg/L	F
0346		11/8/2017	0.16	0.16	U	F	µg/L	F
0346	Dissolved oxygen	2/7/2017	9.86				mg/L	F
0346		5/2/2017	7.8			F	mg/L	F
0346		7/25/2017	1.91			F	mg/L	F
0346		11/8/2017	5.32			F	mg/L	F
0346	Oxidation reduction potential	2/7/2017	94.5				mV	F
0346		5/2/2017	174.6			F	mV	F
0346		7/25/2017	71.2			F	mV	F
0346		11/8/2017	117.2			F	mV	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0346	pH	2/7/2017	7.77				s.u.	F
0346		5/2/2017	7.63			F	s.u.	F
0346		7/25/2017	7.35			F	s.u.	F
0346		11/8/2017	7.21			F	s.u.	F
0346	Specific conductance	2/7/2017	425				µmho/cm	F
0346		5/2/2017	396			F	µmho/cm	F
0346		7/25/2017	640			F	µmho/cm	F
0346		11/8/2017	490			F	µmho/cm	F
0346	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0346		5/2/2017	0.16	0.16	U	F	µg/L	F
0346		7/25/2017	0.16	0.16	U	F	µg/L	F
0346		11/8/2017	0.16	0.16	U	F	µg/L	F
0346	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0346		5/2/2017	0.16	0.16	U	F	µg/L	F
0346		7/25/2017	0.16	0.16	U	F	µg/L	F
0346		11/8/2017	0.16	0.16	U	F	µg/L	F
0346	Trichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0346		5/2/2017	0.16	0.16	U	F	µg/L	F
0346		7/25/2017	0.16	0.16	U	F	µg/L	F
0346		11/8/2017	0.16	0.16	U	F	µg/L	F
0346	Tritium	2/7/2017	47.3	361	U		pCi/L	F
0346		7/25/2017	211	310	U	F	pCi/L	F
0346	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0346		5/2/2017	0.16	0.16	U	F	µg/L	F
0346		7/25/2017	0.16	0.16	U	F	µg/L	F
0346		11/8/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0347	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0347		2/7/2017	0.16	0.16	U		µg/L	D
0347		5/1/2017	0.16	0.16	U	F	µg/L	F
0347		7/25/2017	0.16	0.16	U	F	µg/L	F
0347		11/7/2017	0.16	0.16	U	F	µg/L	F
0347	Dissolved oxygen	2/7/2017	0.2				mg/L	F
0347		5/1/2017	0.1			F	mg/L	F
0347		7/25/2017	1.67			F	mg/L	F
0347		11/7/2017	0.47			F	mg/L	F
0347	Oxidation reduction potential	2/7/2017	-36.4				mV	F
0347		5/1/2017	-21.5			F	mV	F
0347		7/25/2017	-34.5			F	mV	F
0347		11/7/2017	-13.3			F	mV	F
0347	pH	2/7/2017	6.89				s.u.	F
0347		5/1/2017	6.97			F	s.u.	F
0347		7/25/2017	7.15			F	s.u.	F
0347		11/7/2017	6.92			F	s.u.	F
0347	Specific conductance	2/7/2017	1660				µmho/cm	F
0347		5/1/2017	1690			F	µmho/cm	F
0347		7/25/2017	1670			F	µmho/cm	F
0347		11/7/2017	1600			F	µmho/cm	F
0347	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0347		2/7/2017	0.16	0.16	U		µg/L	D
0347		5/1/2017	0.16	0.16	U	F	µg/L	F
0347		7/25/2017	0.16	0.16	U	F	µg/L	F
0347		11/7/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0347	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0347		2/7/2017	0.16	0.16	U		µg/L	D
0347		5/1/2017	0.16	0.16	U	F	µg/L	F
0347		7/25/2017	0.16	0.16	U	F	µg/L	F
0347		11/7/2017	0.16	0.16	U	F	µg/L	F
0347	Trichloroethene	2/7/2017	20.4	0.16			µg/L	F
0347		2/7/2017	18.9	0.16			µg/L	D
0347		5/1/2017	18	0.16		F	µg/L	F
0347		7/25/2017	18	0.16		F	µg/L	F
0347		11/7/2017	25.7	0.16		F	µg/L	F
0347	Tritium	2/7/2017	1260	365			pCi/L	F
0347		2/7/2017	1380	364			pCi/L	D
0347		7/25/2017	1390	309		F	pCi/L	F
0347	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0347		2/7/2017	0.16	0.16	U		µg/L	D
0347		5/1/2017	0.16	0.16	U	F	µg/L	F
0347		7/25/2017	0.16	0.16	U	F	µg/L	F
0347		11/7/2017	0.16	0.16	U	F	µg/L	F
0379	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0379		5/1/2017	0.16	0.16	U	F	µg/L	F
0379		7/24/2017	0.16	0.16	U	F	µg/L	F
0379		7/24/2017	0.16	0.16	U	F	µg/L	D
0379		11/6/2017	0.16	0.16	U	F	µg/L	F
0379	Dissolved oxygen	2/7/2017	0.32				mg/L	F
0379		5/1/2017	1.23			F	mg/L	F
0379		7/24/2017	1.11			F	mg/L	F
0379		11/6/2017	2.15			F	mg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0379	Oxidation reduction potential	2/7/2017	47.6				mV	F
0379		5/1/2017	57.1			F	mV	F
0379		7/24/2017	30.4			F	mV	F
0379		11/6/2017	-44.2			F	mV	F
0379	pH	2/7/2017	7.12				s.u.	F
0379		5/1/2017	7.05			F	s.u.	F
0379		7/24/2017	6.99			F	s.u.	F
0379		11/6/2017	6.95			F	s.u.	F
0379	Specific conductance	2/7/2017	1790				µmho/cm	F
0379		5/1/2017	1700			F	µmho/cm	F
0379		7/24/2017	1620			F	µmho/cm	F
0379		11/6/2017	1660			F	µmho/cm	F
0379	Tetrachloroethene	2/7/2017	0.33	0.16	J		µg/L	F
0379		5/1/2017	0.45	0.16	J	F	µg/L	F
0379		7/24/2017	0.35	0.16	J	F	µg/L	F
0379		7/24/2017	0.34	0.16	J	F	µg/L	D
0379		11/6/2017	0.6	0.16	J	F	µg/L	F
0379	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0379		5/1/2017	0.16	0.16	U	F	µg/L	F
0379		7/24/2017	0.16	0.16	U	F	µg/L	F
0379		7/24/2017	0.16	0.16	U	F	µg/L	D
0379		11/6/2017	0.16	0.16	U	F	µg/L	F
0379	Trichloroethene	2/7/2017	1.33	0.16			µg/L	F
0379		5/1/2017	1.53	0.16		F	µg/L	F
0379		7/24/2017	1.54	0.16		F	µg/L	F
0379		7/24/2017	1.54	0.16		F	µg/L	D
0379		11/6/2017	1.46	0.16		F	µg/L	F
0379	Tritium	2/7/2017	882	368		J	pCi/L	F
0379		7/24/2017	846	311		JF	pCi/L	F
0379		7/24/2017	847	301		JF	pCi/L	D

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0379	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0379		5/1/2017	0.16	0.16	U	F	µg/L	F
0379		7/24/2017	0.16	0.16	U	F	µg/L	F
0379		7/24/2017	0.16	0.16	U	F	µg/L	D
0379		11/6/2017	0.16	0.16	U	F	µg/L	F
0386	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0386		5/2/2017	0.16	0.16	U	F	µg/L	F
0386		7/24/2017	0.16	0.16	U	F	µg/L	F
0386		11/7/2017	0.16	0.16	U	F	µg/L	F
0386	Dissolved oxygen	2/7/2017	3.54				mg/L	F
0386		5/2/2017	2.26			F	mg/L	F
0386		7/24/2017	3.73			F	mg/L	F
0386		11/7/2017	2.11			F	mg/L	F
0386	Oxidation reduction potential	2/7/2017	117.3				mV	F
0386		5/2/2017	192.9			F	mV	F
0386		7/24/2017	241.7			F	mV	F
0386		11/7/2017	182.4			F	mV	F
0386	pH	2/7/2017	6.83				s.u.	F
0386		5/2/2017	6.81			F	s.u.	F
0386		7/24/2017	6.79			F	s.u.	F
0386		11/7/2017	6.76			F	s.u.	F
0386	Specific conductance	2/7/2017	1250				µmho/cm	F
0386		5/2/2017	1350			F	µmho/cm	F
0386		7/24/2017	1370			F	µmho/cm	F
0386		11/7/2017	1300			F	µmho/cm	F
0386	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0386		5/2/2017	0.16	0.16	U	F	µg/L	F
0386		7/24/2017	0.16	0.16	U	F	µg/L	F
0386		11/7/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0386	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0386		5/2/2017	0.16	0.16	U	F	µg/L	F
0386		7/24/2017	0.16	0.16	U	F	µg/L	F
0386		11/7/2017	0.16	0.16	U	F	µg/L	F
0386	Trichloroethene	2/7/2017	1.83	0.16			µg/L	F
0386		5/2/2017	1.83	0.16		F	µg/L	F
0386		7/24/2017	2.22	0.16		F	µg/L	F
0386		11/7/2017	2.22	0.16		F	µg/L	F
0386	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0386		5/2/2017	0.16	0.16	U	F	µg/L	F
0386		7/24/2017	0.16	0.16	U	F	µg/L	F
0386		11/7/2017	0.16	0.16	U	F	µg/L	F
0387	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0387		5/2/2017	0.16	0.16	U	F	µg/L	F
0387		7/24/2017	0.16	0.16	U	F	µg/L	F
0387		11/7/2017	0.16	0.16	U	F	µg/L	F
0387	Dissolved oxygen	2/7/2017	0.53				mg/L	F
0387		5/2/2017	0.43			F	mg/L	F
0387		7/24/2017	1.32			F	mg/L	F
0387		11/7/2017	1.94			F	mg/L	F
0387	Oxidation reduction potential	2/7/2017	125.1				mV	F
0387		5/2/2017	130.1			F	mV	F
0387		7/24/2017	228			F	mV	F
0387		11/7/2017	210			F	mV	F
0387	pH	2/7/2017	6.99				s.u.	F
0387		5/2/2017	7.02			F	s.u.	F
0387		7/24/2017	6.86			F	s.u.	F
0387		11/7/2017	6.86			F	s.u.	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0387	Specific conductance	2/7/2017	1270				µmho/cm	F
0387		5/2/2017	1270			F	µmho/cm	F
0387		7/24/2017	1270			F	µmho/cm	F
0387		11/7/2017	1290			F	µmho/cm	F
0387	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0387		5/2/2017	0.16	0.16	U	F	µg/L	F
0387		7/24/2017	0.16	0.16	U	F	µg/L	F
0387		11/7/2017	0.16	0.16	U	F	µg/L	F
0387	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0387		5/2/2017	0.16	0.16	U	F	µg/L	F
0387		7/24/2017	0.16	0.16	U	F	µg/L	F
0387		11/7/2017	0.16	0.16	U	F	µg/L	F
0387	Trichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0387		5/2/2017	0.16	0.16	U	F	µg/L	F
0387		7/24/2017	0.16	0.16	U	F	µg/L	F
0387		11/7/2017	0.16	0.16	U	F	µg/L	F
0387	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0387		5/2/2017	0.16	0.16	U	F	µg/L	F
0387		7/24/2017	0.16	0.16	U	F	µg/L	F
0387		11/7/2017	0.16	0.16	U	F	µg/L	F
0389	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0389		5/2/2017	0.16	0.16	U	F	µg/L	F
0389		7/24/2017	0.16	0.16	U	F	µg/L	F
0389		11/7/2017	0.16	0.16	U	F	µg/L	F
0389	Dissolved oxygen	2/7/2017	1.89				mg/L	F
0389		5/2/2017	2.29			F	mg/L	F
0389		7/24/2017	1.33			F	mg/L	F
0389		11/7/2017	2.71			F	mg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0389	Oxidation reduction potential	2/7/2017	123.7				mV	F
0389		5/2/2017	119.5			F	mV	F
0389		7/24/2017	206.5			F	mV	F
0389		11/7/2017	186.6			F	mV	F
0389	pH	2/7/2017	6.86				s.u.	F
0389		5/2/2017	6.94			F	s.u.	F
0389		7/24/2017	6.85			F	s.u.	F
0389		11/7/2017	6.82			F	s.u.	F
0389	Specific conductance	2/7/2017	1360				µmho/cm	F
0389		5/2/2017	1340			F	µmho/cm	F
0389		7/24/2017	1340			F	µmho/cm	F
0389		11/7/2017	1330			F	µmho/cm	F
0389	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0389		5/2/2017	0.16	0.16	U	F	µg/L	F
0389		7/24/2017	0.16	0.16	U	F	µg/L	F
0389		11/7/2017	0.16	0.16	U	F	µg/L	F
0389	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0389		5/2/2017	0.16	0.16	U	F	µg/L	F
0389		7/24/2017	0.16	0.16	U	F	µg/L	F
0389		11/7/2017	0.16	0.16	U	F	µg/L	F
0389	Trichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0389		5/2/2017	0.16	0.16	U	F	µg/L	F
0389		7/24/2017	0.16	0.16	U	F	µg/L	F
0389		11/7/2017	0.72	0.16	J	F	µg/L	F
0389	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0389		5/2/2017	0.16	0.16	U	F	µg/L	F
0389		7/24/2017	0.16	0.16	U	F	µg/L	F
0389		11/7/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0392	*cis*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0392		5/2/2017	0.16	0.16	U	F	µg/L	F
0392		7/24/2017	0.16	0.16	U	F	µg/L	F
0392		11/7/2017	0.16	0.16	U	F	µg/L	F
0392	Dissolved oxygen	2/7/2017	3.39				mg/L	F
0392		5/2/2017	3.88			F	mg/L	F
0392		7/24/2017	4.01			F	mg/L	F
0392		11/7/2017	4.18			F	mg/L	F
0392	Oxidation reduction potential	2/7/2017	136				mV	F
0392		5/2/2017	188.7			F	mV	F
0392		7/24/2017	252.1			F	mV	F
0392		11/7/2017	238.8			F	mV	F
0392	pH	2/7/2017	6.82				s.u.	F
0392		5/2/2017	6.83			F	s.u.	F
0392		7/24/2017	6.7			F	s.u.	F
0392		11/7/2017	6.72			F	s.u.	F
0392	Specific conductance	2/7/2017	1250				µmho/cm	F
0392		5/2/2017	1360			F	µmho/cm	F
0392		7/24/2017	1400			F	µmho/cm	F
0392		11/7/2017	1290			F	µmho/cm	F
0392	Tetrachloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0392		5/2/2017	0.16	0.16	U	F	µg/L	F
0392		7/24/2017	0.16	0.16	U	F	µg/L	F
0392		11/7/2017	0.16	0.16	U	F	µg/L	F
0392	*trans*-1,2-Dichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0392		5/2/2017	0.16	0.16	U	F	µg/L	F
0392		7/24/2017	0.16	0.16	U	F	µg/L	F
0392		11/7/2017	0.16	0.16	U	F	µg/L	F

