Date: March 1, 2019

To: Dustin Armstrong, PADEP

From: Justin Kowalkoski, P.G., Roux Associates, Inc.
Gregory Martin, P.G., Roux Associates, Inc.

Subject: **Former Bishop Tube Site – Modeling Work Plan**

1.0 Introduction

On behalf of the Bishop Tube Project Team ("BT Team"), Roux Associates, Inc. ("Roux") has prepared this Modeling Work Plan ("WP") pursuant to the Amended Consent Order and Agreement ("COA") between the BT Team and the Pennsylvania Department of Environmental Protection ("DEP"), dated August 4, 2009.

A discussion of the modeling objectives is presented in Section 2.0. Model selection, assumptions, input parameters, calibration procedures, sensitivity analysis, and reporting are discussed in Sections 3.0, 4.0, 5.0, 6.0, 7.0, and 8.0, respectively.

2.0 Modeling Objectives

The principal objective of the analytical fate and transport model analysis is to provide an additional line of evidence to establish the downgradient boundary of the Site. Specifically, to delineate the point at which site-related chlorinated volatile organic compounds ("CVOCs") comply with groundwater Medium-Specific Concentrations ("MSCs"). The model will incorporate information generated during the RI related to a) structural data from coring and borehole geophysics; b) groundwater elevation gradients; c) contaminant-specific physical properties; d) hydraulic conductivities; e) source characteristics; and f) field-observed contaminant rates of decay.

Because of the limitations inherent in the application of any groundwater flow and contaminant transport model (particularly given Site-specific conditions, e.g., a fractured bedrock aquifer), and as discussed previously with DEP[1], the results of the model will be employed as one of the lines of evidence evaluated jointly with an assessment of contaminant gradients and trends, linear regression analysis, and groundwater analytical results to establish the downgradient boundary of the Site. Also, as noted in Roux's February 15, 2019 Progress Report, the data collected during the compound specific isotopic analysis ("CSIA") investigation indicate there are additional sources of CVOCs contributing to the observed concentrations of CVOCs in groundwater within the boundary of the CVOC plume that are unrelated to historical activities at the former Bishop Tube property. The presence of additional sources further complicates establishing the downgradient boundary of the Site-related CVOCs.

Remedial investigation activities to-date have led to progressive installation and sampling of monitoring wells, tracing CVOCs downgradient from the former Bishop Tube property to where groundwater concentrations approach or meet MSCs. However, in the interest of time, DEP ordered that contaminant transport modeling be conducted in lieu of additional groundwater data collection, for "delineation to achieve completion of the RI" (DEP, December 3, 2018). This delineation is necessary prior to completing a feasibility study and selecting a remedy.

[1] See for example correspondence to DEP dated May 13, 2016, December 15, 2016, July 6, 2018, and November 2, 2018 (provided in Attachment A).

3.0 Model Selection

As required by DEP, the BT Team will conduct a fate and transport analysis for the Site using an analytical model with both flow and transport components. The BT Team will use WinFlow (groundwater flow) and WinTran (contaminant transport), which are part of the AquiferWin32 software suite (Version 5.0) developed by Environmental Simulations, Inc. A combination of Site-specific data and literature references will be used to establish input parameter values.

WinFlow

WinFlow is an analytical modeling tool that simulates two-dimensional groundwater flow. For the purposes of completing the fate and transport model, the groundwater flow field will be considered horizontal. While WinFlow (and most commonly used groundwater flow models[2]) was designed to simulate flow in unconsolidated porous media, use of WinFlow to approximate groundwater flow in fractured bedrock for this case was considered appropriate due to the large scale of the model domain and the general objectives of the analysis noted above. At a large scale it sometimes can be assumed that fractured bedrock aquifers approximate porous media.

WinTran

WinTran is a modeling tool that simulates the fate and transport of a dissolved contaminant in a groundwater system. The WinTran model pairs the WinFlow groundwater flow model with a contaminant transport model. WinTran incorporates: a) two-dimensional dispersion; b) sorption; c) diffusion; and d) first-order biodegradation/biotransformation.

4.0 Model Input Assumptions

Assumptions related to Site conditions are provided below.

- The shallow bedrock interval is the most transmissive zone (highest fracture density and conductivity) and contains trichloroethene ("TCE") slightly above its MSC in the most downgradient monitoring wells (i.e., MW-81 and MW-82A). Therefore, the fate and transport analysis will focus on the shallow bedrock conditions, thereby presenting a conservative/protective evaluation for all depth intervals. Empirical data for the overburden aquifer and the intermediate and deep bedrock aquifers already define the extent of TCE.

- Additional non-Site-related sources of CVOCs exist downgradient of the former Bishop Tube property. The nature and extent of these CVOCs are neither characterized, nor does it appear that they are subject to active DEP investigation(s). To the extent DEP expects the modeling analysis to define the downgradient extent of TCE in groundwater solely attributable to sources on the former Bishop Tube property, the downgradient CVOC source(s) will complicate or prevent (i.e., introduce additional uncertainty) such a determination.

- As described in the RIR dated August 31, 2015 ("2015 RIR"), groundwater analytical data in monitoring wells for which sufficient groundwater sampling data exist (i.e., a minimum of six sampling events) demonstrate a stable or decreasing trend for TCE. As part of the fate and transport model, the BT Team will update the previous assessment of groundwater concentration trends with data collected since the 2015 RIR was issued. The results of the updated assessment will be considered in the development and calibration of the model.

- Based on the site conceptual model and empirical data as described in the 2015 RIR, Little Valley Creek ("LVC") acts as a hydraulic barrier along the northern edge of the plume. Thus, LVC will define the northern extent of the model domain.

[2] Modflow, Biochlor and most other models share this limitation.

Assumptions associated with WinFlow, and WinTran are provided below (*Environmental Simulations, Inc., 2011*).

- Groundwater flow is horizontal and occurs in an infinite aquifer.
- The aquifer hydraulic conductivity is isotropic and homogeneous.
- The upgradient model boundary is defined by a constant head.
- Fate and transport processes can include: two-dimensional dispersion; sorption; first-order biodegradation/biotransformation; and diffusion.

5.0 Model Input Parameters

The input parameters that are necessary to complete the fate and transport model for the Site using WinFlow/WinTran are provided below (*Environmental Simulations, Inc., 2011*).

- Hydraulic gradient ("i") – the slope of the potentiometric surface;
- Hydraulic conductivity ("K") – the horizontal hydraulic conductivity of the saturated medium;
- Aquifer top – elevation of the top of the aquifer;
- Aquifer bottom – elevation of the bottom of the aquifer;
- Porosity ("n") – dimensionless ratio of the volume of interconnected voids to the bulk volume of the aquifer matrix;
- Longitudinal dispersivity ("Ax") – a scale-dependent parameter that represents the spreading of the contaminant in the direction of groundwater flow;
- Transverse dispersivity ("Ay") – a scale-dependent parameter that represents the spreading of the contaminant in the direction perpendicular to groundwater flow;
- Diffusion coefficient – the coefficient of molecular diffusion (the spreading of a contaminant in water due to concentration gradients);
- Half-life – time required for dissolved contaminant concentration to decay by one half as contaminants migrate through the aquifer;
- Retardation coefficient ("R") – the ratio of groundwater velocity to the rate that organic chemicals migrate in groundwater; and
- Analytical data – distribution of analytical results for TCE for one or more sampling events.

Initial values for the above parameters will be set using a combination of Site-specific and literature values. Selected parameters will be adjusted during calibration and sensitivity analysis, as outlined the sections below.

6.0 Model Calibration

Flow model calibration will be achieved through establishing a constant head elevation and incrementally adjusting the hydraulic gradient to produce a good fit with potentiometric head data in selected monitoring wells. The initial hydraulic gradient will be calculated using existing Site well gauging data from recent groundwater sampling events.

Transport model calibration will be achieved through incrementally adjusting selected parameters to produce a good fit with observed Site conditions (i.e., spatial and temporal distribution of TCE). Initial transport parameters will be established using a combination of Site-specific parameters and literature values. The parameters that may be modified to calibrate the transport model are listed below.

- Hydraulic conductivity;
- Porosity;
- Longitudinal dispersivity;
- Transverse dispersivity;
- Diffusion coefficient;
- Biodegradation/Biotransformation half-life; and
- Retardation coefficient.

7.0 Sensitivity Analysis

Once the flow and transport models have been calibrated, selected parameters for each model will be individually tested to quantitatively evaluate the uncertainty associated with model calibration and predictions. The sensitivity analysis will be performed by systematically varying the value of a particular parameter using a multiplier (*Anderson and Woessner, 1992*).

The parameters that may be included in sensitivity analysis are provided below.

- Hydraulic gradient;
- Hydraulic conductivity;
- Porosity;
- Longitudinal dispersivity;
- Transverse dispersivity;
- Biodegradation/biotransformation half-life; and
- Retardation coefficient[3].

A discussion of the sensitivity analysis for each of the tested parameters will be presented in the Modeling Report, along with summary tables and/or graphs, where appropriate. Sensitivity analysis data will be used, where and if appropriate, to refine the model calibration.

8.0 Reporting

The results of the groundwater flow and contaminant transport models will be incorporated into the Modeling Report. The Modeling Report will describe model goals, model design, model assumptions and limitations, Site-specific assumptions, calibration results, predictive simulations, evaluation of results, and a discussion of model sensitivity. Results of the predictive model will be used in conjunction with other lines of evidence to define (to the degree possible) the Site boundary as required by DEP under Act 2.

[3] In large measure, the retardation coefficient will be used to replicate matrix diffusion in the fractured bedrock aquifer. As demonstrated through case studies, matrix diffusion of dissolved and non-aqueous phase contaminants within fractured bedrock can have a demonstrable impact on downgradient extent and persistence of contaminants (e.g., TCE).

REFERENCES

1) Anderson and Woessner, 1992, Applied Groundwater Modeling – Simulation of Flow and Advective Transport, Academic Press.

2) Environmental Simulations, Inc., 2011, Guide to Using AquiferWin32.

3) Pennsylvania Department of Environmental Protection, 2019, Land Recycling Program Technical Guidance Manual.

ATTACHMENT A

ENVIRONMENTAL CONSULTING & MANAGEMENT
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May 13, 2016

Mr. Dustin Armstrong
Environmental Cleanup Program
PA Department of Environmental Protection
2 East Main Street
Norristown, Pennsylvania 19401

Re: Bishop Tube Site
Remedial Investigation and Treatability Study Completion Reports
Response to DEP Comment Letter dated December 31, 2015

Dear Mr. Armstrong:

In a letter dated December 31, 2015, the Pennsylvania Department of Environmental Protection ("DEP") provided comments on the Remedial Investigation Report ("RIR") dated August 31, 2015 and the Treatability Study Completion Report ("TSCR") dated October 9, 2015. Further clarification of DEP's comments was obtained during a conference call between Roux Associates and DEP on January 28, 2016. In addition, a meeting was held between DEP and The Bishop Tube Project Team ("BT Team") on April 8, 2016 to discuss the DEP's comments. The DEP's comments and the BT Team's responses (*in italics*) are presented below.

Section 5.1 Soil Quality Criteria

1. DEP Comment #1. (Bullet point 3) Residential Soil Statewide Health Standard Vapor Intrusion Screening Values are not appropriate criteria for compounds of concern at this site.

   As stated in the RIR, soil was screened on a <u>preliminary</u> basis using the standards identified in Section 5.1. However, these draft default soil screening values were not relied upon to make a determination whether a soil contribution to vapor intrusion ("VI") was an exposure pathway of potential concern. Rather, empirical data in the form of indoor air quality ("IAQ") samples were collected as a direct measure of IAQ conditions.

   Based on verbal discussion with DEP, we recognize and agree that if the Site-Specific Standard is to be employed for this Site, then the VI pathway must be evaluated under the requirements of the Site-Specific Standard (as outlined currently in Section K of the draft, revised Technical Guidance for Vapor Intrusion into Buildings from Groundwater and Soil under Act 2 [Document Number 261-0300-101], released for public comment on July 25, 2015). We anticipate that a Site-Specific Standard will be developed in the future and may

include remedial actions comprised of pathway elimination measures to address both the direct contact and vapor intrusion pathways.

Based on verbal discussion with DEP, we understand that DEP's intent with this comment was to clarify DEP policy and that no additional information is required to address this comment.

2. DEP Comment #2. The 1/10 rule should apply to any soils that are between the seasonal highs and lows of the water table. Permanently saturated soils may demonstrate the standard via groundwater equivalency which consequently is above SHS as suggested in the report.

   As indicated in the RIR, soil data presented in the report were compared to the Residential Direct Contact ("RDC") Medium Specific Concentrations ("MSCs") and Residential Used Aquifer ("RUA") Soil-to-Groundwater ("SGW") MSCs on a preliminary basis only. It is anticipated that attainment will be demonstrated using Site-Specific Standards in the future.

   Based on verbal discussion with DEP, we understand that DEP's intent with this comment was to clarify DEP policy and that no additional information is required to address this comment.

Section 5.3 Indoor Air Quality Criteria

3. DEP Comment #3. A risk assessment will need to be performed for each property (occupied building), which does not screen out using the VISL (CRL > 10^{-6} or HQ > 0.1).

   Based on verbal discussion with DEP, consensus was reached that the VI screening process consists of the following steps, as outlined in the RIR:

   1. *Screen empirical data against one-tenth of the draft VI guidance indoor air screening levels or the appropriate USEPA RSLs (adjusted to a target hazard quotient ["HQ"] of 0.1 and target cancer risk of 1E-05)*[1] *to eliminate substances from the cumulative risk assessment in Step 2.*

   2. *Evaluate cumulative risk using the USEPA VISL calculator screening tool for those compounds that do not screen out based on the criteria in Step 1, against a cumulative cancer risk level of 1E-04 and a HI of 1.*

   3. *Conduct further site-specific risk assessment employing property-specific exposure assumptions for properties that exceed the criteria set forth in Step 2.*

[1] Page 29 of the PADEP Draft Vapor Intrusion Guidance (Document No. 261-0300-101), released for public comment by DEP on July 25, 2015, obtained from the DEP website, indicates to "use the current EPA residential or industrial indoor air Regional Screening Level ("RSL") values (based on a target cancer risk of 10^{-6} and a target hazard quotient of 0.1) (U.S. EPA, 2015). RSLs based on a 10^{-5} cancer risk may be used for screening when it can be demonstrated that VI is the only complete exposure pathway for a receptor."

At the April 8, 2016 meeting DEP confirmed that the 3-step protocol described above is correct and that the above protocol may also be applied to other environmental media, including groundwater as discussed under Comment #19.

In the RIR, VI screening by Step 1 was completed for Residential and Non-Residential properties in Tables 15 and 16, respectively. During this process, a list of substances was identified for inclusion in the cumulative VI risk assessment for each property (all compounds were "screened out" of the cumulative risk assessment for three properties). The cumulative risk assessment was completed for the remaining properties in accordance with Step 2 as discussed in Section 6.3.8 of the RIR using the USEPA VISL calculator. The results of the cumulative risk assessment for indoor air showed that three properties exceeded the cumulative risk criteria (i.e., carcinogenic risk level 1E-04 and/or HI of 1).

Based on the above, the properties that are potentially subject to additional property-specific risk assessment by Step 3 are 154 Lancaster Avenue (Store), 172 Lancaster Avenue, and 97 Village Way when all compounds are carried into the cumulative risk assessment. However, each of these properties will be reevaluated under Steps 1 and 2 using only Site-related constituents of concern ("COCs"), as directed by DEP during the April 8, 2016 meeting and discussed in more detail under Comment #7, below.

4. DEP Comment #4. The DEP does not consider indoor air to be an environmental media under Act 2. However, indoor air quality data may be used [to] demonstrate that vapor intrusion is not of concern with respect to soil or groundwater contamination.

   As indicated in footnote #25 of the RIR, the Residential and Non-Residential MSCs for Indoor Air found on Table 3, Section IV.A.4 of the Technical Guidance Manual ("TGM") are intended as screening values, not formal MSCs. At DEP's request and because it is anticipated the Site-Specific Standard will be applied to the Site, a cumulative risk evaluation was conducted as described in Comment #3, above.

   Based on verbal discussion with DEP, we understand that DEP's intent with this comment was to clarify DEP policy and that no additional information is required to address this comment.

Section 5.4 Surface Water Quality Criteria

5. DEP Comment #5. Roux used published water quality standards. Would these standards be protective if cumulative risk is considered?