Table D-2. Parcels 6, 7, and 8 Groundwater Data (continued)

Location ID	Analytes	Sample Date	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0392	Trichloroethene	2/7/2017	0.16	0.16	U		µg/L	F
0392		5/2/2017	0.16	0.16	U	F	µg/L	F
0392		7/24/2017	0.16	0.16	U	F	µg/L	F
0392		11/7/2017	0.16	0.16	U	F	µg/L	F
0392	Vinyl chloride	2/7/2017	0.16	0.16	U		µg/L	F
0392		5/2/2017	0.16	0.16	U	F	µg/L	F
0392		7/24/2017	0.16	0.16	U	F	µg/L	F
0392		11/7/2017	0.16	0.16	U	F	µg/L	F

Abbreviations:
D = analyte determined in diluted sample
F = low flow sampling method used
J = estimated value
µg/L = micrograms per liter
µmho/cm = micromhos per centimeter
mg/L = milligrams per liter
mV = millivolts
pCi/L = picocuries per liter
Q = quantitative result due to sampling technique
s.u. = standard unit
U = analytical result below detection limit

Table D-3. Seep Data

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0601	*cis*-1,2-Dichloroethene	2/6/2017	0.64	0.16	J		µg/L	F
0601		5/2/2017	0.65	0.16	J		µg/L	F
0601		7/25/2017	0.87	0.16	J		µg/L	F
0601		11/7/2017	1	0.16			µg/L	F
0601	Dissolved oxygen	2/6/2017	8.2				mg/L	F
0601		5/2/2017	3.44				mg/L	F
0601		7/25/2017	3.2				mg/L	F
0601		11/7/2017	4.08				mg/L	F
0601	Oxidation reduction potential	2/6/2017	112.2				mV	F
0601		5/2/2017	193.2				mV	F
0601		7/25/2017	143				mV	F
0601		11/7/2017	265				mV	F
0601	pH	2/6/2017	7.16				s.u.	F
0601		5/2/2017	7.26				s.u.	F
0601		7/25/2017	6.86				s.u.	F
0601		11/7/2017	6.94				s.u.	F
0601	Specific conductance	2/6/2017	1510				µmho/cm	F
0601		5/2/2017	1190				µmho/cm	F
0601		7/25/2017	1320				µmho/cm	F
0601		11/7/2017	1150				µmho/cm	F
0601	Tetrachloroethene	2/6/2017	8.67	0.16			µg/L	F
0601		5/2/2017	11.5	0.16			µg/L	F
0601		7/25/2017	10.8	0.16			µg/L	F
0601		11/7/2017	13.3	0.16			µg/L	F
0601	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0601		5/2/2017	0.16	0.16	U		µg/L	F
0601		7/25/2017	0.16	0.16	U		µg/L	F
0601		11/7/2017	0.16	0.16	U		µg/L	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0601	Trichloroethene	2/6/2017	7.15	0.16			µg/L	F
0601		5/2/2017	3.62	0.16			µg/L	F
0601		7/25/2017	6.26	0.16			µg/L	F
0601		11/7/2017	3.72	0.16			µg/L	F
0601	Tritium	2/6/2017	19200	363			pCi/L	F
0601		7/25/2017	16300	310			pCi/L	F
0601	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0601		5/2/2017	0.16	0.16	U		µg/L	F
0601		7/25/2017	0.16	0.16	U		µg/L	F
0601		11/7/2017	0.16	0.16	U		µg/L	F
0602	*cis*-1,2-Dichloroethene	2/6/2017	5.82	0.16			µg/L	F
0602		5/2/2017	8.74	0.16			µg/L	F
0602		7/25/2017	8.3	0.16			µg/L	F
0602		11/7/2017	8.3	0.16			µg/L	F
0602	Dissolved oxygen	2/6/2017	5.46				mg/L	F
0602		5/2/2017	5.22				mg/L	F
0602		7/25/2017	5.5				mg/L	F
0602		11/7/2017	7.15				mg/L	F
0602	Oxidation reduction potential	2/6/2017	-27.5				mV	F
0602		5/2/2017	205.4				mV	F
0602		7/25/2017	166				mV	F
0602		11/7/2017	244				mV	F
0602	pH	2/6/2017	7.26				s.u.	F
0602		5/2/2017	7				s.u.	F
0602		7/25/2017	6.8				s.u.	F
0602		11/7/2017	7.12				s.u.	F
0602	Specific conductance	2/6/2017	1520				µmho/cm	F
0602		5/2/2017	1180				µmho/cm	F
0602		7/25/2017	1330				µmho/cm	F
0602		11/7/2017	1110				µmho/cm	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0602	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0602		5/2/2017	0.16	0.16	U		µg/L	F
0602		7/25/2017	0.16	0.16	U		µg/L	F
0602		11/7/2017	0.16	0.16	U		µg/L	F
0602	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0602		5/2/2017	0.32	0.16	J		µg/L	F
0602		7/25/2017	0.16	0.16	U		µg/L	F
0602		11/7/2017	0.16	0.16	U		µg/L	F
0602	Trichloroethene	2/6/2017	4.58	0.16			µg/L	F
0602		5/2/2017	13.6	0.16			µg/L	F
0602		7/25/2017	2.78	0.16			µg/L	F
0602		11/7/2017	12.5	0.16			µg/L	F
0602	Tritium	2/6/2017	4110	365			pCi/L	F
0602		7/25/2017	3210	306			pCi/L	F
0602	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0602		5/2/2017	0.16	0.16	U		µg/L	F
0602		7/25/2017	0.16	0.16	U		µg/L	F
0602		11/7/2017	0.16	0.16	U		µg/L	F
0605	*cis*-1,2-Dichloroethene	2/6/2017	2.72	0.16			µg/L	F
0605		5/2/2017	1.87	0.16			µg/L	F
0605		7/25/2017	1.72	0.16			µg/L	F
0605		11/7/2017	0.95	0.16	J		µg/L	F
0605	Dissolved oxygen	2/6/2017	8.89				mg/L	F
0605		5/2/2017	7.38				mg/L	F
0605		7/25/2017	1.38				mg/L	F
0605		11/7/2017	2.52				mg/L	F
0605	Oxidation reduction potential	2/6/2017	38.2				mV	F
0605		5/2/2017	216.5				mV	F
0605		7/25/2017	-106.7				mV	F
0605		11/7/2017	-0.1				mV	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0605	pH	2/6/2017	7.52				s.u.	F
0605		5/2/2017	7.4				s.u.	F
0605		7/25/2017	6.88				s.u.	F
0605		11/7/2017	7.25				s.u.	F
0605	Specific conductance	2/6/2017	2190				µmho/cm	F
0605		5/2/2017	1480				µmho/cm	F
0605		7/25/2017	1170				µmho/cm	F
0605		11/7/2017	1120				µmho/cm	F
0605	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0605		5/2/2017	0.16	0.16	U		µg/L	F
0605		7/25/2017	0.16	0.16	U		µg/L	F
0605		11/7/2017	0.16	0.16	U		µg/L	F
0605	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0605		5/2/2017	0.16	0.16	U		µg/L	F
0605		7/25/2017	0.16	0.16	U		µg/L	F
0605		11/7/2017	0.16	0.16	U		µg/L	F
0605	Trichloroethene	2/6/2017	9.21	0.16			µg/L	F
0605		5/2/2017	6.22	0.16			µg/L	F
0605		7/25/2017	9.88	0.16			µg/L	F
0605		11/7/2017	4.3	0.16			µg/L	F
0605	Tritium	2/6/2017	6480	369			pCi/L	F
0605		7/25/2017	4560	312			pCi/L	F
0605	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0605		5/2/2017	0.16	0.16	U		µg/L	F
0605		7/25/2017	0.16	0.16	U		µg/L	F
0605		11/7/2017	0.16	0.16	U		µg/L	F
0606	*cis*-1,2-Dichloroethene	2/6/2017	0.5	0.16	J		µg/L	F
0606		5/2/2017	0.16	0.16	U		µg/L	F
0606		7/25/2017	0.75	0.16	J		µg/L	F
0606		11/7/2017	0.16	0.16	U		µg/L	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0606	Dissolved oxygen	2/6/2017	10.99				mg/L	F
0606		5/2/2017	4.58				mg/L	F
0606		7/25/2017	7.16				mg/L	F
0606		11/7/2017	0.42				mg/L	F
0606	Oxidation reduction potential	2/6/2017	57.4				mV	F
0606		5/2/2017	131.2				mV	F
0606		7/25/2017	54.3				mV	F
0606		11/7/2017	49.1				mV	F
0606	pH	2/6/2017	7.5				s.u.	F
0606		5/2/2017	7.44				s.u.	F
0606		7/25/2017	7.23				s.u.	F
0606		11/7/2017	7.15				s.u.	F
0606	Specific conductance	2/6/2017	1700				µmho/cm	F
0606		5/2/2017	1240				µmho/cm	F
0606		7/25/2017	1660				µmho/cm	F
0606		11/7/2017	830				µmho/cm	F
0606	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0606		5/2/2017	0.16	0.16	U		µg/L	F
0606		7/25/2017	0.16	0.16	U		µg/L	F
0606		11/7/2017	0.16	0.16	U		µg/L	F
0606	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0606		5/2/2017	0.16	0.16	U		µg/L	F
0606		7/25/2017	0.16	0.16	U		µg/L	F
0606		11/7/2017	0.16	0.16	U		µg/L	F
0606	Trichloroethene	2/6/2017	1.7	0.16			µg/L	F
0606		5/2/2017	0.77	0.16	J		µg/L	F
0606		7/25/2017	1.95	0.16			µg/L	F
0606		11/7/2017	0.16	0.16	U		µg/L	F
0606	Tritium	2/6/2017	2980	352			pCi/L	F
0606		7/25/2017	2840	311			pCi/L	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0606	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0606		5/2/2017	0.16	0.16	U		µg/L	F
0606		7/25/2017	0.16	0.16	U		µg/L	F
0606		11/7/2017	0.16	0.16	U		µg/L	F
0607	*cis*-1,2-Dichloroethene	2/6/2017	1.02	0.16			µg/L	F
0607		5/2/2017	0.41	0.16	J		µg/L	F
0607		7/25/2017	0.6	0.16	J		µg/L	F
0607		11/7/2017	0.16	0.16	U		µg/L	F
0607	Dissolved oxygen	2/6/2017	9.55				mg/L	F
0607		5/2/2017	6.57				mg/L	F
0607		7/25/2017	8.74				mg/L	F
0607		11/7/2017	5.08				mg/L	F
0607	Oxidation reduction potential	2/6/2017	112.8				mV	F
0607		5/2/2017	184.7				mV	F
0607		7/25/2017	50.3				mV	F
0607		11/7/2017	269				mV	F
0607	pH	2/6/2017	7.42				s.u.	F
0607		5/2/2017	7.51				s.u.	F
0607		7/25/2017	7.19				s.u.	F
0607		11/7/2017	7.13				s.u.	F
0607	Specific conductance	2/6/2017	1870				µmho/cm	F
0607		5/2/2017	1220				µmho/cm	F
0607		7/25/2017	1340				µmho/cm	F
0607		11/7/2017	1100				µmho/cm	F
0607	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0607		5/2/2017	0.16	0.16	U		µg/L	F
0607		7/25/2017	0.16	0.16	U		µg/L	F
0607		11/7/2017	0.16	0.16	U		µg/L	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0607	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0607		5/2/2017	0.16	0.16	U		µg/L	F
0607		7/25/2017	0.16	0.16	U		µg/L	F
0607		11/7/2017	0.16	0.16	U		µg/L	F
0607	Trichloroethene	2/6/2017	4.7	0.16			µg/L	F
0607		5/2/2017	3.3	0.16			µg/L	F
0607		7/25/2017	4.66	0.16			µg/L	F
0607		11/7/2017	1.33	0.16			µg/L	F
0607	Tritium	2/6/2017	3100	366			pCi/L	F
0607		7/25/2017	2080	306			pCi/L	F
0607	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0607		5/2/2017	0.16	0.16	U		µg/L	F
0607		7/25/2017	0.16	0.16	U		µg/L	F
0607		11/7/2017	0.16	0.16	U		µg/L	F
0617	*cis*-1,2-Dichloroethene	2/6/2017	2.25	0.16			µg/L	F
0617		7/25/2017	2.28	0.16			µg/L	F
0617	Dissolved oxygen	2/6/2017	9.46				mg/L	F
0617		7/25/2017	6.41				mg/L	F
0617	Oxidation reduction potential	2/6/2017	220.8				mV	F
0617		7/25/2017	71.5				mV	F
0617	pH	2/6/2017	7.06				s.u.	F
0617		7/25/2017	6.74				s.u.	F
0617	Specific conductance	2/6/2017	1660				µmho/cm	F
0617		7/25/2017	1690				µmho/cm	F
0617	Tetrachloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0617		7/25/2017	0.16	0.16	U		µg/L	F
0617	*trans*-1,2-Dichloroethene	2/6/2017	0.16	0.16	U		µg/L	F
0617		7/25/2017	0.16	0.16	U		µg/L	F