   Based on verbal discussion with DEP, we understand that DEP does not consider current published surface water standards to be sufficient for assessing human health risks associated with diffuse discharge of groundwater to surface water. We understand that DEP is asking for a human health cumulative risk assessment considering recreational and trespasser exposure scenarios based on the measured concentration(s) of Site-related compounds in discrete locations along

the stream feature. The BTT team agrees that it will complete such a risk assessment. It is understood that if risk assessment is conducted as stated above and the cumulative risk at each discrete location is determined to be below 1E-04, then this assessment would be utilized to demonstrate attainment of a Site-Specific Standard for surface water.

Section 6.2.4 Surface Water Quality

6. DEP Comment #6. Were there any other variables that may have contributed to the decrease in TCE concentrations in the SW-4 and SW-5 samples (e.g., rain events, stream volume and flow, seasonal variation)?

As identified in Appendix D of the RIR, Roux stream sampling events were conducted after at least three days without precipitation. Other than temperature, weather conditions were similar for all Roux events. No data regarding stream flow conditions were available in DEP surface water sampling reports. The embedded table below shows trichloroethene ("TCE") concentrations and volumetric flow rate as measured at the time of sampling, where available. Based on these data, volumetric flow does not appear to be a causal factor in the overall declining trends observed.

Sampler	Year	10-day Precipitation (inches)^	3-day Precipitation (inches)^	Roux SW-4		Roux SW-5	
				TCE (ug/L)	Volumetric Flow (gpm)	TCE (ug/L)	Volumetric Flow (gpm)
DEP	2003	0.49	0.40	55	--	44	--
DEP	2004	1.26	0.53	51	--	NS	NS
DEP	2008	1.13	0.82	44.2	--	38.7	--
Roux	2009	3.08	0.00	19.9	*	NS	NS
Roux	2011	0.78	0.00	26.3	208	22.9	337
Roux	2014	0.55	0.00	15.5	428	11.8	354

NS = Not Sampled. ug/L = micrograms/liter. gpm = gallons per minute.
^ = Precipitation prior to date of sampling.
** = Volumetric flow not measured at time of sampling.*

Precipitation data are also provided in the above table for the 10-day and 3-day periods prior to sampling. Based on the above, a correlation between precipitation (as a surrogate for stream flow) and TCE concentrations is not observed, with the possible exception of 2009. Rather, these data suggest that the observed declining concentration trends for TCE in surface water samples SW-4 and SW-5 are independent of precipitation (flow rates).

Similarly, groundwater trends discussed in RIR Section 6.8.2.8.3, Groundwater Quality Trends, show an overall decline in concentrations for the Site. For reference, trend charts with non-logarithmic scales (modified from Appendix A of the RIR) for monitoring well clusters MW-25, MW-26, MW-28 and 30CR and the supply well for 54CR are provided as Attachment 1. These charts show a moderate spike in TCE concentrations shortly after installation of new bedrock wells followed by a gradual decline between 2004 and 2014. This decline appears to mirror declining concentrations in SW-4 and SW-5. Consistent with the

hypothesis that groundwater discharge is the likely source of chlorinated volatile organic compounds ("CVOCs") in samples SW-4 and SW-5, a decreasing trend in groundwater TCE concentrations at the former Bishop Tube property explains a decline in the referenced surface water concentrations as suggested in the Site Conceptual Model ("SCM") presented in the RIR. The overall decreasing concentration trends in groundwater and surface water for TCE are also consistent with a plume that is in equilibrium and/or contracting, as discussed in more detail under Comment #16.

Section 6.3.8 Cumulative Risk Assessment for Indoor Air Quality

7. DEP Comment #7. Should the risk assessment be all-encompassing (i.e., including site-related and non-site-related compounds)?

   Section 6.3.8 of the RIR describes the cumulative risk assessment protocol employed for all compounds that did not "screen out" in Step 1 of the process previously described in Comment #3. In the RIR, Step 2 of the cumulative risk assessment included both Site-related and non-Site-related compounds. In response to DEP's comment and based on clarification from DEP during the April 8, 2016 meeting, cumulative risk for each property has been recalculated excluding non-Site-related compounds. Below is a table providing the recalculated cumulative risks for each property where IAQ data were collected (the revised VISL calculation sheets are provided as Attachment 2).

Property Address	Property Type	Cumulative Carcinogenic Risk (1E-04 target)	Cumulative Hazard Quotient (1 target)
39 Conestoga Road	Commercial	NA	NA
54 Conestoga Road*	Residential	6E-06	1
152 Lancaster Avenue	Commercial	NA	NA
154 Lancaster Avenue (Garage)	Commercial	6E-07	0.2
154 Lancaster Avenue (Store)	Commercial	8E-06	3
172 Lancaster Avenue*	Commercial	NA	NA
92 Village Way	Residential	NA	NA
95 Village Way	Residential	8E-06	0.1
97 Village Way*	Residential	4E-06	0.9
10 Winding Way	Residential	8E-07	0.2

NA = Not applicable, all compounds screened out of assessment (Step 1).
** = Primary and duplicate samples were collected for this property. The average of the analytical results for the two samples was used in the cumulative risk assessment screening process and in the calculation of cumulative risk.*

8. DEP Comment # 8. Is the correct Cancer Risk Level being used? 1E-05 is referenced.

   The RIR referenced a carcinogenic risk of 1E-05 in the context of establishing screening values during Step 1 of the process outlined in Comment #3, above. More specifically, the RIR references this value in the context of using "USEPA regional screening levels ("RSLs") for non-carcinogens (adjusted HQ of 0.1) or

carcinogens (adjusted target risk of 1E-05)." As indicated under footnote 41 on page 58 of the RIR, "In accordance with DEP draft Document Number 261-0300-101, USEPA RSLs based on a 1E-05 carcinogenic risk may be used when VI is the only complete exposure pathway for a receptor." For the properties being evaluated there is no direct contact exposure to soil and a public water supply (or a treated private supply in the case of 54 Conestoga Road), thus VI is deemed to be the only potential exposure pathway.

Based on DEP's concurrence at the April 8, 2016 meeting that the 3-step process described in Comment #3 accurately reflects the DEP's protocols, 1E-05 is the appropriate target cancer risk with respect to screening using USEPA RSLs and 1E-04 is the appropriate cancer risk level for comparison of the cumulative results derived from the VISL calculator under the Site-Specific Standard.

Unless DEP advises otherwise, no additional information is required to address this comment.

9. DEP Comment #9. Should 39 Conestoga Road (i.e., temporary actors' quarters associated with the theatre) be considered non-residential?

   Based on the April 8, 2016 meeting, we understand that DEP's central office considers the temporary actors' quarters that are reportedly present at 39 Conestoga Road to preclude a non-residential exposure scenario for this property. Conversely, the Bishop Tube Project Team views this property as non-residential based on its zoning designation and use. During the April 8, 2016 meeting, DEP agreed to ask its Central Office to clarify the Act 2 requirements regarding use of the residential/non-residential standard for the actors' quarters.

10. DEP Comment #10. Hazard Index ("HI") calculations cannot be rounded under the Act 2 regulations. The HI value for 54 Conestoga Road was rounded from 1.4 to 1. PADEP requires two significant figures for target hazard quotients.

    The calculation of HQ values for individual compounds are presented with two significant figures on the calculation sheets presented in Appendix I of the RIR. The summed HQ results for an individual property produce a HI which is reported to one significant figure. Use of one significant figure for reporting both HI and HQ results is in accordance with USEPA Human Health Risk Assessment Protocol[2] and USEPA OSWER Technical Guidance[3] as well as references made in the Act 2 Regulation for Target Hazard Quotient or Hazard Index, which are listed in Sections 250.306(d), 250.307(d), 250.307(h), 250.402, and 250.702 as "1" or

[2] Pages 7-2 and 7-3 of the USEPA Human Health Risk Assessment Protocol for Hazardous Waste Combustion Facilities dated September 2005, indicate "For presentation purposes, hazard quotients (and hazard indices) and cancer risk estimates are usually reported as one significant figure. We recommend rounding only the final reported results, not the intermediate calculations."

[3] Page 127 of the OSWER Technical Guidance for Assessing and Mitigating the Vapor Intrusion Pathway from Subsurface Vapor Sources to Indoor Air dated June 2015, states "In making such risk management determinations, EPA generally recommends reporting the HQ and HI to one significant figure."

"one" (i.e., one significant figure).

As discussed at the April 8 meeting, DEP will provide this response to its Central Office for a response and clarification of DEP protocols.

11. DEP Comment # 11. Two rounds of follow up sub-slab sampling may be warranted at 154 Lancaster Avenue, 172 Lancaster Avenue, and 54 Conestoga Road where potential background sources of site-related compounds are potentially responsible for elevated indoor air concentrations.

    Based on discussion at the April 8, 2016 meeting, DEP advised that this was simply a potential sampling alternative that might help address Comment # 13 below. It was noted that sub-slab sampling may not be a viable option at 54 Conestoga Road as a limited vadose zone exists beneath the basement floor slab and the water table. The use of sub-slab sampling to evaluate select properties will be considered following completion of activities summarized in the response to Comment #13.

12. DEP Comment #12. At properties with apparent elevated levels of non-site-related compounds (i.e., BTEX), were detection limits for site-related CVOCs within the acceptable range?

    All tables included in the RIR use the qualifier "U" to indicate parameters not detected above the laboratory reporting limit. In cases where the reporting limit exceeded the applicable regulatory standard or criteria being utilized, the U qualifier was flagged with an apostrophe (i.e., U').

    There were four properties where non-Site-related COCs were detected at levels that carried them into the VISL calculator[4] (154 Lancaster Avenue, 172 Lancaster Avenue, 95 Village Way and 97 Village Way). As shown on Tables 15 and 16 of the RIR, the detection limits for Site-related CVOCs were met for all of these properties. For two properties (95 Village Way and 172 Lancaster Avenue), TCE was not carried into the VISL calculator (i.e., TCE was non-detect with detection limits that were below the screening value or detected at levels below the screening value). IAQ data is presented on Tables 8 through 13, 15 and 16 of the RIR.

13. DEP Comment #13. For the properties referenced in #11 above, if the indoor air quality has been degraded by vapor intrusion from site derived volatile organic compounds, then vapor mitigation systems must be installed immediately. Additional indoor air sampling or pressure differential tests must be performed to show that these mitigation systems are effectively working. That stated, two rounds of favorable sub-sample results (also referenced in #11) may negate the need to mitigate indoor air.

    Based on discussion with DEP at the April 8, 2016 meeting, "degraded" indoor

[4] These non-Site-related compounds were removed from the VISL cumulative risk evaluation as summarized in the response to Comment #7, above.

air quality is initially considered at any property where the cumulative carcinogenic risk exceeds 1E-04 or the HI exceeds 1 for Site-related compounds (see recalculated values excluding non-Site-related compounds in Comment #7). Based on the clarification of VI protocol above, none of the properties have a cumulative carcinogenic risk exceeding 1E-04. However, one property (154 Lancaster Avenue – Store) had a HI greater than 1.

As noted in the RIR, the property at 154 Lancaster Avenue consists of a single structure with two portions separated by a dividing wall. The store portion was leased for furniture manufacturing, including finishing operations using varnish and other coatings. Comparing the garage and store data, the IAQ results were markedly higher in the store area suggesting a possible contributing source from the furniture finishing operations. Since the time of sampling, the furniture store has ceased operations. Based on the change in use, the BT Team proposes two supplemental indoor air sampling events to assess the IAQ under the current use conditions.

Alternatively, DEP expressed that the determination of "degraded" can also be assessed by employing further risk assessment using property-specific exposure assumptions for properties that exceed the criteria set forth in Step 3 of Comment #3. DEP also stated that the sub-slab samples discussed under Comment #11, above, could be employed to potentially demonstrate the absence of a VI pathway for certain compounds that might be the result of indoor air contributions (i.e., non-Site-related). If this were demonstrated, then these compounds would be screened out and the cumulative risk calculation could be revised using the VISL calculator.

If supplemental sampling and/or additional risk assessment that employs Step 3 of the VI screening process result in a HI greater than 1, additional sampling data or vapor mitigation may be required.

Section 6.6.1, 6.6.2, & 6.6.3

14. DEP Comment #14. Since the original locations of the Baker samples were not known when the new set of soil borings were installed, the recent samples only demonstrate that soils are not ubiquitously contaminated in the area of Building 5VDA, the Drum Storage Area, and Building 8VDA. It does not demonstrate that soil CVOC concentrations in the vicinity of these three areas of concern have actually decreased. In order to demonstrate this, sampling would need to occur in accordance with Section 250.703.

    During RI activities, the locations of Baker's soil borings were identified in the field by a Pennsylvania-licensed surveyor. The sample depths targeted by Roux were designed to mimic those collected by Baker in order to generate contemporary data.

    As discussed at the April 8, 2016 meeting with DEP, the recent soil sampling

results were neither designed to nor do they meet the requirements for demonstrating attainment in accordance with Section 250.703.

Section 8.3 Site Conceptual Model

15. DEP Comment #15. Can any conclusions be drawn from the forensic analysis discussed in Section 6.8.2.5?

    Please refer to the response to DEP RIR Comment #18, below.

16. DEP Comment #16. A 30-year groundwater fate and transport was not developed. Since site related contaminants have been found in the most distant offsite wells. A model will be required to show the borders of the contaminant plume.

    As also discussed in responses to Comments #17 and #19, below, the extent of CVOC distribution has been determined based upon empirical groundwater quality data collected from Site monitoring wells. The groundwater quality results presented in the RIR report represent a robust data set (both spatially and temporally) upon which definitive conclusions can be drawn regarding the fate and transport of CVOCs associated with the Site. In aggregate, these data indicate that the CVOC plume is either in a spatial equilibrium or is contracting back toward the source as a function of declining mass flux. In contrast, as illustrated by the model prepared by Baker (on behalf of DEP), a combination of: 1) requisite simplifying mathematical assumptions; 2) complex and heterogeneous hydrogeologic conditions; and 3) the limited available historic groundwater quality data needed to accurately reconstruct a source term, the application of a numerical fate and transport model will produce highly uncertain and unreliable results. For this reason, Roux made an informed decision not to diminish the quality of the data used and conclusions presented in the RIR through the dependence upon an unreliable and speculative model output.

    As described above, given 1) Site hydrogeologic conditions; 2) available data; and 3) the current life-cycle stage of the CVOC plume (stable or contracting), a fate and transport model would produce highly uncertain results with regard to current plume boundaries. As discussed at the April 8, 2016 meeting, DEP and the BTT team anticipate additional dialog regarding alternative approaches to establishing plume (Site) borders.

17. DEP Comment #17. CVOC Isoconcentration maps are required for offsite wells for each identified aquifer.

    As discussed with DEP, it was agreed that the Site consists of two groundwater aquifers (i.e., overburden and bedrock). DEP is looking for an area outlined on an aerial figure which circumscribes the extent of contamination for each aquifer. More specifically DEP wants this to define the boundaries of the Site (in this case the regulatory extent under Act 2 for which there would be a future release of liability). This desired definition of the Site is also directly related to the modeling

request in Comment #16, above, and the VI cumulative risk evaluation discussed under Comment #19, below.

As discussed under Comments #16 and #19, a robust empirical groundwater quality data set is used to establish the spatial distribution of CVOCs in both aquifers, further summarized as follows:

- *Overburden: Contaminant distribution in the shallow overburden zone is considered to exist within the area hypothetically exhibiting VI cumulative risk based upon the conservative assumption of a complete exposure pathway from groundwater to indoor air. Where applicable, indoor air sample results are included in this assessment. Based on the SCM and empirical data for groundwater and indoor air, the extent of potential VI risk is bound to the northwest/north by LVC and Conestoga Road to the east (see response to Comment #19).*

- *Bedrock: As summarized in the RIR, groundwater flow in bedrock principally occurs through the fracture fabric, therefore attempts to simplistically illustrate a homogeneous CVOC distribution, through the use of isoconcentration lines, impart considerable uncertainly, diminishing the accuracy of the data interpretation based upon discrete data points (i.e., monitoring wells).*

In summary, the BT Team feels that the existing depictions regarding groundwater quality in the RIR are technically sound. As discussed at the April 8, 2016 meeting, DEP and the BT Team anticipate additional dialog regarding alternative approaches to establishing plume (Site) borders.

Section 8.3.3 DNAPL

18. DEP Comment #18. Does the presumed presence of DNAPL in the area of MW-26 indicate another source area near this location? If so, has sufficient soil sampling been conducted at the northeast corner of the site?