Table D-3. Seep Data (continued)

Location ID	Analyte	Date Sampled	Value	Detection Limit	Lab Qualifiers	Validation Qualifiers	Units	Sample Type
0617	Trichloroethene	2/6/2017	8.19	0.16			µg/L	F
0617		7/25/2017	8.17	0.16			µg/L	F
0617	Vinyl chloride	2/6/2017	0.16	0.16	U		µg/L	F
0617		7/25/2017	0.16	0.16	U		µg/L	F

Abbreviations:
D = analyte determined in diluted sample
F = low flow sampling method used
J = estimated value
µg/L = micrograms per liter
µmhos/cm = micromhos per centimeter
mg/L = milligrams per liter
mV = millivolts
pCi/L = picocuries per liter
Q = quantitative result due to sampling technique
s.u. = standard unit
U = analytical result below detection limit

Appendix E

Data Assessment Reports

Data Review and Validation Report

General Information

Requisition No. (RIN):	17018249
Sample Event:	February 6 – 8, 2017
Site(s):	Mound, Ohio; Groundwater
Laboratory:	GEL Laboratories, Charleston, South Carolina
Work Order No.:	416167
Analysis:	Organics and Radiochemistry
Validator:	Samantha Tigar
Review Date:	April 26, 2017

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325), *"Standard Practice for Validation of Environmental Data."* The procedure was applied at Level 2, Data Deliverables Verification. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Tritium	LSC-A-001	EPA 906.0 Mod	EPA 906.0 Mod
Volatile Organics, VOA	VOA-A-007	SW-846 5030B	SW-846 8260 LL

Data Qualifier Summary

Analytical results were qualified as listed in Table 2. Refer to the sections below for an explanation of the data qualifiers applied.

Table 2. Data Qualifier Summary

Sample Number	Location	Analyte(s)	Flag	Reason
416167018	0999	2-Butanone	J	CCV difference greater than 20%
416167008	0379	Tritium	J	Less than the Determination Limit

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received 20 water samples on February 10, 2017, accompanied by Chain of Custody (COC) forms. The COC forms were checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC forms were complete with no errors or omissions. The air waybill numbers were listed on the receiving documentation.

Several vials for locations 0347 (duplicate), 0386, 0389, 0392, and 0601 were received with headspace. At least one vial from each location was received with no headspace and could be analyzed.

Preservation and Holding Times

The sample shipment was received intact with the temperature inside the iced cooler at 2 °C, which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all organic analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL.

For radiochemical analytes (those measured by radiometric counting) the MDL and PQL are not applicable, and these results are evaluated using the minimum detectable concentration (MDC), Decision Level Concentration (DLC), and Determination Limit (DL). The MDC is a measure of radiochemical method performance and was calculated and reported as specified in the *Quality Systems Manual*. The DLC is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is estimated as 3 times the one-sigma total propagated uncertainty. Results that are greater than the MDC, but less than the DLC are qualified with a “U” flag (not detected). The DL for radiochemical results is the lowest concentration that can be reliably measured, and is defined as 3 times the MDC. Results not previously “U” qualified that are less than the DL are qualified with a “J” flag as estimated values.

The reported MDLs for all organic analytes and MDCs for radiochemical analytes demonstrate compliance with contractual requirements.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

The Continuing Calibration Verification standards associated with the samples exhibited percent difference values within acceptance criteria for all compounds except 2-butanone. All associated results above the MDL were qualified with a “J” flag as an estimated value.

Volatiles Internal Standards and Surrogates

The volatile internal standard recoveries and surrogate recoveries were within the acceptance ranges for all samples.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. The method blank results were below the MDL for all target organic compounds. The tritium method blank result was less than the DLC.

Trip Blank

Trip blanks were prepared and analyzed to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples. Two trip blanks were submitted with these samples. Acetone and 2-butanone were detected in the trip blanks at a concentration greater than the MDL. All associated results were below the MDL, requiring no qualification.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The spike recoveries met the acceptance criteria for all analytes evaluated.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative percent difference (RPD) for organic replicate results should be less than the laboratory-derived control limits. For radiochemical measurements, the relative error ratio (the ratio of the absolute difference between the sample and duplicate results and the sum of the 1-sigma uncertainties) is used to evaluate duplicate results and should be less than 3. All replicate results met these criteria.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Field Duplicate

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. Duplicate samples were collected from location 0347 (field duplicate ID 9347). For non-radiochemical measurements, the relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results less than 5 times the PQL, the range should be no greater than the PQL. For radiochemical measurements, the relative error ratio (the ratio of the absolute difference between the sample and duplicate results and the sum of the 1-sigma uncertainties) is used to evaluate duplicate results and should be less than 3. All duplicate results met these criteria, demonstrating acceptable precision.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on March 10, 2016. The Sample Management System EDD validation module was used to verify that the EDD file was complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

Outliers Report

Potential outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Potential outliers may result from transcription errors, data-coding errors, or measurement system problems. However, outliers may also represent true extreme values of a distribution and indicate more variability in the population than was expected.

Statistical outlier tests give probabilistic evidence that an extreme value does not "fit" with the distribution of the remainder of the data and is therefore a statistical outlier. These tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set.

There are three steps involved in identifying extreme values or outliers:

1. Identify extreme values that may be potential outliers by generating the Outliers Report using the Sample Management System from data in the environmental database. The application compares the new data set (in standard environmental database units) with historical data and lists the new data that fall outside the historical data range. A determination is also made if the data are normally distributed using the Shapiro-Wilk Test.