    As verbally discussed with DEP, the presence of dense, non-aqueous phase liquid ("DNAPL") in the area of MW-26 is not indicative of shallow discharge of TCE or an additional "source area" in the northeast corner of the Site. This conclusion is based largely on the following:

    - *The nearest Areas of Concern ("AOCs") at the Site that were historically identified by DEP are the "solvent spill areas" and the "waste disposal lagoon" (identified on Figure 2 of the RIR as AOCs 13 and 16, respectively). Evidence of source material (i.e., DNAPL) was not observed in either of these AOCs during investigative activities conducted by Baker.*

    - *Soil gas results collected by Roux in the area north of Building 8 do not indicate elevated concentrations of CVOCs in the shallow soil or groundwater in the northeast corner of the Site (see Figure 26 of the RIR).*

Elevated soil gas levels were observed in the vicinity of the former TCE aboveground storage tank ("AST").

- *DNAPL was only observed in bedrock at depths greater than 375 feet below surface in MW-75. During drilling activities, the overburden and shallower bedrock at this location did not exhibit signs that DNAPL was present (i.e., solvent odor, etc.).*

- *A supplemental soil boring installed near MW-8, summarized in Section 6.9.3.1 of the RIR, did not exhibit signs that DNAPL was present (i.e., solvent odor, etc.).*

The presence of DNAPL in this portion of the Site at depths greater than 375 feet below surface is presumed to be the result of transport from the VDA8 Area via vertical migration along bedding planes and laterally along bedrock strike to the northeast (i.e., along structure), similar to groundwater transport as summarized in the SCM. The Compound Specific Isotope Analysis ("CSIA") and Broad Spectrum Hydrocarbon Analysis ("BSHA") forensic data support a relationship between the CVOCs observed in the vicinity of the former Building 8 degreaser and the CVOCs observed in the northeast corner of the Site. These forensic data are consistent with the overall SCM described in the RIR.

Collectively, the available data indicate that a known source area has produced the observed conditions near the northeast corner of the Site. There is no evidence to suggest there is another, as yet unidentified, source that has produced the observed conditions at the northeast corner of the Site.

Section 8.4.4 Inhalation Exposure to Indoor Air Caused by VI

19. DEP Comment #19. As part of the 30-year groundwater model, an area should be circumscribed where unacceptable vapor intrusion risks may be present based off of groundwater sampling results. Figure 24 came close to satisfying this need where empirical groundwater sampling results were used to show where unacceptable risk ranges may exist based on screening numbers. However, groundwater modelling should also be incorporated when delineating this boundary. Furthermore, the compounds need to be cumulatively risked out. Figure 24 depicts single well locations where "one or more compound exceeds the applicable draft PADEP vapor screening criteria." Risk assessed data is required instead.

    As discussed above, an attempt to develop and use a 30-year groundwater/contaminant transport model to predict past and future CVOC distribution will produce unreliable and uncertain results. However, in order to conservatively evaluate potential human health risk, the groundwater data depicted on Figure 24 of the RIR were evaluated in the context of cumulative risk calculations in accordance with the procedures outlined in Comment #3. Preliminary screening of groundwater data is presented on Tables 1 and 2 comparing analytical results to 1/10th of the residential and non-residential

screening values (based on zoning), respectively, found on Table 1 of the draft, revised TGM. For the purposes of this evaluation, the following notes apply:

- *Only Site-related constituents of concern were utilized in the screening process consistent with Comment #7, above;*
- *54 Conestoga Road data were screened using a residential exposure scenario; and*
- *Data at all other properties were screened using a non-residential exposure scenario.*

The VISL calculator data sheets for monitoring wells are included as Attachment 3. The results of the groundwater VI cumulative risk evaluation are provided on Table 3, depicted on Figure 1 and summarized below.

- *The overall distribution of potential VI cumulative risk is consistent with Figure 24 from the RIR with the exception of MW-40, MW-46 and PZ-1 on the vacant parcels north of Lancaster Avenue.*
- *At 39 Conestoga Road, the cumulative risk evaluation for groundwater showed that MW-32 and TW-17 pass under a non-residential exposure scenario. As summarized under Comment #9, this property is considered non-residential based on zoning designation. Therefore, based on the groundwater and indoor air results, the downgradient extent of potential VI risk does not extend beyond Conestoga Road.*
- *Groundwater at 54 Conestoga Road does not pass the residential VISL cumulative risk evaluation.[5] As discussed with DEP, the required buffer zone from groundwater to the basement slab does not exist for this property (i.e., sub-slab soil gas sampling is impractical). However, indoor air results presented in the RIR show that the HI for the basement of this property is 1.*

As summarized above, the extent of potential VI risk is defined by the shallow overburden groundwater conditions and the potential VI risk is bounded to the northwest by LVC (based on the SCM) and to the east by Conestoga Road (based on empirical groundwater and VI data). Groundwater quality data regarding CVOCs in the bedrock aquifer are discussed separately under Comments #16 and #17 above.

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[5] The cumulative risk evaluation included only TCE in the VISL calculator for groundwater at 54 Conestoga Road. All other compounds were non-detect or below applicable screening levels. However, the detection limit for vinyl chloride (1 ug/L) was above 1/10th of the residential VI screening level (0.2 ug/L). If the detection limit were used as the concentration for vinyl chloride in groundwater, the resulting HQ is 0.01, which would not change the HI for any wells at 54 Conestoga Road, and thus was not included in the calculator.

TREATABILITY STUDY

General Comments

1. DEP Comment #1. Did Roux consider evaluating high pressure injections to the area at temporary soil injection points to achieve better distribution of amendment?

   The original delivery method for the amendment, as proposed in the Treatability Study Work Plan ("TSWP"), was evaluated prior to each additional injection and adjusted as feasible within the scope of that TSWP. High pressure injection methods were beyond the scope of the approved work plan.

2. DEP Comment #2. No alternative recommendations are provided for addressing the saturated overburden zone soils in the Plant #8 vapor degreaser area. If in-situ bioremediation ("ISB") is not viable, other options to address the three hot spot areas incorporated into the Interim Response (i.e., the Plant #8 VDA, drum storage area, and Plant #5 VDA) should be evaluated as an alternative approach to air sparging/soil vapor extraction and ISB.

   The TSWP was conducted to evaluate whether ISB was a feasible technology to remediate the shallow overburden zone within Building 8. A pilot study was conducted in accordance with the scope of work outlined in the TSWP and the results were reported in the TSCR. The development of alternative recommendations for the shallow overburden zone within Building 8 or for other remedial options to address the "three hot spot areas" at the Site was beyond the scope of the RIR and TSCR. Identification of potential alternative remedial strategies, consistent with non-residential use, would be conducted in conjunction with a Feasibility Study (which has not been requested by DEP).

3. DEP Comment #3. It appears that the enhanced reductive dechlorination ("ERD") was indeed successful and that it was the delivery method that was insufficient. An alternative delivery method could be proposed. Perhaps a cost analysis could be provided in terms of what applying full scale ERD would mean.

   Please refer to the response to DEP TSCR Comment #2, above.

Section 4.1.1 TOC and Bromide Distribution Analyses

4. DEP Comment #4. The second paragraph states that increases in TOC and Br observed at the MW-25 triplet and MW-26 are not necessarily attributable to injections. Please explain other potential reasons for these increases.

   The distribution of total organic carbon ("TOC") and Bromide were provided on Figure 4 of the TSCR.

   Bromide data qualified with a "B" flag indicates data that was detected between the method detection limit and reporting limit of the laboratory equipment, essentially equivalent to the "J" flag used for organic data. The analytical data in all three MW-26 wells were non-detect or "B" flagged, indicating that the detections of bromide were outside the calibration range of the equipment. Without

more conclusive data, we cannot attribute with certainty the minor fluctuations in bromide value to injections.

As TOC analysis can be biased by contaminant concentrations, the small variations in TOC seen in monitoring wells MW-25 and MW-26 may simply be related to the high concentrations of CVOCs in groundwater in these 2 well clusters.

Additionally, since these sample locations were added to the Treatability Study sampling plan for investigation after Injection #2, no data is available to establish baseline conditions for these wells with respect to TOC and Bromide.

Section 4.2.2 Surface Water Field Indicator Parameter Monitoring

5. DEP Comment #5. Please provide a tabulated summary of this data, for potential use in decision-making or as baseline monitoring information.

   The tabulated summary of the field parameter data is contained in Table 5 of the TSCR.

Section 4.3 Bacterial Sampling Results

6. DEP Comment #6. Was analysis conducted to determine if the appropriate strain of *Dhc* was present to fully reduce the contaminants to chloride and ethene?

   Yes. These analyses are contained in Table 8 of the TSCR.

Should you have any questions or comments, please contact the undersigned at (856) 423-8800.

Sincerely,
ROUX ASSOCIATES, INC.

Justin Kowalkoski, P.G.
Senior Geologist

Greg Martin, P.G.
Vice President/Principal Hydrogeologist

cc: Richard Staron - PADEP
Anderson Hartzell - PADEP
Robert Schena - PADEP
John Nagel - East Whiteland Township, Manager
Jon Buzan - East Whiteland Township, EAC
Bishop Tube Project Team

TABLES

Table 1. Summary of Groundwater Vapor Instrusion Screening - Residential. Bishop Tube Project Team; Malvern, PA.

Sample ID Lab Sample ID Sample Date	1/10th of the DRAFT PADEP VI Groundwater Screening Values Residential	MW-33 JB78423-41 10/2/2014	MW-34 JB78423-37 10/2/2014	MW-35 JB78423-38 10/2/2014
VOLATILE ORGANIC COMPOUNDS (µg/l)				
1,1-Dichloroethane	10	**8.9**	**6**	1 U
1,2-Dichloroethane	3.3	1 U	1 U	1 U
Tetrachloroethene	11	1 U	1 U	1 U
1,1,1-Trichloroethane	1200	**42**	**25.7**	**61.4**
Trichloroethene	0.88	**38.7**	**33.7**	**64.1**
Vinyl chloride	0.2	1 U'	1 U'	1 U'

Notes:

R VSGW = Residential Groundwater Vapor Screening.

µg/l = micrograms per liter.

Boxed concentrations exceed the 1/10th of the DRAFT PADEP R VSGW.

U = Not detected above laboratory detection limit.

U' = Laboratory reporting limit exceeds the applicable regulatory standard or criteria being utilized.

J = Result below the reporting limit (estimated value).

Table 2. Summary of Groundwater Vapor Instrusion Screening - Non-Residential. Bishop Tube Project Team; Malvern, PA.

Sample ID Lab Sample ID Sample Date	1/10th of the DRAFT PADEP VI Groundwater Screening Values Non-Residential	MW-14 JB78276-12 10/1/2014	MW-16 JB78276-11 10/1/2014	MW-32 JB78423-33 10/2/2014	MW-36 JB78423-9 10/2/2014	MW-37 JB78423-18 10/2/2014	MW-38 JB78423-11 10/2/2014	MW-40 JB78423-19 10/2/2014	MW-41 JB78423-30 10/2/2014	MW-42 JB78423-12 10/2/2014	MW-46 JB78423-24 10/2/2014	MW-49A JB78423-1 10/2/2014	MW-60 JB78423-45 10/2/2014	MW-62 JB78423-20 10/2/2014	MW-63 JB77981-10 9/29/2014
VOLATILE ORGANIC COMPOUNDS (µg/l)															
1,1-Dichloroethane	170	**0.59 J**	**9.7**	**5.2**	1 U	**21.6**	**149**	**3.7**	1 U	**56.9**	**1.4**	1 U	1 U	**0.57 J**	**144**
1,2-Dichloroethane	55	1 U	5 U	1 U	1 U	1 U	10 U	1 U	1 U	2.5 U	1 U	1 U	1 U	1 U	10 U
Tetrachloroethene	150	1 U	5 U	**0.55 J**	1 U	**2.3**	**12.8**	**1**	1 U	**3.5**	1 U	1 U	1 U	1 U	**19.3**
1,1,1-Trichloroethane	17000	**9.3**	**814**	**9.8**	1 U	**149**	**1060**	**18.3**	1 U	**322**	**2.4**	1 U	1 U	**0.4 J**	**1120**
Trichloroethene	12	**12.9**	**344**	**7.4**	**0.29 J**	**303**	**2910**	**66.3**	**0.5 J**	**1090**	**23.5**	1 U	1 U	**1.3**	**2480**
Vinyl chloride	5.1	1 U	5 U	1 U	1 U	**0.94 J**	10 U'	1 U	1 U	**5.2**	**0.59 J**	1 U	1 U	1 U	10 U'

Notes:

NR VSGW = Non-Residential Groundwater Vapor Screening.

µg/l = micrograms per liter.

Boxed concentrations exceed the 1/10th of the DRAFT PADEP NR VSGW.

U = Not detected above laboratory detection limit.

U' = Laboratory reporting limit exceeds the applicable regulatory standard or criteria being utilized.

J = Result below the reporting limit (estimated value).

Bedrock well MW-49A has a screen interval of 15-35 feet below ground surface. No water was encountered in an overburden layer. This well is therefore included on this table.

Overburden monitoring wells MW-61 and MW-47 are not included in this table as the screened interval is not consitent with the criteria for vapor screening.

Table 2. Summary of Groundwater Vapor Instrusion Screening - Non-Residential. Bishop Tube Project Team; Malvern, PA.

Sample ID	1/10th of the DRAFT PADEP	PZ-1	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7	TW-1	TW-2	TW-3	TW-4	TW-5	TW-8	TW-9	TW-10
Lab Sample ID	VI Groundwater Screening Values	JB78423-17	JB78423-15	JB78423-10	JB78423-42	JB78423-16	JB78423-27	JA34486-1	JA34486-2	JA34486-3	JA34486-4	JA34486-5	JA34498-1	JA34498-2	JA34498-3
Sample Date	Non-Residential	10/2/2014	10/2/2014	10/2/2014	10/2/2014	10/2/2014	10/2/2014	12/3/2009	12/3/2009	12/3/2009	12/3/2009	12/3/2009	12/4/2009	12/4/2009	12/4/2009
VOLATILE ORGANIC COMPOUNDS (µg/l)															
1,1-Dichloroethane	170	**27.3**	1 U	1 U	1 U	**44.1**	1 U	**6.7**	2 U	1 U	1 U	**203**	1 U	**0.39 J**	1 U
1,2-Dichloroethane	55	1 U	1 U	1 U	1 U	1 U	1 U	1 U	2 U	1 U	1 U	5 U	1 U	1 U	1 U
Tetrachloroethene	150	1 U	1 U	1 U	1 U	1 U	1 U	**0.71 J**	**3**	**2.7**	1 U	**19.8**	1 U	1 U	1 U
1,1,1-Trichloroethane	17000	**11.5**	**0.33 J**	**0.46 J**	1 U	**173**	1 U	**811**	**3.8**	**1.9**	1 U	**1020**	1 U	**1.7**	**1.9**
Trichloroethene	12	**64.9**	1 U	**1.8**	**1.3**	**312**	**0.4 J**	**336**	**758**	**3.2**	1 U	**3520**	1 U	**4.9**	**0.51 J**
Vinyl chloride	5.1	**5.9**	1 U	1 U	1 U	**0.8 J**	1 U	1 U	2 U	1 U	1 U	**2.6 J**	1 U	1 U	1 U

Notes:
NR VSGW = Non-Residential Groundwater Vapor Screening.
µg/l = micrograms per liter.
Boxed concentrations exceed the 1/10th of the DRAFT PADEP NR VSGW.
U = Not detected above laboratory detection limit.
U' = Laboratory reporting limit exceeds the applicable regulatory standard or criteria being utilized.
J = Result below the reporting limit (estimated value).
Bedrock well MW-49A has a screen interval of 15-35 feet below ground surface. No water was encountered in an overburden layer. This well is therefore included on this table.
Overburden monitoring wells MW-61 and MW-47 are not included in this table as the screened interval is not consitent with the criteria for vapor screening.

Table 2. Summary of Groundwater Vapor Instrusion Screening - Non-Residential. Bishop Tube Project Team; Malvern, PA.

Sample ID Lab Sample ID Sample Date	1/10th of the DRAFT PADEP VI Groundwater Screening Values Non-Residential	TW-11 JA38356-1 1/21/2010	TW-12R JA41502-8 3/8/2010	TW-13 JA38356-2 1/21/2010	TW-14 JA38356-3 1/21/2010	TW-15 JA38356-4 1/21/2010	TW-16 JA38356-5 1/21/2010	TW-17 JA41502-1 3/8/2010	TW-18 JA41502-2 3/8/2010	TW-18 DUP JA41502-3 3/8/2010	TW-19 JA41502-9 3/8/2010	TW-20 JA41502-4 3/8/2010	TW-21 JA41502-5 3/8/2010
VOLATILE ORGANIC COMPOUNDS (µg/l)													
1,1-Dichloroethane	170	1 U	1 U	1 U	1 U	1 U	1 U	**3.3**	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	55	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Tetrachloroethene	150	1 U	1 U	1 U	1 U	1 U	**0.39 J**	**3.9**	1 U	1 U	1 U	1 U	1 U
1,1,1-Trichloroethane	17000	1 U	1 U	1 U	1 U	1 U	1 U	**15.6**	1 U	1 U	1 U	1 U	1 U
Trichloroethene	12	**0.37 J**	1 U	1 U	1 U	1 U	1 U	**18.3**	1 U	1 U	1 U	1 U	**0.49 J**
Vinyl chloride	5.1	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	**0.73 J**	1 U

Notes:
NR VSGW = Non-Residential Groundwater Vapor Screening.
µg/l = micrograms per liter.
Boxed concentrations exceed the 1/10th of the DRAFT PADEP NR VSGW.
U = Not detected above laboratory detection limit.
U' = Laboratory reporting limit exceeds the applicable regulatory standard or criteria being utilized.
J = Result below the reporting limit (estimated value).
Bedrock well MW-49A has a screen interval of 15-35 feet below ground surface. No water was encountered in an overburden layer. This well is therefore included on this table.
Overburden monitoring wells MW-61 and MW-47 are not included in this table as the screened interval is not consitent with the criteria for vapor screening.

Table 3. VISL Calculator Cumulative Risk Results for Groundwater. Former Bishop Tube Site; Malvern, Pennsylvania.

Property Address	Property Type	Cumulative Carcinogenic Risk (1E-04 target)	Cumulative Hazard Quotient (1 target)
MW-14	Commercial	2E-06	0.6
MW-16	Commercial	5E-05	20
MW-32	Commercial	NA	NA
MW-33	Residential	3E-05	8
MW-34	Residential	3E-05	7
MW-35	Residential	5E-05	10
MW-36	Commercial	NA	NA
MW-37	Commercial	4E-05	10
MW-38	Commercial	4E-04	100
MW-40	Commercial	9E-06	3
MW-41	Commercial	NA	NA
MW-42	Commercial	2E-04	50
MW-46	Commercial	3E-06	1
MW-49A	Commercial	NA	NA
MW-60	Commercial	NA	NA
MW-62	Commercial	NA	NA
MW-63	Commercial	3E-04	100
PZ-1	Commercial	1E-05	3
PZ-3	Commercial	NA	NA
PZ-4	Commercial	NA	NA
PZ-5	Commercial	NA	NA
PZ-6	Commercial	4E-05	10
PZ-7	Commercial	NA	NA
TW-1	Commercial	5E-05	20
TW-2	Commercial	1E-04	40
TW-3	Commercial	NA	NA
TW-4	Commercial	NA	NA
TW-5	Commercial	5E-04	200
TW-8	Commercial	NA	NA
TW-9	Commercial	NA	NA
TW-10	Commercial	NA	NA
TW-11	Commercial	NA	NA
TW-12R	Commercial	NA	NA
TW-13	Commercial	NA	NA
TW-14	Commercial	NA	NA
TW-15	Commercial	NA	NA
TW-16	Commercial	NA	NA
TW-17	Commercial	3E-06	0.8
TW-18	Commercial	NA	NA
TW-19	Commercial	NA	NA
TW-20	Commercial	NA	NA
TW-21	Commercial	NA	NA

Notes:
NA = Not applicable, all compounds screened out of assessment using PADEP draft guidance criteria.

FIGURES

Legend

- Temporary Well Point Location and Identification
- Overburden Monitoring Well Location and Identification
- Bedrock Monitoring Well Location and Identification
- Does not Exceed Cumulative Risk Criteria for Groundwater Vapor Intrusion as Applicable Based on Zoning
- Exceeds Cumulative Risk Criteria for Groundwater Vapor Intrusion as Applicable Based on Zoning
- Stream
- Drainage Swale
- Property Boundary Boundary
- Parcels

Vapor Screening Criteria

Shallow groundwater data at all locations were screened against 1/10th of the draft PADEP residential or non-residential vapor intrusion screening criteria for groundwater as applicable based on zoning. For locations where one or more site-related compounds exceeded 1/10th of the applicable draft PADEP vapor intrusionscreening criteria, site-related data were carried through the cumulative risk evaluation using the USEPA VISL calculator for groundwater.

On-site Information Not Depicted

Concentrations of volatile organic compounds are known to exist in shallow groundwater onsite at levels that exceed the draft residential and non-residential PADEP vapor intrusion screening criteria. Therefore, on-site screening information is not depicted.

Notes:

1. Service Layer Credits: ESRI, DigitalGlobe, GeoEye, Earthstar Geopgraphics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Layer Access Date: 5/12/2016.
2. Wells and temporary well points that were dry at the time of sample collection are not displayed.
3. Monitoring wells MW-61 and MW-47 are not displayed as they do not represent shallow water table conditions.
4. Bedrock well locations, with the exception of MW-49A, are not depicted.
5. MW-49A has a screen interval of 15-35 feet below ground surface. No water was encountered in an overburden layer. This well is therefore included for the purposes of vapor screening.
6. The draft revisions to Land Recycling Program Technical Guidance for Vapor Intrusion into Buildings from Groundwater and Soil under Act 2 (Document Number 261-0300-101), released for public comment by DEP on July 25, 2015, were obtained from the DEP website.
7. The Hazard Quotient was calculated using the USEPA VISL calculator for Site-Related compounds at each sample location.
8. The most recent sample results for each sampling location were used in the groundwater vapor screening and USEPA VISL calculator as appropriate.

125 0 125 250 Feet

Title:

OFF-SITE COMPOSITE SHALLOW GROUNDWATER VAPOR SCREENING MAP 2009 AND 2014

FORMER BISHOP TUBE FACILITY
CHESTER COUNTY, PENNSYLVANIA

Prepared For:

BISHOP TUBE PROJECT TEAM

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

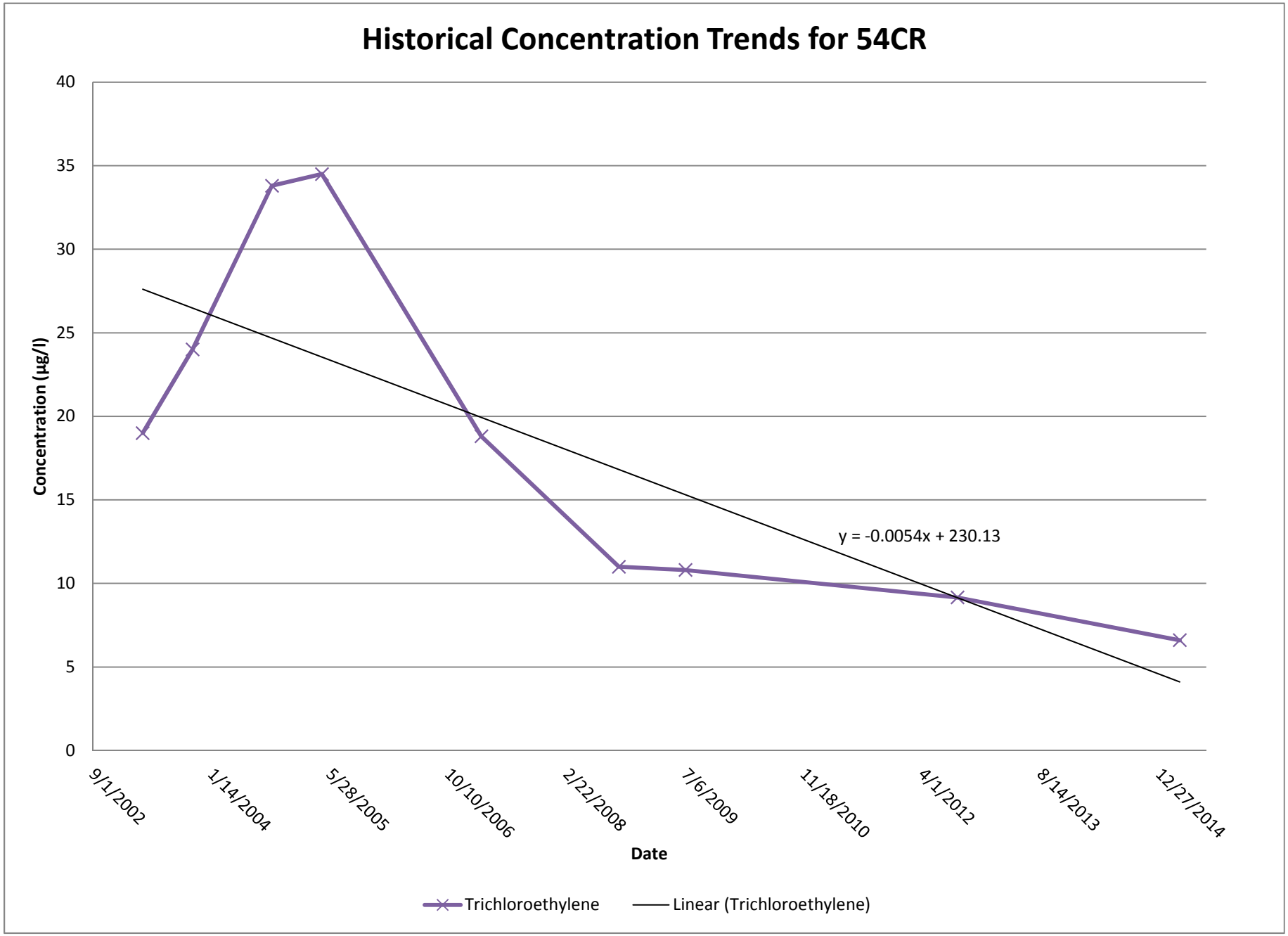
Compiled by: SSPR	Date: 5/12/2016	FIGURE
Prepared by: SSPR	Scale: 1:1,500	1
Project Mgr: JAK	Office: NJ	
File No: 2110.F1(DL)	Project: 0539.0003J000	

C:\PROJECTS\0539\0.3 - Site\Evening - 20150209\PROJECT EARLIAST\GIS\Letter Responses to DEPP\1D\Vapor Screening\Overlaid\TWPR.mxd