2. Apply the appropriate statistical test. Dixon's Extreme Value test is used to test for statistical outliers when the sample size is less than or equal to 25. This test considers both extreme values that are much smaller than the rest of the data (case 1) and extreme values that are much larger than the rest of the data (case 2). This test is valid only if the data without the suspected outlier are normally distributed. Rosner's Test is a parametric test that is used to detect outliers for sample sizes of 25 or more. This test also assumes that the data without the suspected outliers are normally distributed.
3. Scientifically review statistical outliers and decide on their disposition. The review should include an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values.

No results from this sampling event were identified as potential outliers.

Report Prepared By: ____
Samantha Tigar
Data Validator

Data Validation Outliers Report - No Field Parameters

Comparison: All historical Data Beginning 1/1/2007

Laboratory: GEL Laboratories
RIN: 17018249
Report Date: 4/26/2017

					Current			**Historical Maximum**			**Historical Minimum**			**Number of Data Points**		**Statistical Outlier**
						Qualifiers			*Qualifiers*			*Qualifiers*				
Site Code	Location Code	Sample ID	Sample Date	Analyte	Result	*Lab*	*Data*	Result	*Lab*	*Data*	Result	*Lab*	*Data*	N	N Below Detect	
MND01	0126	N001	02/08/2017	Tetrachloroethene	0.690	J		1.18	J		0.730	J	F	40	0	No
MND01	0315	N001	02/07/2017	Carbon tetrachloride	0.450	J		2.82			0.560	J	F	42	0	No
MND01	0602	N001	02/06/2017	Tritium	4110			45100			4570			19	0	No

STATISTICAL TESTS:
The distribution of the data is tested for normality or lognormality using the Shapiro-Wilk Test
Outliers are identified using Dixon's Test when there are 25 or fewer data points.
Outliers are identified using Rosner's Test when there are 26 or more data points.
See Data Quality Assessment: Statistical Methods for Practitioners, EPA QC/G-9S, February 2006.

NA: Data are not normally or lognormally distributed.

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 17018249 **Lab Code:** GEN **Validator:** Samantha Tigar **Validation Date:** 4/26/2017

Project: Mound LTS&M Ground Water **Analysis Type:** ☐ Metals ☐ General Chem ☑ Rad ☑ Organics

# of Samples: 20 **Matrix:** Water **Requested Analysis Completed:** Yes

Chain of Custody

Present: OK **Signed:** OK **Dated:** OK

Sample

Integrity: OK **Preservation:** OK **Temperature:** OK

Select Quality Parameters

☑ Holding Times	All analyses were completed within the applicable holding times.
☑ Detection Limits	The reported detection limits are equal to or below contract requirements.
☑ Field/Trip Blanks	There were 2 trip/equipment blanks evaluated.
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Equipment/Trip Blanks

RIN: 17018249 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 4/26/2017

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	416167017	SW-846 8260	Acetone (Lab Contaminant)	2.52	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
416167002	PCX 671	0386	0.500	1.00	U	
416167003	PCX 672	0387	0.500	1.00	U	
416167004	PCX 673	0389	0.500	1.00	U	
416167005	PCX 674	0392	0.500	1.00	U	
416167007	PCX 676	0346	0.500	1.00	U	
416167008	PCX 677	0379	0.500	1.00	U	
416167009	PCX 678	0347	0.500	1.00	U	
416167010	PCX 679	0315	0.500	1.00	U	
416167019	PCX 688	9347	0.500	1.00	U	

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	416167018	SW-846 8260	2-Butanone (Lab Contaminant)	3.11	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
416167001	PCX 670	0138	0.500	1.00	U	
416167006	PCX 675	0118	0.500	1.00	U	
416167011	PCX 680	0124	0.500	1.00	U	
416167012	PCX 681	0126	0.500	1.00	U	

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	416167018	SW-846 8260	Acetone (Lab Contaminant)	15.5		0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
416167001	PCX 670	0138	0.500	1.00	U	
416167006	PCX 675	0118	0.500	1.00	U	
416167011	PCX 680	0124	0.500	1.00	U	
416167012	PCX 681	0126	0.500	1.00	U	

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17018249 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 4/26/2017

Duplicate: 9347 **Sample:** 0347

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
1,1,1,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,1-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	1.50	U		1.00	1.50	U		1.00			ug/L
1,1,2-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,3-Trichlorobenzene	0.200	U		1.00	0.200	U		1.00			ug/L
1,2,3-Trichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromo-3-chloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromoethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,3,5-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,4-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
2,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
2-Butanone	0.500	U		1.00	0.500	U		1.00			ug/L
2-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
2-Hexanone	0.500	U		1.00	0.500	U		1.00			ug/L
4-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Isopropyltoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Methyl-2-pentanone	0.500	U		1.00	0.500	U		1.00			ug/L
Acetone	0.500	U		1.00	0.500	U		1.00			ug/L
Benzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromodichloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromoform	0.160	U		1.00	0.160	U		1.00			ug/L
Bromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Carbon Disulfide	0.500	U		1.00	0.500	U		1.00			ug/L
Carbon Tetrachloride	1.20			1.00	1.02			1.00	NA		ug/L
Chlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroethane	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17018249 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 4/26/2017

Duplicate: 9347 **Sample:** 0347

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
Chloroform	0.440	J		1.00	0.450	J		1.00			ug/L
Chloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dichlorodifluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Ethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Hexachlorobutadiene	0.160	U		1.00	0.160	U		1.00			ug/L
Isopropylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Methylene Chloride	0.160	U		1.00	0.160	U		1.00			ug/L
Naphthalene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Propylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
sec-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Styrene	0.160	U		1.00	0.160	U		1.00			ug/L
tert-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Tetrachloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
Toluene	0.160	U		1.00	0.160	U		1.00			ug/L
Total Xylenes	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Trichloroethene	20.4			1.00	18.9			1.00	7.63		ug/L
Trichlorofluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Tritium	1260		358	1.00	1380		378	1.00		0.5	pCi/L
Vinyl Chloride	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM
Organics Data Validation Summary

RIN: 17018249 **Project:** Mound LTS&M Ground Water **Lab Code:** GEN **Validation Date:** 4/26/2017

LCS Recovery:	All LCS recoveries were within the laboratory acceptance limits.
Method Blank(s):	All method blanks results were below the method detection limit.
MS/MSD Recovery:	All MS/MSD recoveries were within the laboratory acceptance limits.
Surrogate Recovery:	All surrogate recoveries were within the laboratory acceptance limits.

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 17018249 **Lab Code:** GEN **Date Due:** 3/10/2017

Matrix: Water **Site Code:** MND03 **Date Completed:** 3/10/2017

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
0347	Tritium	02/18/2017						0.84
Blank_Spike	Tritium	02/18/2017				94.10		
0347	Tritium	02/18/2017					91.6	
Blank	Tritium	02/18/2017	-25.9000	U				

Data Review and Validation Report

General Information

Requisition No. (RIN):	17018250
Sample Event:	February 6, 2017
Site(s):	Mound, Ohio; Groundwater
Laboratory:	GEL Laboratories, Charleston, South Carolina
Work Order No.:	416169
Analysis:	Organics
Validator:	Samantha Tigar
Review Date:	April 27, 2017

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325), *"Standard Practice for Validation of Environmental Data."* The procedure was applied at Level 2, Data Deliverables Verification. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Volatile Organics, VOA	VOA-A-007	SW-846 5030B	SW-846 8260 LL

Data Qualifier Summary

None of the analytical results required qualification.

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received 11 water samples on February 10, 2017, accompanied by Chain of Custody (COC) forms. The COC forms were checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC forms were complete with no errors or omissions. The air waybill numbers were listed on the receiving documentation.

Several sample vials from location 0411 were received with headspace but sufficient volume remained for analysis. For location 0445, all the vials contained headspace and the laboratory did not proceed with analysis.

Preservation and Holding Times

The sample shipment was received intact with the temperature inside the iced cooler at 2 °C, which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL. The reported MDLs for all analytes demonstrate compliance with contractual requirements.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

The Continuing Calibration Verification standards associated with the samples exhibited percent drift values less than 20 percent for all target compounds.

Volatiles Internal Standards and Surrogates

The volatile internal standard recoveries and surrogate recoveries were within the acceptance ranges for all samples.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. All method blank results associated with the samples were below the PQL for all analytes. In cases where a blank concentration exceeds or equals the MDL, the associated sample results are qualified with a “U” flag (not detected) when the sample result is greater than the MDL but less than 5 times the blank concentration.

Trip Blank

Trip blanks were prepared and analyzed to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples. One trip blank was submitted with these samples. No analytes were detected in the trip blank at a concentration greater than the MDL.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The spike recoveries met the acceptance criteria for all target compounds.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative percent difference (RPD) for organic replicate results should be less than the laboratory-derived control limits. All replicate results met these criteria.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Field Duplicate

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location 0411. The relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results that are less than 5 times the PQL, the range should be no greater than the PQL. The duplicate results met the criteria.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on March 10, 2017. The Sample Management System EDD validation module was used to verify that the EDD file was complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

Outliers Report

Potential outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Potential outliers may result from transcription errors, data-coding errors, or measurement system problems. However, outliers may also represent true extreme values of a distribution and indicate more variability in the population than was expected.

Statistical outlier tests give probabilistic evidence that an extreme value does not "fit" with the distribution of the remainder of the data and is therefore a statistical outlier. These tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set.

There are three steps involved in identifying extreme values or outliers:

1. Identify extreme values that may be potential outliers by generating the Outliers Report using the Sample Management System from data in the environmental database. The application compares the new data set (in standard environmental database units) with historical data and lists the new data that fall outside the historical data range. A determination is also made if the data are normally distributed using the Shapiro-Wilk Test.
2. Apply the appropriate statistical test. Dixon's Extreme Value test is used to test for statistical outliers when the sample size is less than or equal to 25. This test considers both extreme values that are much smaller than the rest of the data (case 1) and extreme values that are much larger than the rest of the data (case 2). This test is valid only if the data without the suspected outlier are normally distributed. Rosner's Test is a parametric test that is used to detect outliers for sample sizes of 25 or more. This test also assumes that the data without the suspected outliers are normally distributed.
3. Scientifically review statistical outliers and decide on their disposition. The review should include an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values.

No results from this sampling event were identified as potential outliers.