ATTACHMENT 1

HISTORICAL GROUNDWATER TREND CHARTS FOR SELECT WELLS

2003-PRESENT


Historical Concentration Trends for 54CR
Concentration (µg/l)
40
35
30
25
20
15
10
5
0
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
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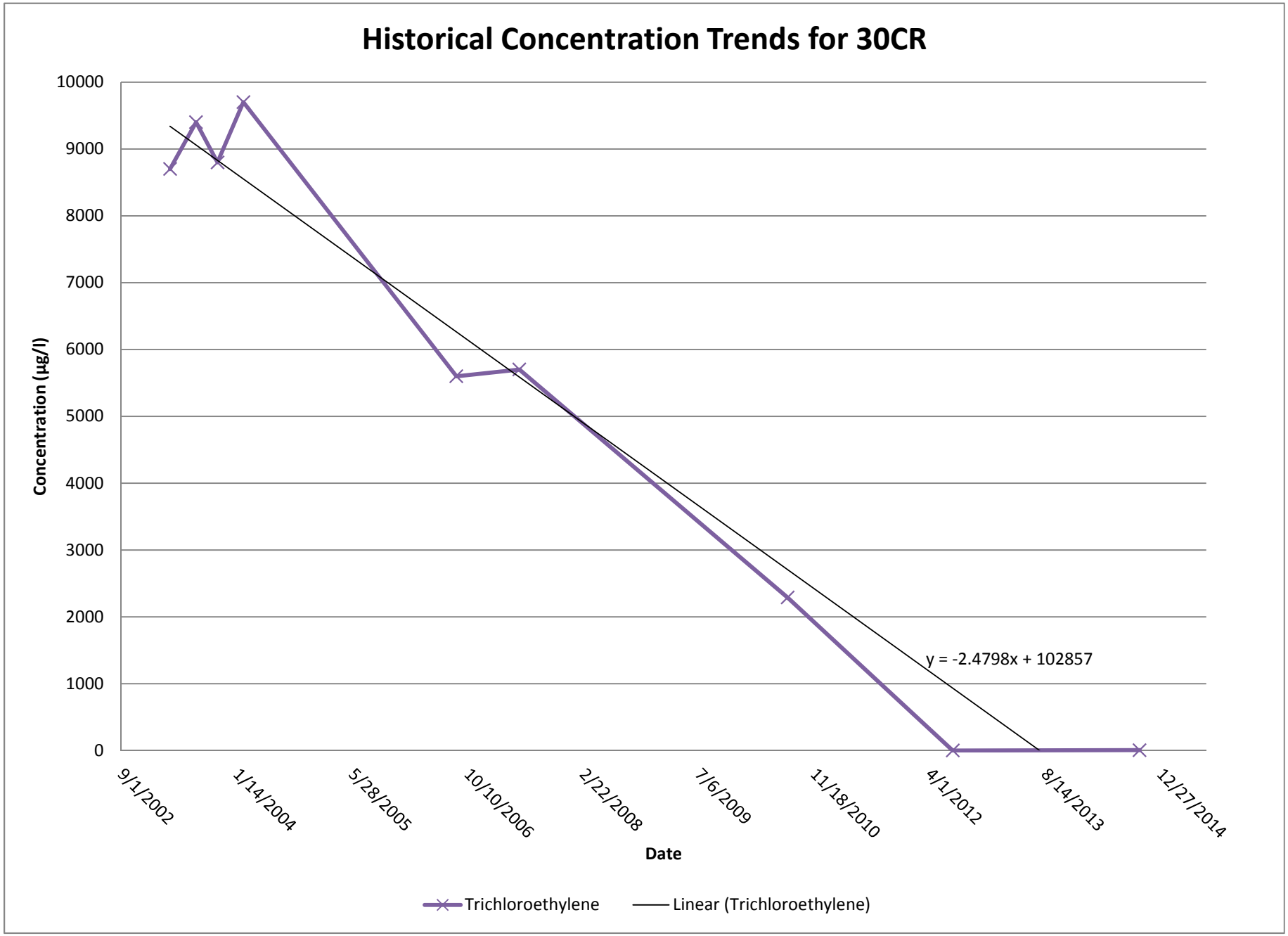
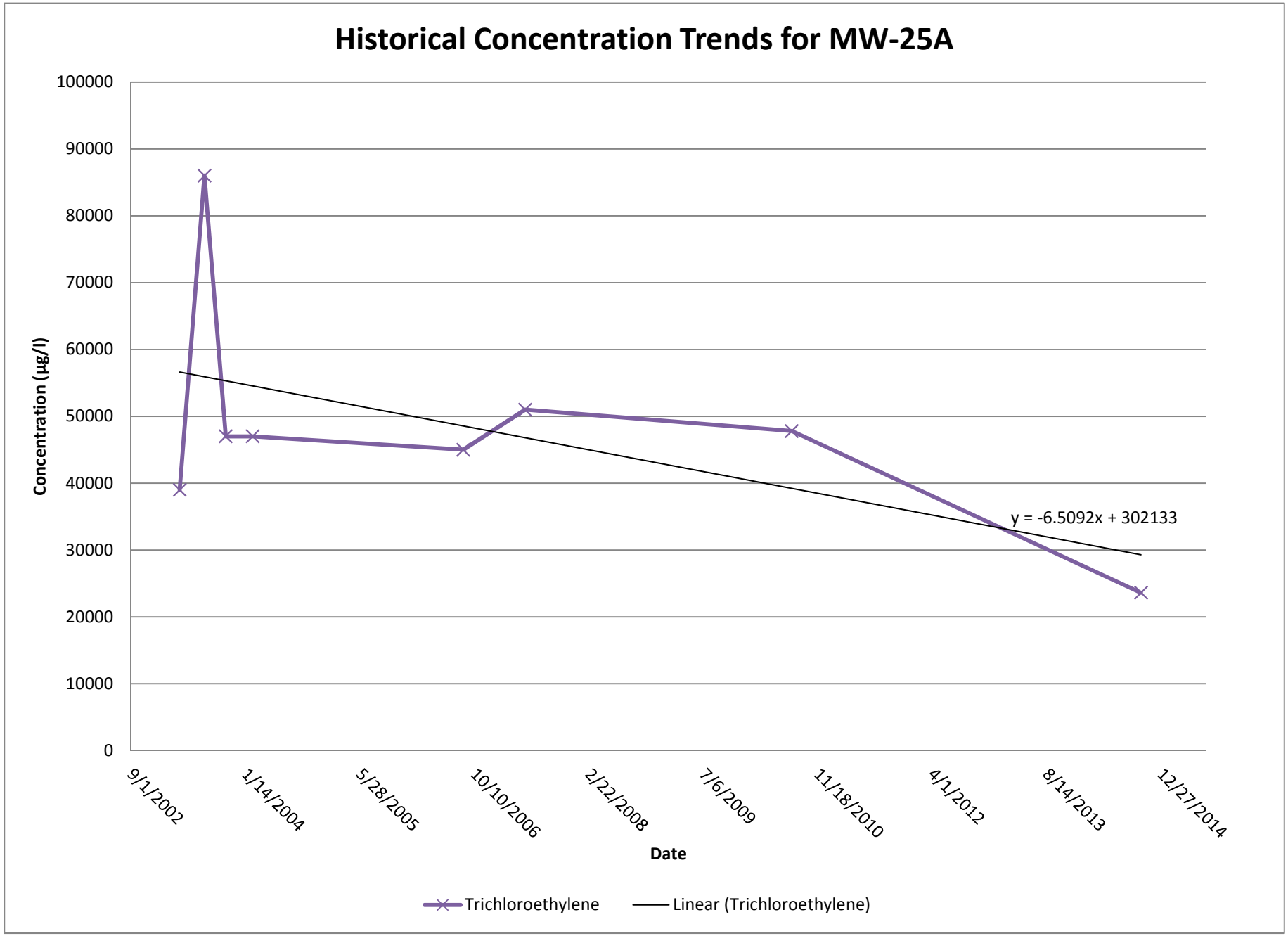
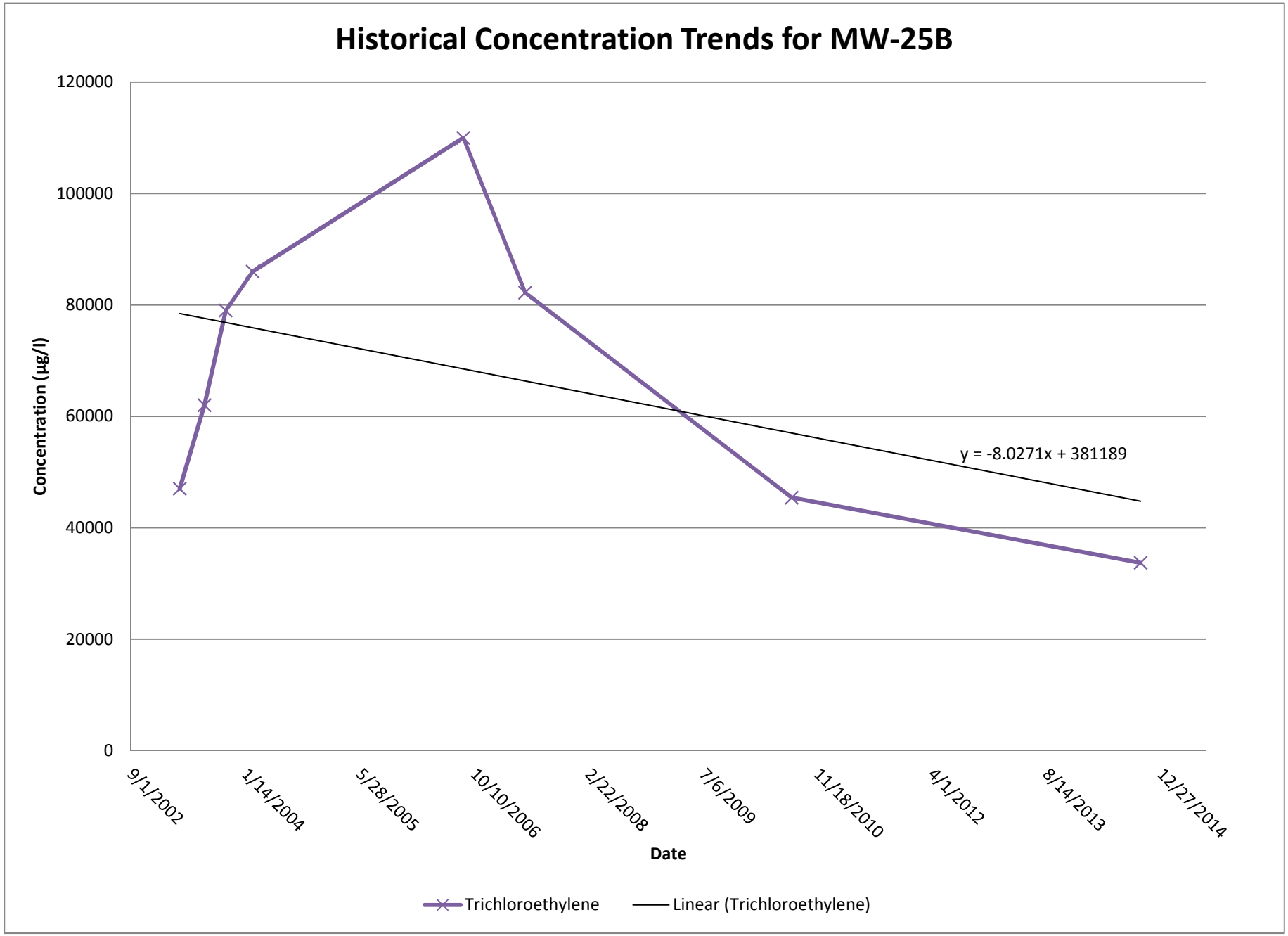
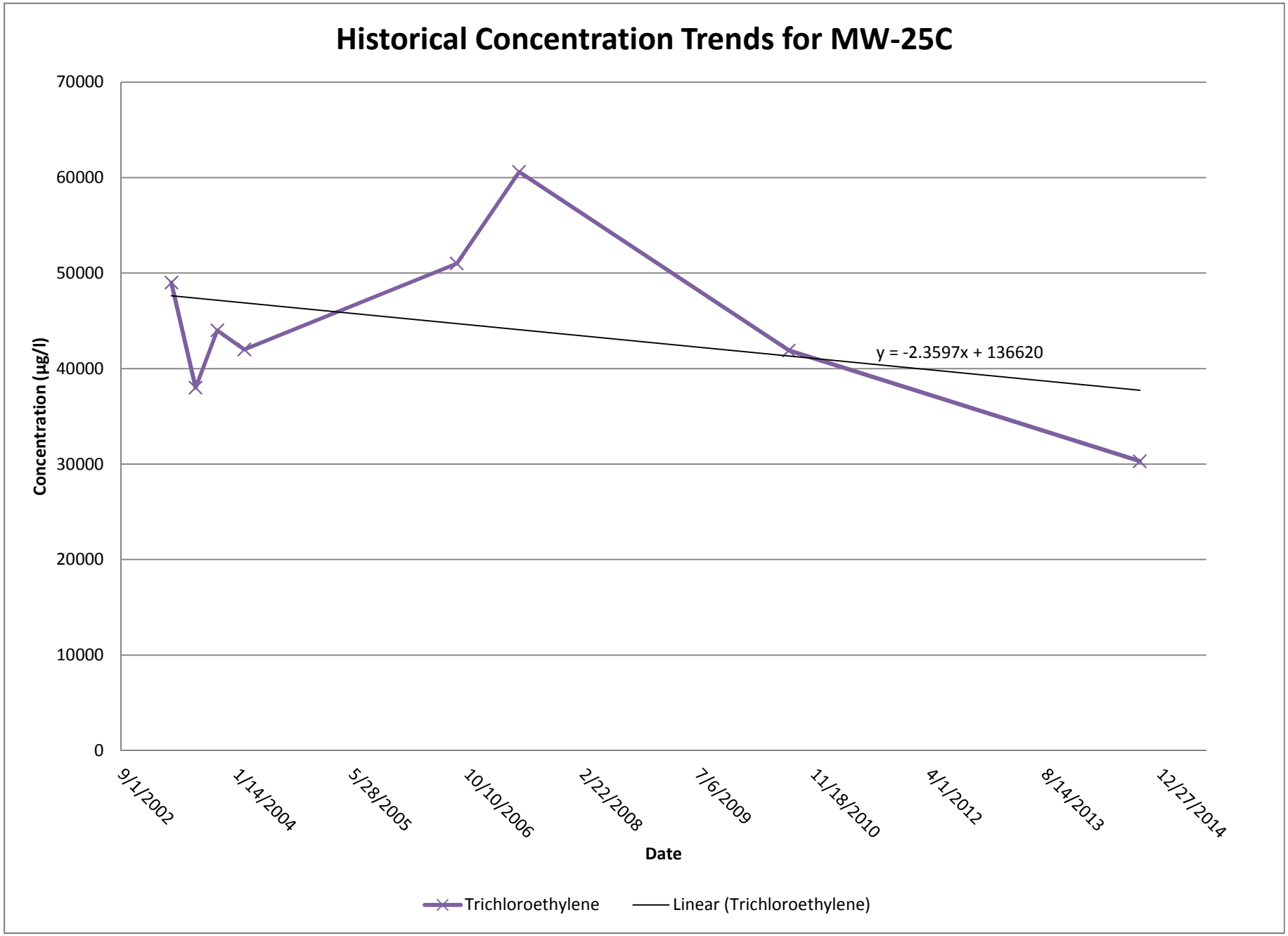
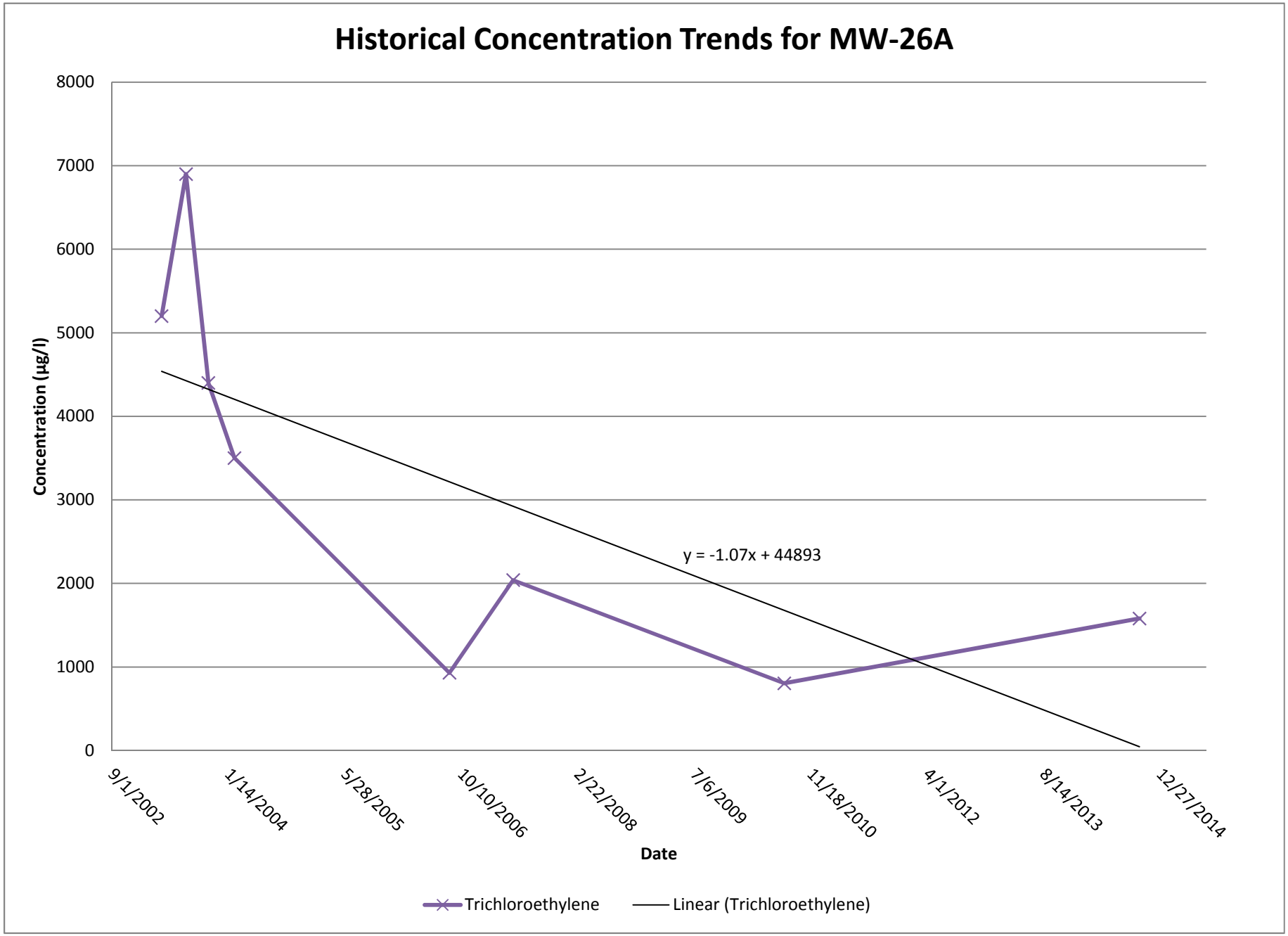
Trichloroethylene
Linear (Trichloroethylene)

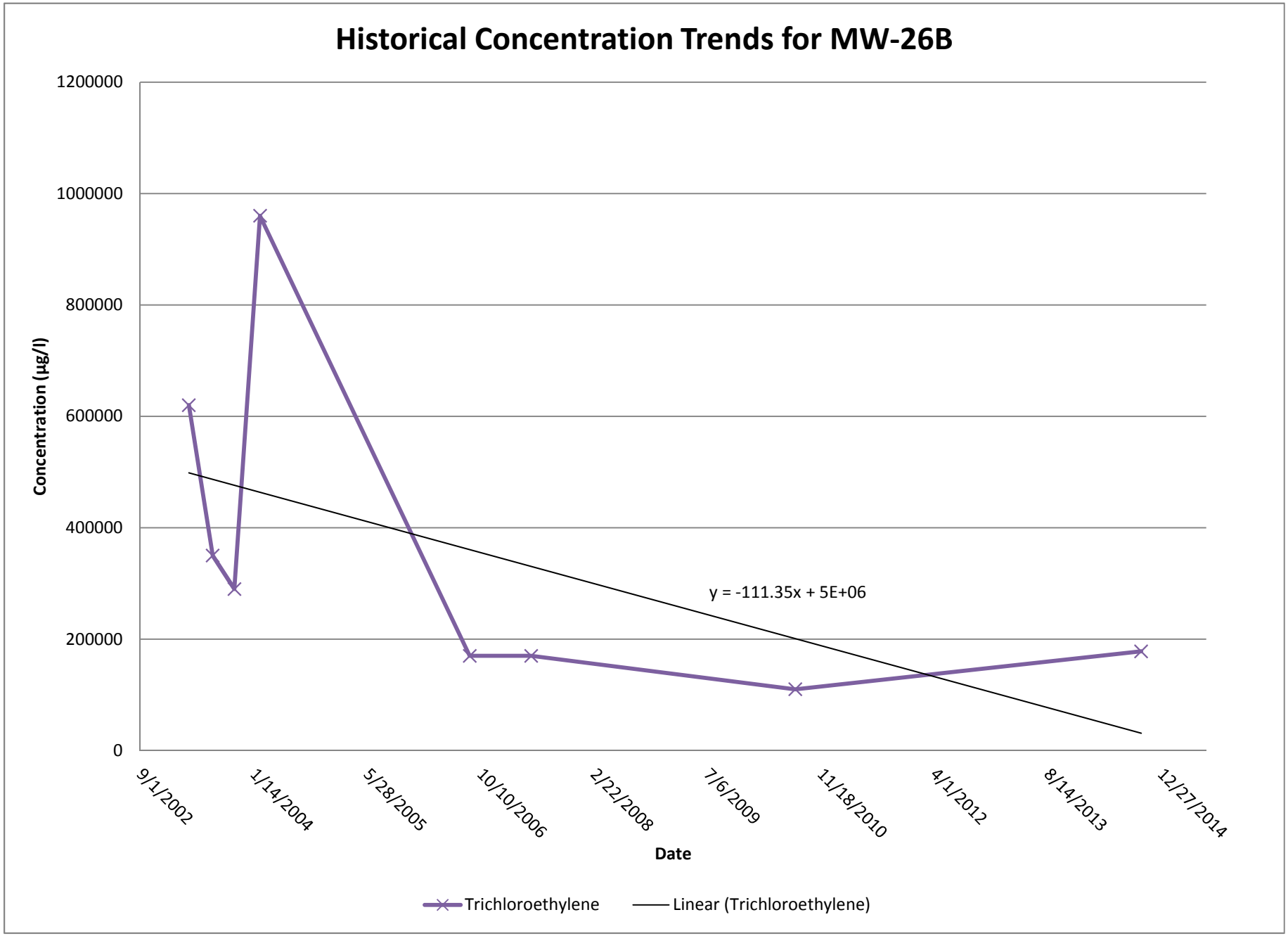

Historical Concentration Trends for 30CR
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Concentration (µg/l)
y = -2.4798x + 102857
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)