Report Prepared By: ____

Samantha Tigar
Data Validator

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 17018250 **Lab Code:** GEN **Validator:** Samantha Tigar **Validation Date:** 4/26/2017

Project: Mound LTS&M Ground Water **Analysis Type:** ☐ Metals ☐ General Chem ☐ Rad ☑ Organics

# of Samples: 10 **Matrix:** Water **Requested Analysis Completed:** Yes

Chain of Custody

Present: OK **Signed:** OK **Dated:** OK

Sample

Integrity: OK **Preservation:** OK **Temperature:** OK

Select Quality Parameters

☑ Holding Times	All analyses were completed within the applicable holding times.
☑ Detection Limits	The reported detection limits are equal to or below contract requirements.
☑ Field/Trip Blanks	There was 1 trip/equipment blank evaluated.
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17018250 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 4/26/2017

Duplicate: 9411 **Sample:** 0411

	Sample				Duplicate						
Analyte	**Result**	**Flag**	**Error**	**Dilution**	**Result**	**Flag**	**Error**	**Dilution**	**RPD**	**RER**	**Units**
1,1,1,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,1-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	1.50	U		1.00	1.50	U		1.00			ug/L
1,1,2-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,3-Trichlorobenzene	0.200	U		1.00	0.200	U		1.00			ug/L
1,2,3-Trichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromo-3-chloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromoethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,3,5-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,4-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
2,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
2-Butanone	0.500	U		1.00	0.500	U		1.00			ug/L
2-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
2-Hexanone	0.500	U		1.00	0.500	U		1.00			ug/L
4-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Isopropyltoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Methyl-2-pentanone	0.500	U		1.00	0.500	U		1.00			ug/L
Acetone	0.500	U		1.00	0.500	U		1.00			ug/L
Benzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromodichloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromoform	0.160	U		1.00	0.160	U		1.00			ug/L
Bromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Carbon Disulfide	0.500	U		1.00	0.500	U		1.00			ug/L
Carbon Tetrachloride	0.160	U		1.00	0.160	U		1.00			ug/L
Chlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroethane	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17018250 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 4/26/2017

Duplicate: 9411 **Sample:** 0411

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
Chloroform	0.160	U		1.00	0.160	U		1.00			ug/L
Chloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,2-Dichloroethene	1.17			1.00	1.22			1.00	4.18		ug/L
cis-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dichlorodifluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Ethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Hexachlorobutadiene	0.160	U		1.00	0.160	U		1.00			ug/L
Isopropylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Methylene Chloride	0.160	U		1.00	0.160	U		1.00			ug/L
Naphthalene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Propylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
sec-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Styrene	0.160	U		1.00	0.160	U		1.00			ug/L
tert-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Tetrachloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
Toluene	0.160	U		1.00	0.160	U		1.00			ug/L
Total Xylenes	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Trichloroethene	10.5			1.00	10.7			1.00	1.89		ug/L
Trichlorofluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Vinyl Chloride	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM
Organics Data Validation Summary

RIN: 17018250 **Project:** Mound LTS&M Ground Water **Lab Code:** GEN **Validation Date:** 4/26/2017

LCS Recovery:	All LCS recoveries were within the laboratory acceptance limits.
Method Blank(s):	All method blanks results were below the method detection limit.
MS/MSD Recovery:	All MS/MSD recoveries were within the laboratory acceptance limits.
Surrogate Recovery:	All surrogate recoveries were within the laboratory acceptance limits.

Data Review and Validation Report

General Information

Requisition No. (RIN): 17048418
Sample Event: May 1-2, 2017
Site(s): Mound, Ohio; Groundwater
Laboratory: GEL Laboratories, Charleston, South Carolina
Work Order No.: 422351
Analysis: Organics
Validator: Stephen Donivan
Review Date: July 7, 2017

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325), *"Standard Practice for Validation of Environmental Data."* The procedure was applied at Level 2, Data Deliverables Verification. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Volatile Organics, VOA	VOA-A-007	SW-846 5030B	SW-846 8260 LL

Data Qualifier Summary

Analytical results were qualified as listed in Table 2. Refer to the sections below for an explanation of the data qualifiers applied.

Table 2. Data Qualifier Summary

Sample Number	Location	Analyte	Flag	Reason
422351001	0138	Acetone	U	Less than 10 times the trip blank
422351003	0387	Acetone	U	Less than 10 times the trip blank
422351004	0389	Acetone	U	Less than 10 times the trip blank
422351005	0392	Acetone	U	Less than 10 times the trip blank
422351010	0347	Acetone	U	Less than 10 times the trip blank

Sample Number	Location	Analyte	Flag	Reason
422351014	0605	Acetone	U	Less than 10 times the trip blank
422351015	0607	Acetone	U	Less than 10 times the trip blank

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received six water samples on May 4, 2017, accompanied by a Chain of Custody (COC) form. The COC form was checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC form was complete with no errors or omissions. The air waybill numbers were listed on the receiving documentation.

Preservation and Holding Times

The sample shipments were received intact with the temperature inside the iced cooler at 4 °C, which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL. The reported MDLs for all analytes demonstrate compliance with contractual requirements.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

The Continuing Calibration Verification standards associated with the samples exhibited percent drift values less than 20 percent for all target compounds.

Volatiles Internal Standards and Surrogates

The volatile internal standard recoveries and surrogate recoveries were within the acceptance ranges for all samples.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. All method blank results associated with the samples were below the PQL for all analytes. In cases where a blank concentration exceeds or equals the MDL, the associated sample results are qualified with a "U" flag (not detected) when the sample result is greater than the MDL but less than 5 times the blank concentration.

Trip Blank

Trip blanks were prepared and analyzed to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples. Two trip blanks were submitted with these samples. Acetone was detected in the trip blanks. Associated sample acetone results that are less than ten times the blank concentration are qualified with a "U" flag as not detected.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The spike recoveries met the acceptance criteria for all target compounds.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative percent difference (RPD) for organic replicate results should be less than the laboratory-derived control limits. All replicate results met these criteria.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Field Duplicate

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location 0315. The relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results that are less than 5 times the PQL, the range should be no greater than the PQL. The duplicate results met the criteria.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on June 1, 2017. The Sample Management System EDD validation module was used to verify that the EDD file was complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

Sampling Protocol

Sample results for all monitoring wells met the Category I low-flow sampling criteria and were qualified with an “F” flag in the database, indicating the wells were purged and sampled using the low-flow sampling method. The final turbidity values for locations 0138, 0315, and 0389 were greater than 50 NTU.

Outliers Report

Potential outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Potential outliers may result from transcription errors, data-coding errors, or measurement system problems. However, outliers may also represent true extreme values of a distribution and indicate more variability in the population than was expected.

Statistical outlier tests give probabilistic evidence that an extreme value does not "fit" with the distribution of the remainder of the data and is therefore a statistical outlier. These tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set.

There are three steps involved in identifying extreme values or outliers:

1. Identify extreme values that may be potential outliers by generating the Outliers Report using the Sample Management System from data in the environmental database. The application compares the new data set (in standard environmental database units) with historical data and lists the new data that fall outside the historical data range. A determination is also made if the data are normally distributed using the Shapiro-Wilk Test.
2. Apply the appropriate statistical test. Dixon's Extreme Value test is used to test for statistical outliers when the sample size is less than or equal to 25. This test considers both extreme values that are much smaller than the rest of the data (case 1) and extreme

values that are much larger than the rest of the data (case 2). This test is valid only if the data without the suspected outlier are normally distributed. Rosner's Test is a parametric test that is used to detect outliers for sample sizes of 25 or more. This test also assumes that the data without the suspected outliers are normally distributed.

3. Scientifically review statistical outliers and decide on their disposition. The review should include an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values.

No results from this sampling event were identified as potential outliers.

Report Prepared By: ____

Stephen Donivan
Laboratory Coordinator

SAMPLE MANAGEMENT SYSTEM
General Data Validation Report

RIN: 17048418 **Lab Code:** GEN **Validator:** Stephen Donivan **Validation Date:** 7/7/2017

Project: Mound LTS&M Ground Water **Analysis Type:** ☐ Metals ☐ General Chem ☐ Rad ☑ Organics

# of Samples: 20 **Matrix:** Water **Requested Analysis Completed:** Yes

Chain of Custody

Present: OK **Signed:** OK **Dated:** OK

Sample

Integrity: OK **Preservation:** OK **Temperature:** OK

Select Quality Parameters

☑ Holding Times	All analyses were completed within the applicable holding times.
☑ Detection Limits	The reported detection limits are equal to or below contract requirements.
☑ Field/Trip Blanks	There were 2 trip/equipment blanks evaluated.
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Equipment/Trip Blanks

RIN: 17048418 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 7/7/2017

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	422351006	SW-846 8260	Acetone (Lab Contaminant)	5.71	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
422351007	PFT 377	0118	0.500	1.00	U	
422351009	PFT 379	0379	0.500	1.00	U	
422351010	PFT 380	0347	2.54	1.00	J	U
422351011	PFT 381	0315	0.500	1.00	U	
422351012	PFT 382	0124	0.500	1.00	U	
422351013	PFT 383	0126	0.500	1.00	U	
422351018	PFT 388	9315	0.500	1.00	U	

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	422351020	SW-846 8260	Acetone (Lab Contaminant)	7.25	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
422351001	PFT 371	0138	2.99	1.00	J	U
422351002	PFT 372	0386	0.500	1.00	U	
422351003	PFT 373	0387	3.09	1.00	J	U
422351004	PFT 374	0389	2.76	1.00	J	U
422351005	PFT 375	0392	2.79	1.00	J	U
422351008	PFT 378	0346	0.500	1.00	U	
422351014	PFT 384	0605	2.64	1.00	J	U
422351015	PFT 385	0607	2.60	1.00	J	U
422351016	PFT 386	0601	0.500	1.00	U	
422351017	PFT 387	0606	0.500	1.00	U	
422351019	PFT 389	0602	0.500	1.00	U	

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17048418 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 7/7/2017

Duplicate: 9315 **Sample:** 0315

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
1,1,1,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,1-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	1.50	U		1.00	1.50	U		1.00			ug/L
1,1,2-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,3-Trichlorobenzene	0.200	U		1.00	0.200	U		1.00			ug/L
1,2,3-Trichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromo-3-chloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromoethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,3,5-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,4-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
2,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
2-Butanone	0.500	U		1.00	0.500	U		1.00			ug/L
2-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
2-Hexanone	0.500	U		1.00	0.500	U		1.00			ug/L
4-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Isopropyltoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Methyl-2-pentanone	0.500	U		1.00	0.500	U		1.00			ug/L
Acetone	0.500	U		1.00	0.500	U		1.00			ug/L
Benzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromodichloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromoform	0.160	U		1.00	0.160	U		1.00			ug/L
Bromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Carbon Disulfide	0.500	U		1.00	0.500	U		1.00			ug/L
Carbon Tetrachloride	0.670	J		1.00	0.630	J		1.00			ug/L
Chlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroform	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17048418 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 7/7/2017

Duplicate: 9315 **Sample:** 0315

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
Chloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dichlorodifluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Ethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Hexachlorobutadiene	0.160	U		1.00	0.160	U		1.00			ug/L
Isopropylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Methylene Chloride	0.160	U		1.00	0.160	U		1.00			ug/L
Naphthalene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Propylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
sec-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Styrene	0.160	U		1.00	0.160	U		1.00			ug/L
tert-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Tetrachloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
Toluene	0.160	U		1.00	0.160	U		1.00			ug/L
Total Xylenes	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Trichloroethene	6.98			1.00	6.90			1.00	1.15		ug/L
Trichlorofluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Vinyl Chloride	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Organics Data Validation Summary

RIN: 17048418 **Project:** Mound LTS&M Ground Water **Lab Code:** GEN **Validation Date:** 7/7/2017

LCS Recovery:	All LCS recoveries were within the laboratory acceptance limits.
Method Blank(s):	All method blanks results were below the method detection limit.
MS/MSD Recovery:	All MS/MSD recoveries were within the laboratory acceptance limits.
Surrogate Recovery:	All surrogate recoveries were within the laboratory acceptance limits.

Data Review and Validation Report

General Information

Requisition No. (RIN):	17078634
Sample Event:	July 24 and 25, 2017
Site(s):	Mound, Ohio; Groundwater
Laboratory:	GEL Laboratories, Charleston, South Carolina
Work Order No.:	429143
Analysis:	Organics and Radiochemistry
Validator:	Samantha Tigar
Review Date:	September 5, 2017

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325), *"Standard Practice for Validation of Environmental Data."* The procedure was applied at Level 2, Data Deliverables Verification. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Tritium	LSC-A-001	EPA 906.0 Mod	EPA 906.0 Mod
Volatile Organics, VOA	VOA-A-007	SW-846 5030B	SW-846 8260 LL

Data Qualifier Summary

Analytical results were qualified as listed in Table 2. Refer to the sections below for an explanation of the data qualifiers applied.

Table 2. Data Qualifier Summary

Sample Number	Location	Analyte(s)	Flag	Reason
429143004	0387	Acetone	U	Less than five times the trip blank
429143013	0126	Acetone	U	Less than five times the trip blank
429143010	0347	Acetone	U	Less than five times the trip blank
429143016	0605	Acetone	U	Less than five times the trip blank

429143002	0138	Tritium	J	Below the determination limit
429143009	0379	Tritium	J	Below the determination limit
429143020	0379 duplicate	Tritium	J	Below the determination limit

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received 20 water samples on July 28, 2017, accompanied by Chain of Custody (COC) forms. The COC forms were checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC forms were complete with no errors or omissions. The air waybill numbers were listed on the receiving documentation.

Preservation and Holding Times

The sample shipment was received intact with the temperature inside the iced cooler at 5 °C, which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all organic analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL.

For radiochemical analytes (those measured by radiometric counting) the MDL and PQL are not applicable, and these results are evaluated using the minimum detectable concentration (MDC), Decision Level Concentration (DLC), and Determination Limit (DL). The MDC is a measure of radiochemical method performance and was calculated and reported as specified in the *Quality Systems Manual*. The DLC is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is estimated as 3 times the one-sigma total propagated uncertainty. Results that are greater than the MDC, but less than the DLC are qualified with a “U” flag (not detected). The DL for radiochemical results is the lowest concentration that can be reliably measured, and is defined as 3 times the MDC. Results not previously “U” qualified that are less than the DL are qualified with a “J” flag as estimated values.

The reported MDLs for all organic analytes and MDCs for radiochemical analytes demonstrate compliance with contractual requirements.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

The Continuing Calibration Verification standards associated with the samples exhibited percent difference values that exceeded the acceptance criteria for several target compounds. All associated results were less than the MDL.

Volatiles Internal Standards and Surrogates

The volatile internal standard recoveries and surrogate recoveries were within the acceptance ranges for all samples.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. The method blank results were below the MDL for all target organic compounds. The tritium method blank result was less than the DLC.

Trip Blank

Trip blanks were prepared and analyzed to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples. Two trip blanks were submitted with these samples. Acetone was detected in the trip blanks. All associated results greater than the MDL and less than 10 times the trip blank were qualified with a “U” as not detected.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The spike recoveries for bromomethane exceeded the acceptance criteria. All associated results were less than the MDL.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative percent difference (RPD) for organic replicate results should be less than the laboratory-derived control limits. For radiochemical measurements, the relative error ratio (the ratio of the absolute difference between the sample and duplicate results and the sum of the 1-sigma uncertainties) is used to evaluate duplicate results and should be less than 3. All replicate results met these criteria.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Field Duplicate

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location 0379. For non-radiochemical measurements, the relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results less than 5 times the PQL, the range should be no greater than the PQL. For radiochemical measurements, the relative error ratio (the ratio of the absolute difference between the sample and duplicate results and the sum of the 1-sigma uncertainties) is used to evaluate duplicate results and should be less than 3. All duplicate results met these criteria, demonstrating acceptable precision.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on August 25, 2017. The Sample Management System EDD validation module was used to verify that the EDD file was complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

Sampling Protocol

Sample results for all monitoring wells met the Category I low-flow sampling criteria and were qualified with an “F” flag in the database, indicating the wells were purged and sampled using the low-flow sampling method. The final turbidity value for locations 0138 and 0315 was greater than 50 NTU.

For location 0347, the temperature was typed into the last two rows of the water level column; a stable water level can be seen from previous readings.

Outliers Report

Potential outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Potential outliers may result from transcription errors, data-coding errors, or measurement system problems. However, outliers may also represent true extreme values of a distribution and indicate more variability in the population than was expected.

Statistical outlier tests give probabilistic evidence that an extreme value does not "fit" with the distribution of the remainder of the data and is therefore a statistical outlier. These tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set.

There are three steps involved in identifying extreme values or outliers:

1. Identify extreme values that may be potential outliers by generating the Outliers Report using the Sample Management System from data in the environmental database. The application compares the new data set (in standard environmental database units) with historical data and lists the new data that fall outside the historical data range. A determination is also made if the data are normally distributed using the Shapiro-Wilk Test.
2. Apply the appropriate statistical test. Dixon's Extreme Value test is used to test for statistical outliers when the sample size is less than or equal to 25. This test considers both extreme values that are much smaller than the rest of the data (case 1) and extreme values that are much larger than the rest of the data (case 2). This test is valid only if the data without the suspected outlier are normally distributed. Rosner's Test is a parametric test that is used to detect outliers for sample sizes of 25 or more. This test also assumes that the data without the suspected outliers are normally distributed.
3. Scientifically review statistical outliers and decide on their disposition. The review should include an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values.

No results from this sampling event were identified as potential outliers.

Report Prepared By: ____

Samantha Tigar
Data Validator

Data Validation Outliers Report - No Field Parameters

Comparison: All historical Data Beginning 1/1/2007

Laboratory:
RIN: 17078634
Report Date: 9/5/2017

					Current			Historical Maximum			Historical Minimum			Number of Data Points		Statistical Outlier
						Qualifiers			*Qualifiers*			*Qualifiers*				
Site Code	Location Code	Sample ID	Sample Date	Analyte	Result	*Lab*	*Data*	Result	*Lab*	*Data*	Result	*Lab*	*Data*	N	N Below Detect	
MND01	0602	N001	07/25/2017	Trichloroethene	2.78			139			4.58			28	0	No
MND01	0602	N001	07/25/2017	Tritium	3210			45100			4110			20	0	No
MND01	0607	N001	07/25/2017	Tritium	2080			14700			2170			34	0	No

STATISTICAL TESTS:
The distribution of the data is tested for normality or lognormality using the Shapiro-Wilk Test
Outliers are identified using Dixon's Test when there are 25 or fewer data points.
Outliers are identified using Rosner's Test when there are 26 or more data points.
See Data Quality Assessment: Statistical Methods for Practitioners, EPA QC/G-9S, February 2006.

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 17078634 **Lab Code:** GEN **Validator:** Samantha Tigar **Validation Date:** 9/5/2017

Project: Mound LTS&M Ground Water **Analysis Type:** ☐ Metals ☐ General Chem ☑ Rad ☑ Organics

# of Samples: 20 **Matrix:** Water **Requested Analysis Completed:** Yes

Chain of Custody

Present: OK **Signed:** OK **Dated:** OK

Sample

Integrity: OK **Preservation:** OK **Temperature:** OK

Select Quality Parameters

☑ Holding Times	All analyses were completed within the applicable holding times.
☑ Detection Limits	The reported detection limits are equal to or below contract requirements.
☑ Field/Trip Blanks	There were 2 trip/equipment blanks evaluated.
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Equipment/Trip Blanks

RIN: 17078634 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 9/5/2017

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	429143001	SW-846 8260	Acetone (Lab Contaminant)	10.4		0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
429143002	PIY 860	0138	0.500	1.00	U	
429143003	PIY 861	0386	0.500	1.00	U	
429143004	PIY 862	0387	2.52	1.00	J	U
429143005	PIY 863	0389	0.500	1.00	U	
429143006	PIY 864	0392	0.500	1.00	U	
429143007	PIY 865	0118	0.500	1.00	U	
429143009	PIY 867	0379	0.500	1.00	U	
429143012	PIY 870	0124	0.500	1.00	U	
429143013	PIY 871	0126	2.55	1.00	J	U

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	429143018	SW-846 8260	Acetone (Lab Contaminant)	10.0		0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
429143008	PIY 866	0346	0.500	1.00	U	
429143010	PIY 868	0347	2.52	1.00	J	U
429143011	PIY 869	0315	0.500	1.00	U	
429143014	PIY 872	0606	0.500	1.00	U	
429143015	PIY 873	0601	0.500	1.00	U	
429143016	PIY 874	0605	2.56	1.00	J	U
429143017	PIY 875	0607	0.500	1.00	U	
429143021	PIY 879	0602	0.500	1.00	U	

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17078634 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 9/5/2017

Duplicate: 9379 **Sample:** 0379

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
1,1,1,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,1-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	1.50	U		1.00	1.50	U		1.00			ug/L
1,1,2-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,3-Trichlorobenzene	0.200	U		1.00	0.200	U		1.00			ug/L
1,2,3-Trichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromo-3-chloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromoethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,3,5-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,4-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
2,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
2-Butanone	0.500	U		1.00	0.500	U		1.00			ug/L
2-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
2-Hexanone	0.500	U		1.00	0.500	U		1.00			ug/L
4-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Isopropyltoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Methyl-2-pentanone	0.500	U		1.00	0.500	U		1.00			ug/L
Acetone	0.500	U		1.00	0.500	U		1.00			ug/L
Benzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromodichloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromoform	0.160	U		1.00	0.160	U		1.00			ug/L
Bromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Carbon Disulfide	0.500	U		1.00	0.500	U		1.00			ug/L
Carbon Tetrachloride	0.690	J		1.00	0.720	J		1.00			ug/L
Chlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroethane	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17078634 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 9/5/2017

Duplicate: 9379 **Sample:** 0379

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
Chloroform	0.160	U		1.00	0.160	U		1.00			ug/L
Chloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dichlorodifluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Ethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Hexachlorobutadiene	0.160	U		1.00	0.160	U		1.00			ug/L
Isopropylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Methylene Chloride	0.160	U		1.00	0.160	U		1.00			ug/L
Naphthalene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Propylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
sec-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Styrene	0.160	U		1.00	0.160	U		1.00			ug/L
tert-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Tetrachloroethene	0.350	J		1.00	0.340	J		1.00			ug/L
Toluene	0.160	U		1.00	0.160	U		1.00			ug/L
Total Xylenes	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Trichloroethene	1.54			1.00	1.54			1.00	0		ug/L
Trichlorofluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Tritium	846		275	1.00	847		270	1.00		0	pCi/L
Vinyl Chloride	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM
Organics Data Validation Summary

RIN: 17078634 **Project:** Mound LTS&M Ground Water **Lab Code:** GEN **Validation Date:** 9/5/2017

LCS Recovery: All LCS recoveries were within the laboratory acceptance limits.

Method Blank(s): All method blanks results were below the method detection limit.

MS/MSD Recovery: There were 2 MS/MSD failures.

Surrogate Recovery: All surrogate recoveries were within the laboratory acceptance limits.