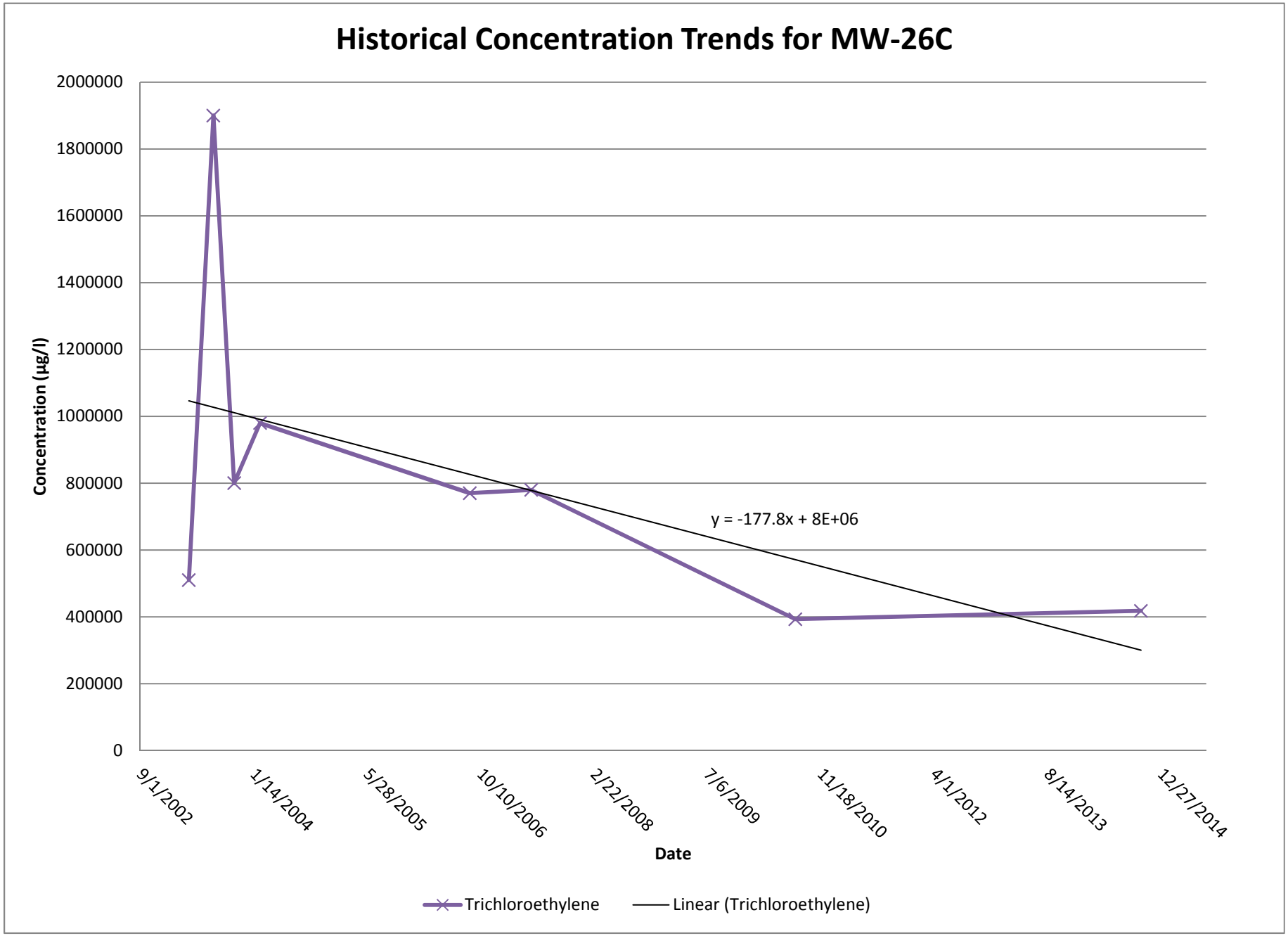

Historical Concentration Trends for MW-25A
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Concentration (µg/l)
y = -6.5092x + 302133
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)

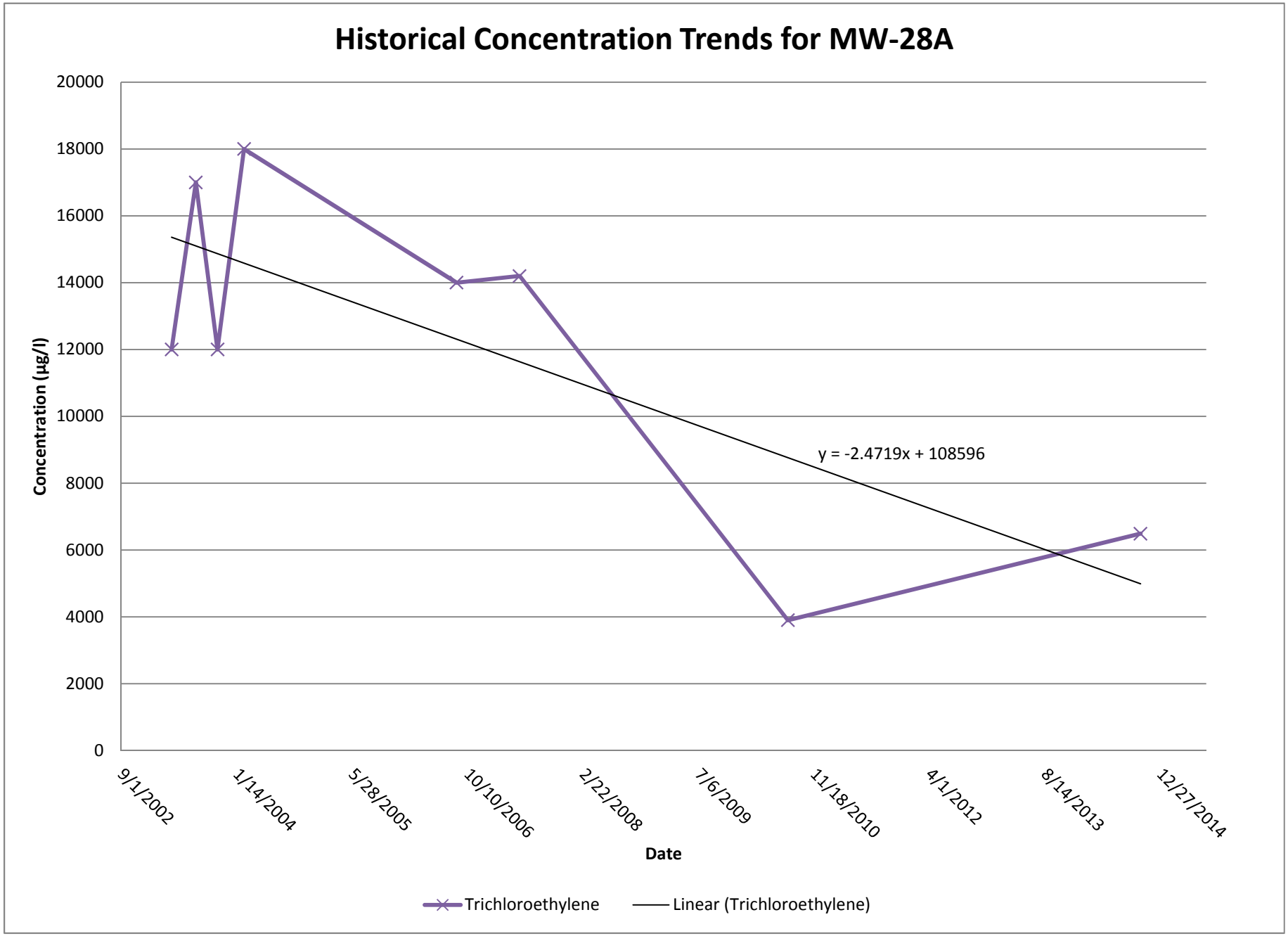

Historical Concentration Trends for MW-25B
120000
100000
80000
60000
40000
20000
0
Concentration (µg/l)
y = -8.0271x + 381189
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)

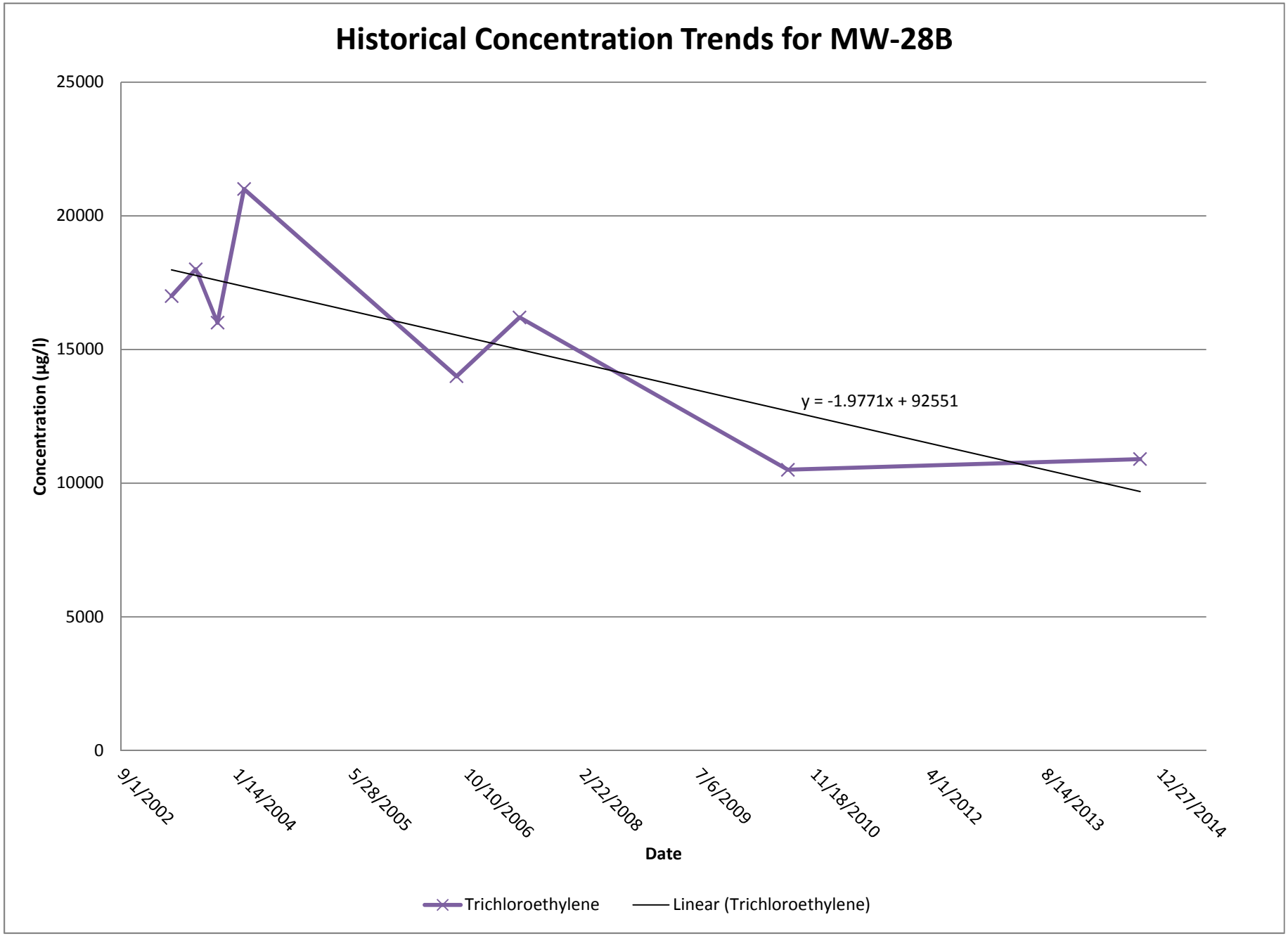

Historical Concentration Trends for MW-25C
70000
60000
50000
40000
30000
20000
10000
0
Concentration (µg/l)
y = -2.3597x + 136620
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)

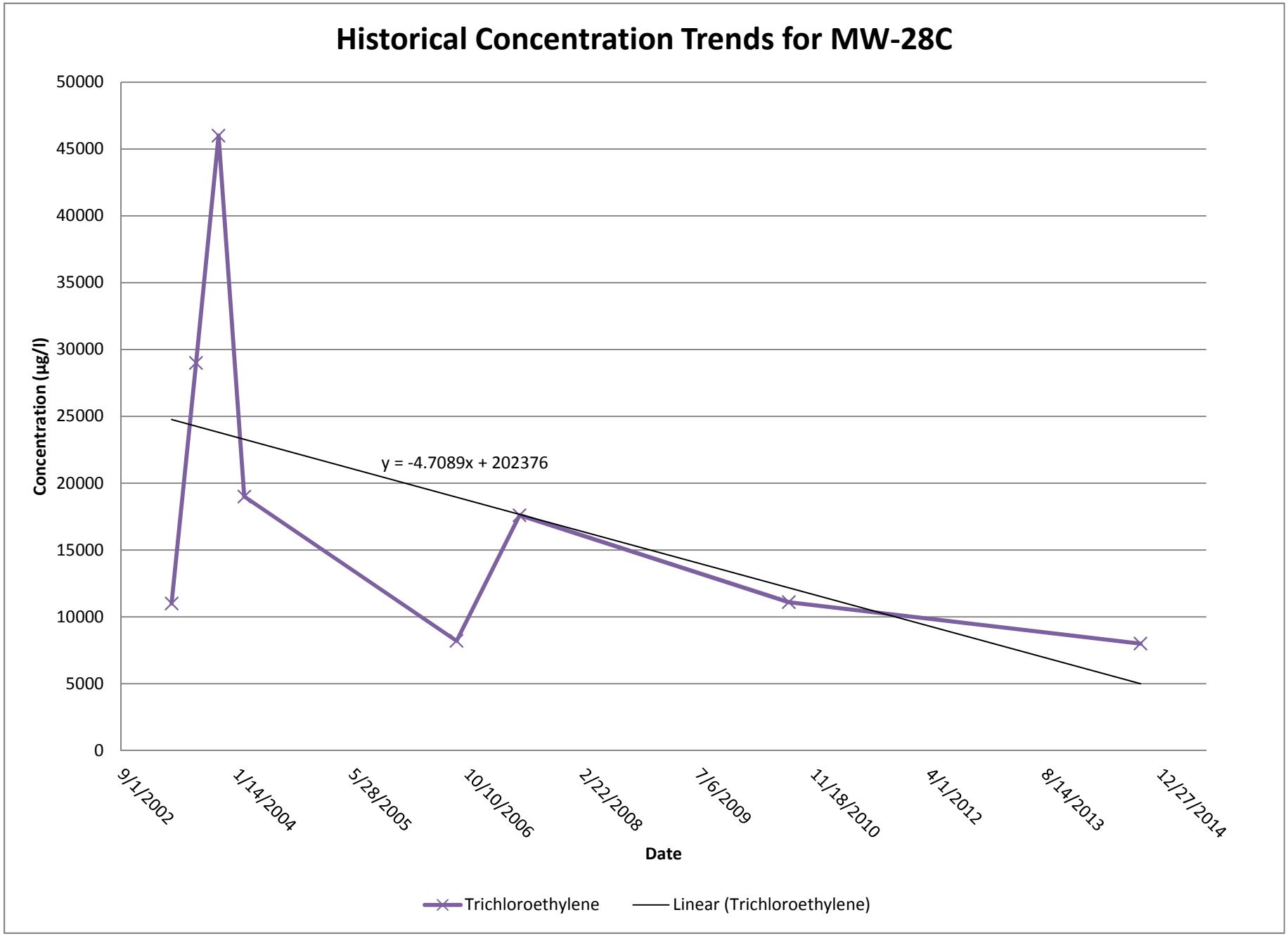

Historical Concentration Trends for MW-26A
8000
7000
6000
5000
4000
3000
2000
1000
0
Concentration (µg/l)
y = -1.07x + 44893
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)


Historical Concentration Trends for MW-26B
1200000
1000000
800000
600000
400000
200000
0
Concentration (µg/l)
y = -111.35x + 5E+06
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)


Historical Concentration Trends for MW-26C
2000000
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
Concentration (µg/l)
y = -177.8x + 8E+06
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)


Historical Concentration Trends for MW-28A
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Concentration (µg/l)
y = -2.4719x + 108596
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)