SAMPLE MANAGEMENT SYSTEM

Non-Compliance Report: MS/MSD Performance

RIN: 17078634 **Lab Code:** GEN

Project: Mound LTS&M Ground Water

Validation Date: 9/5/2017

MS/MSD	Date Analyzed	Method	Analyte	Recovery MS	Recovery MSD	Lower Limit	Upper Limit	MSD RPD	RPD Limit
PIY 867	08/02/2017	SW-846 8260	Bromomethane	176	167.0	66.0	129.0	5.00	20.0

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 17078634 **Lab Code:** GEN **Date Due:** 8/25/2017

Matrix: Water **Site Code:** MND03 **Date Completed:** 8/25/2017

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
0379	Tritium	08/12/2017						0.94
Blank_Spike	Tritium	08/12/2017				102.00		
0379	Tritium	08/12/2017					96.7	
Blank	Tritium	08/12/2017	50.3000	U				

Data Review and Validation Report

General Information

Requisition No. (RIN):	17078637
Sample Event:	July 25 and 26, 2017
Site(s):	Mound, Ohio; Groundwater
Laboratory:	GEL Laboratories, Charleston, South Carolina
Work Order No.:	429148
Analysis:	Organics
Validator:	Samantha Tigar
Review Date:	September 5, 2017

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325), *"Standard Practice for Validation of Environmental Data."* The procedure was applied at Level 2, Data Deliverables Verification. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Volatile Organics, VOA	VOA-A-007	SW-846 5030B	SW-846 8260 LL

Data Qualifier Summary

None of the analytical results required qualification.

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received 12 water samples on July 28, 2017, accompanied by a Chain of Custody (COC) form. The COC form was checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC form was complete with no errors or omissions. The air waybill numbers were listed on the receiving documentation.

Preservation and Holding Times

The sample shipments were received intact with the temperature inside the iced cooler at 5 °C, which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL. The reported MDLs for all analytes demonstrate compliance with contractual requirements.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

The Continuing Calibration Verification standards associated with the samples exhibited percent drift values greater than 20 percent for some target compounds. All associated results were less than the MDL and no qualification was required.

Volatiles Internal Standards and Surrogates

The volatile internal standard recoveries and surrogate recoveries were within the acceptance ranges for all samples.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. All method blank results associated with the samples were below the PQL for all analytes. In cases where a blank concentration exceeds or equals the MDL, the associated sample results are qualified with a “U” flag (not detected) when the sample result is greater than the MDL but less than 5 times the blank concentration.

Trip Blank

Trip blanks were prepared and analyzed to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples. Two trip blanks were submitted with these samples. Acetone was detected in the trip blanks; it was not detected at a concentration greater than the MDL in the associated samples.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The spike recoveries exceeded the acceptance criteria for dichlorodifluoromethane and bromomethane. These compounds were not detected at concentrations greater than the MDL in the associated sample.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative percent difference (RPD) for organic replicate results should be less than the laboratory-derived control limits. All replicate results met these criteria.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Field Duplicate

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location 0443. The relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results that are less than 5 times the PQL, the range should be no greater than the PQL. The duplicate results met the criteria.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on August 22, 2017. The Sample Management System EDD validation module was used to verify that the EDD file was complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

Sampling Protocol

Sample results for all monitoring wells met the Category I or II low-flow sampling criteria and were qualified with an “F” flag in the database, indicating the wells were purged and sampled using the low-flow sampling method. The groundwater sample results for wells 0353, 0444 and 0445 were further qualified with a “Q” flag in the database indicating the data are considered qualitative because these are Category II wells. The final turbidity value for location 0400 was greater than 50 NTU.

Outliers Report

Potential outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Potential outliers may result from transcription errors, data-coding errors, or measurement system problems. However, outliers may also represent true extreme values of a distribution and indicate more variability in the population than was expected.

Statistical outlier tests give probabilistic evidence that an extreme value does not "fit" with the distribution of the remainder of the data and is therefore a statistical outlier. These tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set.

There are three steps involved in identifying extreme values or outliers:

1. Identify extreme values that may be potential outliers by generating the Outliers Report using the Sample Management System from data in the environmental database. The application compares the new data set (in standard environmental database units) with historical data and lists the new data that fall outside the historical data range. A determination is also made if the data are normally distributed using the Shapiro-Wilk Test.
2. Apply the appropriate statistical test. Dixon's Extreme Value test is used to test for statistical outliers when the sample size is less than or equal to 25. This test considers both extreme values that are much smaller than the rest of the data (case 1) and extreme values that are much larger than the rest of the data (case 2). This test is valid only if the data without the suspected outlier are normally distributed. Rosner's Test is a parametric test that is used to detect outliers for sample sizes of 25 or more. This test also assumes that the data without the suspected outliers are normally distributed.
3. Scientifically review statistical outliers and decide on their disposition. The review should include an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values.

There were no potential outliers identified, and the data for this RIN are acceptable as qualified.

Report Prepared By: ____

Samantha Tigar
Data Validator

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 17078637 **Lab Code:** GEN **Validator:** Samantha Tigar **Validation Date:** 9/5/2017

Project: Mound LTS&M Ground Water **Analysis Type:** ☐ Metals ☐ General Chem ☐ Rad ☑ Organics

# of Samples: 12 **Matrix:** Water **Requested Analysis Completed:** Yes

Chain of Custody

Present: OK **Signed:** OK **Dated:** OK

Sample

Integrity: OK **Preservation:** OK **Temperature:** OK

Select Quality Parameters

☑ Holding Times	All analyses were completed within the applicable holding times.
☑ Detection Limits	The reported detection limits are equal to or below contract requirements.
☑ Field/Trip Blanks	There were 2 trip/equipment blanks evaluated.
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

Page 1 of 1

Validation Report: Equipment/Trip Blanks

RIN: 17078637 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 9/5/2017

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	429148001	SW-846 8260	Acetone (Lab Contaminant)	9.23	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
429148002	PIZ 016	0353	0.500	1.00	U	
429148003	PIZ 017	0400	0.500	1.00	U	
429148004	PIZ 018	0402	0.500	1.00	U	
429148005	PIZ 019	0411	0.500	1.00	U	
429148009	PIZ 023	0617	0.500	1.00	U	

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	429148012	SW-846 8260	Acetone (Lab Contaminant)	6.60	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
429148006	PIZ 020	0443	0.500	1.00	U	
429148007	PIZ 021	0444	0.500	1.00	U	
429148008	PIZ 022	0445	0.500	1.00	U	
429148010	PIZ 024	9443	0.500	1.00	U	
429148011	PIZ 025	P033	0.500	1.00	U	

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17078637 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 9/5/2017

Duplicate: 9443 **Sample:** 0443

Analyte	Sample Result	Flag	Error	Dilution	Duplicate Result	Flag	Error	Dilution	RPD	RER	Units
1,1,1,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,1-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	1.50	U		1.00	1.50	U		1.00			ug/L
1,1,2-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,3-Trichlorobenzene	0.200	U		1.00	0.200	U		1.00			ug/L
1,2,3-Trichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromo-3-chloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromoethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,3,5-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,4-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
2,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
2-Butanone	0.500	U		1.00	0.500	U		1.00			ug/L
2-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
2-Hexanone	0.500	U		1.00	0.500	U		1.00			ug/L
4-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Isopropyltoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Methyl-2-pentanone	0.500	U		1.00	0.500	U		1.00			ug/L
Acetone	0.500	U		1.00	0.500	U		1.00			ug/L
Benzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromodichloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromoform	0.160	U		1.00	0.160	U		1.00			ug/L
Bromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Carbon Disulfide	0.500	U		1.00	0.500	U		1.00			ug/L
Carbon Tetrachloride	0.160	U		1.00	0.160	U		1.00			ug/L
Chlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroethane	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17078637 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 9/5/2017

Duplicate: 9443 **Sample:** 0443

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
Chloroform	0.160	U		1.00	0.160	U		1.00			ug/L
Chloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,2-Dichloroethene	0.550	J		1.00	0.580	J		1.00			ug/L
cis-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dichlorodifluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Ethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Hexachlorobutadiene	0.160	U		1.00	0.160	U		1.00			ug/L
Isopropylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Methylene Chloride	0.160	U		1.00	0.160	U		1.00			ug/L
Naphthalene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Propylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
sec-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Styrene	0.160	U		1.00	0.160	U		1.00			ug/L
tert-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Tetrachloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
Toluene	0.160	U		1.00	0.160	U		1.00			ug/L
Total Xylenes	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Trichloroethene	6.02			1.00	6.00			1.00	0.33		ug/L
Trichlorofluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Vinyl Chloride	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM
Organics Data Validation Summary

RIN: 17078637 **Project:** Mound LTS&M Ground Water **Lab Code:** GEN **Validation Date:** 9/5/2017

LCS Recovery: All LCS recoveries were within the laboratory acceptance limits.

Method Blank(s): All method blanks results were below the method detection limit.

MS/MSD Recovery: There were 3 MS/MSD failures.

Surrogate Recovery: All surrogate recoveries were within the laboratory acceptance limits.

SAMPLE MANAGEMENT SYSTEM

Non-Compliance Report: MS/MSD Performance

RIN: 17078637 **Lab Code:** GEN

Project: Mound LTS&M Ground Water

Validation Date: 9/5/2017

MS/MSD	Date Analyzed	Method	Analyte	Recovery MS	Recovery MSD	Lower Limit	Upper Limit	MSD RPD	RPD Limit
PIZ 020	08/02/2017	SW-846 8260	Bromomethane	151.0	144.0	66.0	129.0	5.00	20.0
PIZ 020	08/02/2017	SW-846 8260	Dichlorodifluoromethane	55.0	59.0	56.0	152.0		

Data Review and Validation Report

General Information

Requisition No. (RIN):	17108750
Sample Event:	November 6-8, 2017
Site(s):	Mound, Ohio; Groundwater
Laboratory:	GEL Laboratories, Charleston, South Carolina
Work Order No.:	437518
Analysis:	Organics
Validator:	Samantha Tigar
Review Date:	December 18, 2017

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325), *"Standard Practice for Validation of Environmental Data."* The procedure was applied at Level 2, Data Deliverables Verification. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Volatile Organics, VOA	VOA-A-007	SW-846 5030B	SW-846 8260 LL

Data Qualifier Summary

Analytical results were qualified as listed in Table 2. Refer to the attached validation worksheets and the sections below for an explanation of the data qualifiers applied.

Table 2. Data Qualifiers

Sample Number	Location	Analyte	Flag	Reason
437518007	0601	Acetone	U	Less than 10x the trip blank
437518010	0606	Acetone	U	Less than 10x the trip blank
437518016	0347	Acetone	U	Less than 10x the trip blank

Sample Shipping/Receiving

GEL Laboratories in Charleston, South Carolina, received 22 water samples on November 9, 2017, accompanied by a Chain of Custody (COC) form. The COC form was checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. The COC form was complete with no errors or omissions. The air waybill numbers were listed on the receiving documentation.

Preservation and Holding Times

The sample shipments were received intact with the temperature inside the iced cooler at 1 °C, which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL. The reported MDLs for all analytes demonstrate compliance with contractual requirements.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

The Continuing Calibration Verification standards associated with the samples exhibited percent drift values greater than 20 percent for some target compounds. All associated results were less than the MDL and no qualification was required.