Historical Concentration Trends for MW-28B
25000
20000
15000
10000
5000
0
Concentration (µg/l)
y = -1.9771x + 92551
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)


Historical Concentration Trends for MW-28C
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Concentration (µg/l)
y = -4.7089x + 202376
9/1/2002
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013
12/27/2014
Date
Trichloroethylene
Linear (Trichloroethylene)

ATTACHMENT 2

REVISED INDOOR AIR VISL CALCULATOR SHEETS

OSWER VAPOR INTRUSION ASSESSMENT
Indoor Air Concentration to Risk (IAC-Risk) Calculator Version 3.45, November 2015 RSLs
54 CONESTOGA ROAD (Average)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column E)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column F)

CAS	Chemical Name	Site Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Cia	CR	HQ
		(ug/m^3)		
79-01-6	Trichloroethylene	2.85E+00	6.0E-06	**1.4E+00**

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
see note	I	2.00E-03	I	TCE

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_IA	70	ATc_C_IA	70	ATc_IA	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_IA	26	ATnc_C_IA	25	ATnc_IA	26
Exposure duration	(yrs)	ED_R_IA	26	ED_C_IA	25	ED_IA	26
Exposure frequency	(days/yr)	EF_R_IA	350	EF_C_IA	250	EF_IA	350
Exposure time	(hr/day)	ET_R_IA	24	ET_C_IA	8	ET_IA	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_IA	0.001	AFgw_C_IA	0.001	AFgw_IA	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_IA	0.03	AFss_C_IA	0.03	AFss_IA	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_IA	1.00E-06	mIURTCE_C_IA	0.00E+00	mIURTCE_IA	1.00E-06
	IURTCE_R_IA	3.10E-06	IURTCE_C_IA	4.10E-06	IURTCE_IA	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Indoor Air Concentration to Risk (IAC-Risk) Calculator Version 3.45, November 2015 RSLs
154 LANCASTER AVENUE (Garage)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column E)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column F)

CAS	Chemical Name	Site Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Cia	CR	HQ
		(ug/m^3)		
79-01-6	Trichloroethylene	1.90E+00	6.4E-07	2.2E-01

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
see note	I	2.00E-03	I	TCE

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_IA	70	ATc_C_IA	70	ATc_IA	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_IA	26	ATnc_C_IA	25	ATnc_IA	25
Exposure duration	(yrs)	ED_R_IA	26	ED_C_IA	25	ED_IA	25
Exposure frequency	(days/yr)	EF_R_IA	350	EF_C_IA	250	EF_IA	250
Exposure time	(hr/day)	ET_R_IA	24	ET_C_IA	8	ET_IA	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_IA	0.001	AFgw_C_IA	0.001	AFgw_IA	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_IA	0.03	AFss_C_IA	0.03	AFss_IA	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_IA	1.00E-06	mIURTCE_C_IA	0.00E+00	mIURTCE_IA	0.00E+00
	IURTCE_R_IA	3.10E-06	IURTCE_C_IA	4.10E-06	IURTCE_IA	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Indoor Air Concentration to Risk (IAC-Risk) Calculator Version 3.45, November 2015 RSLs
154 LANCASTER AVENUE (Store)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column E)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column F)

CAS	Chemical Name	Site Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Cia	CR	HQ
		(ug/m^3)		
79-01-6	Trichloroethylene	2.50E+01	8.4E-06	**2.9E+00**

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
see note	I	2.00E-03	I	TCE

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_IA	70	ATc_C_IA	70	ATc_IA	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_IA	26	ATnc_C_IA	25	ATnc_IA	25
Exposure duration	(yrs)	ED_R_IA	26	ED_C_IA	25	ED_IA	25
Exposure frequency	(days/yr)	EF_R_IA	350	EF_C_IA	250	EF_IA	250
Exposure time	(hr/day)	ET_R_IA	24	ET_C_IA	8	ET_IA	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_IA	0.001	AFgw_C_IA	0.001	AFgw_IA	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_IA	0.03	AFss_C_IA	0.03	AFss_IA	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_IA	1.00E-06	mIURTCE_C_IA	0.00E+00	mIURTCE_IA	0.00E+00
	IURTCE_R_IA	3.10E-06	IURTCE_C_IA	4.10E-06	IURTCE_IA	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Indoor Air Concentration to Risk (IAC-Risk) Calculator Version 3.45, November 2015 RSLs
95 VILLAGE WAY

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column E)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column F)

CAS	Chemical Name	Site Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Cia	CR	HQ
		(ug/m^3)		
107-06-2	Dichloroethane, 1,2-	8.10E-01	7.5E-06	1.1E-01

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
2.60E-05	I	7.00E-03	P	

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_IA	70	ATc_C_IA	70	ATc_IA	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_IA	26	ATnc_C_IA	25	ATnc_IA	26
Exposure duration	(yrs)	ED_R_IA	26	ED_C_IA	25	ED_IA	26
Exposure frequency	(days/yr)	EF_R_IA	350	EF_C_IA	250	EF_IA	350
Exposure time	(hr/day)	ET_R_IA	24	ET_C_IA	8	ET_IA	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_IA	0.001	AFgw_C_IA	0.001	AFgw_IA	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_IA	0.03	AFss_C_IA	0.03	AFss_IA	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Trichloroethylene						
	mIURTCE_R_IA	1.00E-06	mIURTCE_C_IA	0.00E+00	mIURTCE_IA	1.00E-06
	IURTCE_R_IA	3.10E-06	IURTCE_C_IA	4.10E-06	IURTCE_IA	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:

I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Indoor Air Concentration to Risk (IAC-Risk) Calculator Version 3.45, November 2015 RSLs
97 VILLAGE WAY (Average)

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column E)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column F)

CAS	Chemical Name	Site Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Cia	CR	HQ
		(ug/m^3)		
79-01-6	Trichloroethylene	1.80E+00	3.8E-06	8.6E-01

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
see note	I	2.00E-03	I	TCE

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_IA	70	ATc_C_IA	70	ATc_IA	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_IA	26	ATnc_C_IA	25	ATnc_IA	26
Exposure duration	(yrs)	ED_R_IA	26	ED_C_IA	25	ED_IA	26
Exposure frequency	(days/yr)	EF_R_IA	350	EF_C_IA	250	EF_IA	350
Exposure time	(hr/day)	ET_R_IA	24	ET_C_IA	8	ET_IA	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_IA	0.001	AFgw_C_IA	0.001	AFgw_IA	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_IA	0.03	AFss_C_IA	0.03	AFss_IA	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Trichloroethylene						
	mIURTCE_R_IA	1.00E-06	mIURTCE_C_IA	0.00E+00	mIURTCE_IA	1.00E-06
	IURTCE_R_IA	3.10E-06	IURTCE_C_IA	4.10E-06	IURTCE_IA	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:

I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Indoor Air Concentration to Risk (IAC-Risk) Calculator Version 3.45, November 2015 RSLs
10 WINDING WAY

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column E)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column F)

CAS	Chemical Name	Site Indoor Air Concentration	VI Carcinogenic Risk	VI Hazard
		Cia	CR	HQ
		(ug/m^3)		
79-01-6	Trichloroethylene	3.90E-01	8.2E-07	1.9E-01

Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator
IUR		RfC		
(ug/m^3)$^{-1}$		(mg/m^3)		i
see note	I	2.00E-03	I	TCE

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_IA	70	ATc_C_IA	70	ATc_IA	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_IA	26	ATnc_C_IA	25	ATnc_IA	26
Exposure duration	(yrs)	ED_R_IA	26	ED_C_IA	25	ED_IA	26
Exposure frequency	(days/yr)	EF_R_IA	350	EF_C_IA	250	EF_IA	350
Exposure time	(hr/day)	ET_R_IA	24	ET_C_IA	8	ET_IA	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_IA	0.001	AFgw_C_IA	0.001	AFgw_IA	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_IA	0.03	AFss_C_IA	0.03	AFss_IA	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_IA	1.00E-06	mIURTCE_C_IA	0.00E+00	mIURTCE_IA	1.00E-06
	IURTCE_R_IA	3.10E-06	IURTCE_C_IA	4.10E-06	IURTCE_IA	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:

I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

ATTACHMENT 3

GROUNDWATER VISL CALCULATOR DATA SHEETS

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-33

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.9E+01	1.56E+01	3.3E-05	**7.5E+00**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	26
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	26
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	350
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	1.00E-06
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
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CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-34

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.4E+01	1.36E+01	2.8E-05	**6.5E+00**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	26
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	26
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	350
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	1.00E-06
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-35

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	6.4E+01	2.58E+01	5.4E-05	**1.2E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	26
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	26
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	350
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	1.00E-06
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-14

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	1.3E+01	5.19E+00	1.7E-06	5.9E-01	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-16

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.4E+02	1.39E+02	4.6E-05	**1.6E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-37

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.0E+02	1.22E+02	4.1E-05	**1.4E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-38

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature °C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	2.9E+03	1.17E+03	**3.9E-04**	**1.3E+02**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-40

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	6.6E+01	2.67E+01	8.9E-06	**3.0E+00**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-42

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	1.1E+03	4.39E+02	**1.5E-04**	**5.0E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	5.2E+00	5.91E+00	2.1E-06	1.3E-02	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-46

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	2.4E+01	9.46E+00	3.2E-06	**1.1E+00**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
MW-63

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	2.5E+03	9.99E+02	**3.3E-04**	**1.1E+02**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
PZ-1

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	6.5E+01	2.61E+01	8.7E-06	**3.0E+00**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	5.9E+00	6.71E+00	2.4E-06	1.5E-02	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
PZ-6

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.1E+02	1.26E+02	4.2E-05	**1.4E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
TW-1

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.4E+02	1.35E+02	4.5E-05	**1.5E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
TW-2

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	7.6E+02	3.05E+02	**1.0E-04**	**3.5E+01**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
TW-5

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR ($(ug/m^3)^{-1}$)	IUR Source*	Reference Concentration RfC ((mg/m^3))	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	2.0E+02	4.66E+01	6.1E-06	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	3.5E+03	1.42E+03	**4.7E-04**	**1.6E+02**	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

OSWER VAPOR INTRUSION ASSESSMENT
Groundwater Concentration to Indoor Air Concentration (GWC-IAC) Calculator Version 3.45, November 2015 RSLs
TW-17

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Commercial	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-04	Enter target risk for carcinogens (for comparison to the calculated VI carcinogenic risk in column F)
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens (for comparison to the calculated VI hazard in column G)
Average Groundwater Temperature (°C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

CAS	Chemical Name	Site Groundwater Concentration Cgw (ug/L)	Calculated Indoor Air Concentration Cia (ug/m^3)	VI Carcinogenic Risk CR	VI Hazard HQ	Inhalation Unit Risk IUR (ug/m^3)$^{-1}$	IUR Source*	Reference Concentration RfC (mg/m^3)	RFC Source*	Mutagenic Indicator i
75-34-3	Dichloroethane, 1,1-	0.0E+00	0.00E+00	0.0E+00	No RfC	1.60E-06	CA			
107-06-2	Dichloroethane, 1,2-	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-05	I	7.00E-03	P	
127-18-4	Tetrachloroethylene	0.0E+00	0.00E+00	0.0E+00	0.0E+00	2.60E-07	I	4.00E-02	I	
71-55-6	Trichloroethane, 1,1,1-	0.0E+00	0.00E+00	No IUR	0.0E+00			5.00E+00	I	
79-01-6	Trichloroethylene	1.8E+01	7.37E+00	2.5E-06	8.4E-01	see note	I	2.00E-03	I	TCE
75-01-4	Vinyl Chloride	0.0E+00	0.00E+00	0.0E+00	0.0E+00	4.40E-06	I	1.00E-01	I	VC

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Averaging time for carcinogens	(yrs)	ATc_R_GW	70	ATc_C_GW	70	ATc_GW	70
Averaging time for non-carcinogens	(yrs)	ATnc_R_GW	26	ATnc_C_GW	25	Atnc_GW	25
Exposure duration	(yrs)	ED_R_GW	26	ED_C_GW	25	ED_GW	25
Exposure frequency	(days/yr)	EF_R_GW	350	EF_C_GW	250	EF_GW	250
Exposure time	(hr/day)	ET_R_GW	24	ET_C_GW	8	ET_GW	8

(2) **Generic Attenuation Factors:**

Source Medium of Vapors		Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
Groundwater	(-)	AFgw_R_GW	0.001	AFgw_C_GW	0.001	AFgw_GW	0.001
Sub-Slab and Exterior Soil Gas	(-)	AFss_R_GW	0.03	AFss_C_GW	0.03	AFss_GW	0.03

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario) Symbol	Selected (based on scenario) Value
	mIURTCE_R_GW	1.00E-06	mIURTCE_C_GW	0.00E+00	mIURTCE_GW	0.00E+00
	IURTCE_R_GW	3.10E-06	IURTCE_C_GW	4.10E-06	IURTCE_GW	4.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 25 — This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at: http://www.oehha.ca.gov/risk/ChemicalDB/index.asp
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
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Pink highlighting indicates VI carcinogenic risk greater than the target risk for carcinogens (TCR) or VI Hazard greater than or equal to the target hazard quotient for non-carcinogens (THQ).

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December 15, 2016

Mr. Dustin Armstrong
Environmental Cleanup Program
PA Department of Environmental Protection
2 East Main Street
Norristown, Pennsylvania 19401

Re: Bishop Tube Site
Remedial Investigation and Treatability Study Completion Reports
Response to DEP Comments

Dear Mr. Armstrong:

On behalf of the Bishop Tube Project Team ("BT Team"), Roux Associates, Inc. ("Roux Associates") has prepared this letter to address outstanding comments from the Pennsylvania Department of Environmental Protection ("DEP") related to the Remedial Investigation Report ("RIR") dated August 31, 2015, as well as the Treatability Study Completion Report ("TSCR") dated October 9, 2015. To date, correspondence has included the following letters, meetings and conference calls:

- DEP comment letter dated December 31, 2015;
- Conference call between DEP and Roux on January 28, 2016;
- Technical meeting with DEP and BT Team representatives on April 8, 2016;
- BT Team response letter dated May 13, 2016;
- DEP response letter dated June 20, 2016;
- Conference call between DEP and Roux on June 27, 2016; and
- Conference call between DEP and the BT Team on November 3, 2016.

The outstanding comments and the BT Team's responses are provided below. In some instances, DEP comments are grouped together where a combined response is warranted.

Vapor Intrusion

Significant Figures

DEP has taken the position that the hazard indices ("HIs") prepared as part of the cumulative vapor intrusion ("VI") risk assessment calculations for indoor air and groundwater are to be reported to two (2) significant figures. While the BT Team continues to believe this requirement is inconsistent with published risk assessment guidance, as previously described in its May 13, 2016 letter to DEP, we will revise our prior submissions to report HIs to two (2) significant figures. Revised cumulative risk calculations will be presented in a future supplemental RI letter report which will include both existing and newly proposed (see below) indoor air and groundwater sampling data.

Residential Exposure Scenario for 39 Conestoga Road

The DEP position is that the use of the property located at 39 Conestoga Road as a theater with temporary housing facilities for itinerant actors requires the assessment of this property under a residential use scenario, despite the non-residential zoning designation. Although the BT Team maintains that the use of this property is inconsistent with residential exposure assumptions,[1] we will revise calculations and submit revised figures and conclusions, as warranted, under a residential exposure scenario. Based on existing data, a site-specific risk assessment should not be necessary to dismiss the VI pathway as a potential concern assuming a residential exposure scenario for this property. The revised evaluation will be presented in a future supplemental RI letter report which will include both existing and newly proposed (see below) indoor air and groundwater sampling data.

Supplemental Indoor Air Sampling

Supplemental indoor air sampling activities have been requested by DEP and/or proposed by the BT Team for several properties. The details (i.e., precise number of samples, sample locations and methodologies) of the supplemental indoor air sampling will be described in a brief work plan addendum submitted via e-mail for DEP approval. In general, all indoor air and ambient air samples will be collected following the same procedures presented in the RIR except where they may warrant modification to conform to the new PADEP VI Guidance published on November 19, 2016 in the PA Bulletin. The work plan addendum will be a stand-alone submission. Expedited DEP review and approval of the work plan is requested to allow the proposed indoor air sampling to be completed during the 2017 winter heating season. Actual sampling timing will be contingent upon access approval from property owners.

To confirm DEP alignment with the general scope of supplemental indoor air sampling, brief summaries of the proposed sampling are below. Results of this indoor air sampling will be assessed using the agreed default protocols for determining cumulative risk. If necessary, a cumulative risk assessment will be conducted using the United States Environmental Protection Agency (USEPA) VI risk calculator (see below).