Volatiles Internal Standards and Surrogates

The volatile internal standard recoveries and surrogate recoveries were within the acceptance ranges for all samples.

Method Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. All method blank results associated with the samples were below the PQL for all analytes. In cases where a blank concentration exceeds or equals the MDL, the associated sample results are qualified with a "U" flag (not detected) when the sample result is greater than the MDL but less than 5 times the blank concentration.

Trip Blank

Trip blanks were prepared and analyzed to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples. Three trip blanks were submitted with these samples. Acetone was detected in the trip blanks. All associated results greater than the MDL and less than ten times the trip blank concentrations were qualified with a "U" flag as not detected.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The spike recoveries exceeded the acceptance criteria for 1,1,1,2-tetrachloroethane. This compound was not detected at concentrations greater than the MDL in the associated samples.

Laboratory Replicate Analysis

Laboratory replicate analyses are used to determine laboratory precision for each sample matrix. The relative percent difference (RPD) for organic replicate results should be less than the laboratory-derived control limits. All replicate results met these criteria.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Field Duplicate

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location P064. The relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results that are less than 5 times the PQL, the range should be no greater than the PQL. The duplicate results met the criteria.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on December 5, 2017. The Sample Management System EDD validation module was used to verify that the EDD file was complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

Sampling Protocol

Sample results for all monitoring wells met the Category I low-flow sampling criteria and were qualified with an “F” flag in the database, indicating the wells were purged and sampled using the low-flow sampling method.

Field data sheets were not provided for the surface water locations (0601, 0602, 0605, 0606, and 0607).

Outliers Report

Potential outliers are measurements that are extremely large or small relative to the rest of the data and, therefore, are suspected of misrepresenting the population from which they were collected. Potential outliers may result from transcription errors, data-coding errors, or measurement system problems. However, outliers may also represent true extreme values of a distribution and indicate more variability in the population than was expected.

Statistical outlier tests give probabilistic evidence that an extreme value does not "fit" with the distribution of the remainder of the data and is therefore a statistical outlier. These tests should only be used to identify data points that require further investigation. The tests alone cannot determine whether a statistical outlier should be discarded or corrected within a data set.

There are three steps involved in identifying extreme values or outliers:

1. Identify extreme values that may be potential outliers by generating the Outliers Report using the Sample Management System from data in the environmental database. The application compares the new data set (in standard environmental database units) with historical data and lists the new data that fall outside the historical data range. A determination is also made if the data are normally distributed using the Shapiro-Wilk Test.
2. Apply the appropriate statistical test. Dixon's Extreme Value test is used to test for statistical outliers when the sample size is less than or equal to 25. This test considers both extreme values that are much smaller than the rest of the data (case 1) and extreme values that are much larger than the rest of the data (case 2). This test is valid only if the

data without the suspected outlier are normally distributed. Rosner's Test is a parametric test that is used to detect outliers for sample sizes of 25 or more. This test also assumes that the data without the suspected outliers are normally distributed.

3. Scientifically review statistical outliers and decide on their disposition. The review should include an evaluation of any notable trends in the data that may indicate the outliers represent true extreme values.

There were no potential outliers identified, and the data for this RIN are acceptable as qualified.

Report Prepared By: ____
Samantha Tigar
Data Validator

Data Validation Outliers Report - No Field Parameters
Comparison: All historical Data Beginning 1/1/2007
Laboratory: GEL Laboratories
RIN: 17108750
Report Date: 12/18/2017

					Current			**Historical Maximum**			**Historical Minimum**			**Number of Data Points**		**Statistical Outlier**
						Qualifiers			*Qualifiers*			*Qualifiers*				
Site Code	Location Code	Sample ID	Sample Date	Analyte	Result	*Lab*	*Data*	Result	*Lab*	*Data*	Result	*Lab*	*Data*	N	N Below Detect	
MND01	0605	N001	11/07/2017	cis-1,2-Dichloroethene	0.950	J		32.2			1.02			44	0	NA
MND01	0605	N001	11/07/2017	Trichloroethene	4.30			24.7			6.22			44	0	No
MND01	0607	N001	11/07/2017	cis-1,2-Dichloroethene	0.160	U		3.96	J		0.280	J		45	0	NA
MND01	0607	N001	11/07/2017	Trichloroethene	1.33			13.0			2.74			45	0	No

STATISTICAL TESTS:
The distribution of the data is tested for normality or lognormality using the Shapiro-Wilk Test
Outliers are identified using Dixon's Test when there are 25 or fewer data points.
Outliers are identified using Rosner's Test when there are 26 or more data points.
See Data Quality Assessment: Statistical Methods for Practitioners, EPA QC/G-9S, February 2006.

NA: Data are not normally or lognormally distributed.

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 17108750 **Lab Code:** GEN **Validator:** Samantha Tigar **Validation Date:** 12/18/2017

Project: Mound LTS&M Ground Water **Analysis Type:** ☐ Metals ☐ General Chem ☐ Rad ☑ Organics

# of Samples: 22 **Matrix:** Water **Requested Analysis Completed:** Yes

Chain of Custody

Present: OK **Signed:** OK **Dated:** OK

Sample

Integrity: OK **Preservation:** OK **Temperature:** OK

Select Quality Parameters

☑ Holding Times	All analyses were completed within the applicable holding times.
☑ Detection Limits	The reported detection limits are equal to or below contract requirements.
☑ Field/Trip Blanks	There were 3 trip/equipment blanks evaluated.
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

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Validation Report: Equipment/Trip Blanks

RIN: 17108750 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 12/18/2017

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	437518006	SW-846 8260	Acetone (Lab Contaminant)	6.04	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
437518001	PLZ 400	0118	0.500	1.00	U	
437518002	PLZ 405	0124	0.500	1.00	U	
437518003	PLZ 406	0126	0.500	1.00	U	
437518004	PLZ 394	0138	0.500	1.00	U	
437518005	PLZ 402	0379	0.500	1.00	U	

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	437518018	SW-846 8260	Acetone (Lab Contaminant)	6.36	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
437518007	PLZ 409	0601	2.73	1.00	J	U
437518008	PLZ 412	0602	0.500	1.00	U	
437518009	PLZ 407	0605	0.500	1.00	U	
437518010	PLZ 410	0606	2.63	1.00	J	U
437518011	PLZ 408	0607	0.500	1.00	U	
437518012	PLZ 395	0386	0.500	1.00	U	
437518013	PLZ 396	0387	0.500	1.00	U	
437518014	PLZ 397	0389	0.500	1.00	U	
437518015	PLZ 398	0392	0.500	1.00	U	
437518016	PLZ 403	0347	2.85	1.00	J	U
437518017	PLZ 404	0315	0.500	1.00	U	

Blank Data

Blank Type	Lab Sample ID	Lab Method	Analyte Name	Result	Qualifier	MDL	Units
Trip Blank	437518022	SW-846 8260	Acetone (Lab Contaminant)	5.65	J	0.500	ug/L

Sample ID	Sample Ticket	Location	Result	Dilution Factor	Lab Qualifier	Validation Qualifier
437518019	PLZ 401	0346	0.500	1.00	U	
437518020	PLZ 411	P964	0.500	1.00	U	
437518021	PMZ 528	P064	0.500	1.00	U	

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17108750 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 12/18/2017

Duplicate: P964 **Sample:** P064

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
1,1,1,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,1-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2,2-Tetrachloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	1.50	U		1.00	1.50	U		1.00			ug/L
1,1,2-Trichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
1,1-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,3-Trichlorobenzene	0.200	U		1.00	0.200	U		1.00			ug/L
1,2,3-Trichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2,4-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromo-3-chloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dibromoethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloroethane	0.160	U		1.00	0.160	U		1.00			ug/L
1,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,3,5-Trimethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
1,3-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
1,4-Dichlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
2,2-Dichloropropane	0.160	U		1.00	0.160	U		1.00			ug/L
2-Butanone	0.500	U		1.00	0.500	U		1.00			ug/L
2-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
2-Hexanone	0.500	U		1.00	0.500	U		1.00			ug/L
4-Chlorotoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Isopropyltoluene	0.160	U		1.00	0.160	U		1.00			ug/L
4-Methyl-2-pentanone	0.500	U		1.00	0.500	U		1.00			ug/L
Acetone	0.500	U		1.00	0.500	U		1.00			ug/L
Benzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Bromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromodichloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Bromoform	0.160	U		1.00	0.160	U		1.00			ug/L
Bromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Carbon Disulfide	0.500	U		1.00	0.500	U		1.00			ug/L
Carbon Tetrachloride	0.160	U		1.00	0.160	U		1.00			ug/L
Chlorobenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Chloroethane	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 17108750 **Lab Code:** GEN **Project:** Mound LTS&M Ground Water **Validation Date:** 12/18/2017

Duplicate: P964 **Sample:** P064

	Sample				Duplicate						
Analyte	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution	RPD	RER	Units
Chloroform	0.160	U		1.00	0.160	U		1.00			ug/L
Chloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
cis-1,2-Dichloroethene	2.43			1.00	2.52			1.00	3.64		ug/L
cis-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromochloromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dibromomethane	0.160	U		1.00	0.160	U		1.00			ug/L
Dichlorodifluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Ethylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Hexachlorobutadiene	0.160	U		1.00	0.160	U		1.00			ug/L
Isopropylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Methylene Chloride	0.160	U		1.00	0.160	U		1.00			ug/L
Naphthalene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
n-Propylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
sec-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Styrene	0.160	U		1.00	0.160	U		1.00			ug/L
tert-Butylbenzene	0.160	U		1.00	0.160	U		1.00			ug/L
Tetrachloroethene	0.710	J		1.00	0.750	J		1.00			ug/L
Toluene	0.160	U		1.00	0.160	U		1.00			ug/L
Total Xylenes	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,2-Dichloroethene	0.160	U		1.00	0.160	U		1.00			ug/L
trans-1,3-Dichloropropene	0.160	U		1.00	0.160	U		1.00			ug/L
Trichloroethene	1.44			1.00	1.54			1.00	6.71		ug/L
Trichlorofluoromethane	0.160	U		1.00	0.160	U		1.00			ug/L
Vinyl Chloride	0.160	U		1.00	0.160	U		1.00			ug/L

SAMPLE MANAGEMENT SYSTEM
Organics Data Validation Summary

RIN: 17108750 **Project:** Mound LTS&M Ground Water **Lab Code:** GEN **Validation Date:** 12/18/2017

LCS Recovery:	All LCS recoveries were within the laboratory acceptance limits.
Method Blank(s):	All method blanks results were below the method detection limit.
MS/MSD Recovery:	There was 1 MS/MSD failure.
Surrogate Recovery:	All surrogate recoveries were within the laboratory acceptance limits.

SAMPLE MANAGEMENT SYSTEM

Non-Compliance Report: MS/MSD Performance

RIN: 17108750 **Lab Code:** GEN

Project: Mound LTS&M Ground Water

Validation Date: 12/18/2017

MS/MSD	Date Analyzed	Method	Analyte	Recovery MS	Recovery MSD	Lower Limit	Upper Limit	MSD RPD	RPD Limit
PMZ 528	11/10/2017	SW-846 8260	1,1,1,2-Tetrachloroethane	120.0	121.0	78.0	120.0	1.00	20.0

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