154 Lancaster Avenue

As previously described in the May 13, 2016 letter, the BT Team proposes to collect two supplemental rounds of additional indoor air samples at this property during the heating season. One sample each will be collected from both the garage and store sides of the existing structure during each round (consistent with previous sampling events).

54 Conestoga Road

The BT Team proposes to collect two supplemental rounds of indoor air sampling during the heating season. One sample each will be collected from both the first floor (i.e., lowest living space) and the basement (i.e., lowest level of structure) during each round.

39 Conestoga Road

[1] Residential exposure presumes the structures are occupied 24 hours per day for 350 days per year for 30 years.

One supplemental round of indoor air samples will be collected from this property during the heating season. It should be noted that two rounds were previously collected in April 2010 and March 2011; however, the average outdoor temperature for the April 2010 event was not more than 15 degrees below the minimum indoor air temperature (i.e., room temperature). One sample will be collected from the lowest level of the theater (i.e., lobby area), consistent with prior sampling events.

97 Village Way
Following installation of a sump at 97 Village Way, the BT Team collected two rounds of indoor air samples. However, as noted by DEP in their June 20, 2016 letter, the second confirmatory round was collected in May 2015 when the average outdoor temperature was not more than 15 degrees below the minimum indoor air temperature (i.e., room temperature). The BT Team proposes collecting one sample during the heating season from the basement, biased towards the location of the sump (consistent with previous sampling events).

Cumulative Vapor Intrusion Risk Assessment – Indoor Air
The cumulative VI risk assessment for indoor air will be recalculated for all properties and presented in a future supplemental RI letter report. The recalculated HIs for each property will a) be reported to two (2) significant figures, b) incorporate the supplemental indoor air sampling data proposed above, and c) consider exposure scenarios for residential and non-residential properties based on zoning, except for 39 Conestoga Road which will be assessed as residential although zoned non-residential. As previously directed by DEP, the calculated HIs will exclude compounds that have not been identified as constituents of concern for the Site.

Cumulative Vapor Intrusion Risk Assessment – Groundwater
DEP has requested maps that summarize the findings from the groundwater-to-VI analysis; one for residential and a second for non-residential exposure scenarios. As described in more detail below in the *30-Year Fate and Transport Model and Sentinel Monitoring Wells* response, both empirical groundwater quality data and concentration/distance regression analysis will be used to define the relevant area for these maps. The results of the VI exposure assessment for groundwater will be presented in a future supplemental RI letter report using the most recent sampling data, including the groundwater sampling proposed below.

Source Area and Groundwater Delineation
30-Year Fate and Transport Model and Sentinel Monitoring Wells
As communicated by DEP, the existing monitoring well network adequately characterizes the overall horizontal and vertical extent of chlorinated volatile organic compounds ("CVOC") impacted groundwater. However, DEP has asked that a combination of groundwater quality data and modeling be used to define the "Site" boundary under Act 2 (i.e., the area potentially subject to institutional controls and/or future monitoring) to ensure effective management of potential exposure pathways from groundwater use and/or the VI pathway. In a related comment, DEP stated that sentinel monitoring points were necessary to evaluate both groundwater and vapor conditions over time.

The BT Team believes the robust groundwater quality dataset provides the most reliable basis for defining and monitoring the groundwater conditions both today and in the future. The existing data support a conclusion that the CVOC plume is at steady state or retracting. The requisite simplifying assumptions of either a numerical (e.g., MODFLOW/MT3D) or analytical model (e.g., BIOCHLOR) analysis are not compatible with the observed complex hydrogeologic conditions and the extended operational history of the site. In part, for this reason, a high degree of uncertainty is inherent with such model analyses, rendering output with little or no value.

As discussed with DEP prior to submission of this response, we believe the approach outlined below more reliably satisfies DEP's stated objectives while minimizing predictive uncertainty.

1. Conduct Additional Groundwater Sampling: Collect two rounds of groundwater samples from selected monitoring wells to: a) confirm existing groundwater quality data; b) further establish temporal data trends; and c) facilitate a robust concentration vs. distance regression analysis (see below).

2. Prepare Distance vs Concentration Graphs: Prepare semi-logarithmic distance versus concentration graphs for overburden, shallow bedrock and deep bedrock intervals. These graphs will be prepared using existing and new groundwater data from monitoring wells located along the centerline of CVOC distribution for overburden, shallow bedrock and deep bedrock aquifer depth intervals. These distance concentration graphs will be utilized to conduct regression analyses to spatially project the area where groundwater Medium Specific Concentrations ("MSCs") may be exceeded (see below).

3. Define Potential VI Exposure Extent: Utilizing groundwater quality data and regression analysis projections, the area where shallow overburden groundwater quality may potentially present a VI exposure risk will be estimated. This area will be depicted in plan view on a map (see previous discussion under "Vapor Intrusion").

4. Define Potential Groundwater Exposure Extent: Utilizing groundwater quality data and regression analysis projections, the area where overburden, shallow bedrock and deep bedrock groundwater may potentially present a groundwater exposure risk will be estimated. This area will be depicted in plan view on a map.

5. Establish Sentinel Monitoring Well Network: Based on the Site boundaries, as defined through existing/new groundwater quality data and regression analysis projections, a sentinel monitoring well network will be proposed. This network will include existing and new (as required) monitoring points. As discussed with DEP, the monitoring points may be designed to assess either soil gas or groundwater.

A Supplemental RI Work Plan ("Supplemental RIWP") will be prepared that includes the following: a) locations and methodology to be employed for supplemental monitoring well sampling; b) methods and details for conducting the distance versus concentration

regression analysis; and c) the approach and criteria for purposes of constructing the potential VI and groundwater exposure MSC area maps. A completion schedule will be included with the work plan. A proposed sentinel monitoring network will be submitted for DEP comment and/or approval after finalization of the potential VI exposure and potential groundwater exposure extent maps described previously.

Assessment of Vapor Intrusion along Little Valley Creek

Based on the Conceptual Site Model ("CSM"), which includes the discharge ("upwelling") of groundwater to Little Valley Creek ("LVC"), DEP requested further assessment of the potential for VI in areas immediately proximate to LVC. Specifically, DEP posed the question whether upwelling of shallow bedrock groundwater containing CVOCs to shallow overburden groundwater might produce potential VI concerns in areas adjacent to LVC, downgradient of MW-32. While this is an appropriate question in the context of the overall CSM, the BT Team does not believe there is a reasonable expectation of exposure beyond that already defined by shallow overburden groundwater quality data. Furthermore, in the unlikely event that such a condition were to exist, it would be limited to undeveloped land adjacent to LVC (i.e., review of aerial photographs shows parking lots, grass fields and no structures).

The bases for this position include the following: a) shallow overburden groundwater analytical results in this area do not reveal CVOC conditions suggestive of hot spot CVOC concentrations potentially attributable to preferential upwelling (e.g., low-level CVOCs are detected in MW-32); b) MW-32 was placed at an identified spring discharge location proximal to LVC to specifically assess the potential for upwelling of deeper (higher concentration) CVOCs in a gaining segment of LVC; c) assessment of surface water quality data from gaining segments of LVC do not demonstrate evidence of increases in CVOC concentrations potentially attributable to preferential upwelling; d) shallow bedrock groundwater CVOC concentrations adjacent to LVC are sufficiently low that there is no reasonable expectation that upwelling would produce hot spot concentrations in the overburden aquifer, and e) a series of piezometers installed immediately adjacent to LVC (for the purpose of assessing groundwater discharge), demonstrated the absence of CVOCs. Collectively, for these reasons, this potential exposure pathway is not a concern which warrants additional investigation.

The steps described in the above discussion on *30-Year Fate and Transport Model and Sentinel Monitoring Wells* combined with a bedrock evaluation (discussed below) will suffice in identifying any potential VI concerns along LVC emanating from overburden groundwater or upwelling of groundwater from the bedrock aquifer. In addition to the cumulative VI risk assessment proposed for shallow overburden groundwater (the appropriate media for VI exposure assessment), a similar evaluation will be conducted for the shallow bedrock aquifer (to demonstrate that upwelling shallow bedrock groundwater would not produce a hypothetical VI exposure concern different than or beyond the predicted area associated with overburden groundwater). The results of the potential VI exposure assessment for groundwater will be presented in a future supplemental RI letter report using the most recent sampling data at that time.

Northeast Corner of Site – Potential DNAPL Source Area

DEP has expressed the view that additional data would be beneficial in the northeast corner of the Site to demonstrate that a) a shallow CVOC source (i.e. an actual CVOC

discharge location sufficient to have produced the DNAPL present in MW-26) is not present proximate to MW-26 and b) that the DNAPL found in this area is not the result of a local CVOC discharge. One minor concern also raised by DEP was a very slight mass detection of CVOCs in the passive soil gas survey point near MW-26.

The BT Team maintains that existing data demonstrates the absence of a CVOC source/discharge in this area of the Site as described in detail in Roux's May 13, 2016 letter and reiterated/supplemented below:

- Soil gas results in the northeast corner of Building 8 do not indicate elevated concentrations of CVOCs. Elevated soil gas levels were restricted to the vicinity of the former solvent above-ground storage tank ("AST") in the Building 8 Vapor Degreaser Area ("VDA8"). However, soil gas results decline sharply just east of the AST and are generally consistently low through the alley at soil gas sampling points SG-1, SG-3, SG-5, SG-7 and SG-9. The stark difference in mass observed at the VDA8 samples and MW-26 area samples demonstrate the difference between a CVOC discharge area (i.e., proximate to the former AST) and the presence of some low concentration dissolved phase constituents in the shallow ground water near MW-26. Soil gas results adjacent to MW-26 (SG-1 = 0.8 ug) were 2 orders of magnitude lower than those observed adjacent to the VDA8 (SG-13 = 81.85 ug).

- The de minimus soil gas conditions observed in the area of MW-26 are inconsistent with a surface or shallow discharge of CVOCs in this area.

- The nearest Areas of Concern ("AOCs") at the Site that were historically identified by DEP are the "solvent spill areas" and the "waste disposal lagoon." Evidence of source material (i.e., DNAPL or elevated soil/groundwater concentrations) was not observed in these AOCs during multiple investigative activities conducted by the historical contractors for Christiana Metals or by Baker on behalf of DEP.

- DNAPL was only observed in bedrock at depths greater than 380 feet below ground surface ("bgs") in MW-75. During drilling activities, the overburden and shallower bedrock at this location did not exhibit signs that DNAPL was present (i.e., solvent odor, etc.). Further, PID readings in unsaturated soil at MW-75 ranged between 0.0 and 75.9 ppm, which is orders of magnitude lower than an expected PID response in the presence of DNAPL.

- The presence of DNAPL in this portion of the Site at depths greater than 380 feet below surface is the result of transport from the VDA8 Area via vertical movement along bedding planes and lateral movement along bedrock strike to the northeast (i.e., structure controlled transport), similar to groundwater transport as summarized in the CSM. The DNAPL conditions observed proximate to MW-26 and MW-75 are not sourced from a surface or shallow CVOC discharge immediately proximate to these monitoring wells that migrated vertically downward.

- To further assess DEP's concern, soil boring logs, PID readings, odor observations, and soil sample results are presented from 11 soil borings/monitoring wells located in the northeast corner of the site. The boring locations and an overlay of the above-referenced soil gas survey results are shown on Figure 1 and the geologic logs are provided in Attachment 1. The observations are summarized below.

    - Soil Boring LAG-01: No odors are reported for the entire overburden depth to 20 feet bgs. PID readings are 0.0 ppm throughout this boring.

    - Soil Boring LAG-02: No odors are reported for the entire overburden depth to 24 feet bgs, except a "slight organic odor" reported in the 2 to 3 foot bgs depth. PID readings range from 0.4 to 39.1 (5 to 6 feet bgs) ppm in this boring. A soil sample collected at the interval of the highest PID reading had results of 0.05 U (i.e., non-detect) mg/kg and 0.1 mg/kg for 1,1,1-trichloroethane ("TCA") and TCE, respectively.

    - Soil Boring LAG-03: No odors are reported for the entire overburden depth to 20 feet bgs. PID readings range from 0.0 to 2.3 ppm in this boring.

    - Soil Boring LAG-04: No odors are reported for the entire overburden depth to 19 feet bgs. PID readings range from 0.0 to 1.0 ppm in this boring.

    - Soil Boring SSA-05: No odors are reported for the entire overburden depth to 14 feet bgs. PID readings range from 0.0 to 251 ppm.[2]

    - Soil Boring MW-08-SB: No odors are reported for the entire overburden depth to 15.5 feet bgs, except a "petroleum odor" reported in the 8 to 10 foot bgs depth and an "unidentified odor" in the 12 to 14 feet bgs depth (coincident with wet conditions). PID readings range from 0.0 to 53 ppm in the 0 to 10 foot bgs depth in this boring and 1.2 to 279 (11 to 11.5 feet bgs) ppm in the 10 to 15 foot bgs depth in this boring (coincident with wet conditions). A soil sample collected at the interval of the highest PID reading had results of 0.003 mg/kg and 50 mg/kg for TCA and TCE, respectively.

    - Monitoring Well MW-6: Other than a petroleum odor at 15 feet bgs, there are no odors reported to the total overburden depth of 20 feet bgs.

    - Monitoring Well MW-8: There are no odors reported to the total overburden depth of 18 feet bgs.

    - Monitoring Well MW-9: There are no odors reported to the total overburden depth of 20 feet bgs.

[2] A PID reading in the 0-4' interval was recorded by Baker as "9999over." However, the corresponding sample result for this interval was non-detect for TCA and TCE.

- Monitoring Well MW-26: There are no odors reported to the total overburden depth of 26.5 feet bgs. PID readings are 0.0 ppm throughout the overburden in this boring. The PID readings from 26.5 to 222 feet bgs are 0.0 ppm throughout. By contrast, the maximum PID reading in the interval between 222 to 232 feet bgs was 572 ppm with a "strong solvent odor" indicated on the monitoring well log.

- Monitoring Well MW-75: No odors are reported for the entire overburden depth to 30 feet bgs, except a "plant decay odor" reported in the 7 to 15 foot bgs depth. PID readings range from 5.0 to 75.9 (7 to 8 feet bgs) ppm throughout the overburden in this boring. The PID readings from 30 to 380 feet bgs range from 0.4 to 52.7 ppm. By contrast, the PID readings below 380 feet bgs (in the depth interval where DNAPL is actually observed) were off scale at >2,000 ppm with strong and obvious solvent odors reported by field personnel.

Collectively, the available data indicate that a known source area (i.e., VDA8) has produced the observed DNAPL conditions at depth near the northeast corner of the Site. There is no evidence to suggest there is another, as yet unidentified, shallow discharge of CVOCs that has produced the deep DNAPL conditions at the northeast corner of the Site. Unless DEP can cite to specific evidence to substantiate its concern regarding a shallow discharge of CVOCs in this area of the site, the BT Team respectfully declines to conduct additional remedial investigation in this area.

Treatability Study

Bromide in MW-25

DEP requested additional information regarding the bromide data for the MW-25 triplet.

The reported bromide data in all three MW-25 well couplet intervals is commonly qualified with a "B" flag, indicating data that was detected between the method detection limit and reporting limit of the laboratory equipment, essentially equivalent to the "J" flag used for organic data. Thus, the bromide results are both very low in concentration and qualified. As discussed with DEP, the collection of bromide data from MW-25 began after the initiation of injections using a bromide tracer; hence, no baseline data is available for the MW-25 wells. Given the low and qualified results, and given the absence of baseline data for comparison, we cannot draw conclusions as to whether the bromide values observed in MW-25 couplet wells can be attributed to the injection program.

Supplemental Remedial Investigation Work Plan

Upon receipt of DEP comments and/or approval of this letter, a Supplemental RIWP will be prepared and submitted to DEP in accordance with the existing Amended Consent Order and Agreement (Amended CO&A). A preliminary schedule for upcoming activities is provided below; a formal implementation schedule will be included in the Supplemental RIWP. Results of these activities will be presented in a Supplemental Remedial Investigation (RI) letter report anticipated to be prepared in mid-2017 (see preliminary schedule, below).

Preliminary Schedule

As discussed above, indoor air sampling activities must be completed during the heating season. Thus, we anticipate that at least one round of indoor air sampling may be conducted prior to submittal of the Supplemental RIWP. Accordingly, a preliminary schedule is outlined below for completion of the supplemental activities outlined herein:

- Submittal of indoor air sampling work plan (via e-mail) – Q4 2016;
- Access coordination for indoor air sampling – Q4 2016;
- Collection of indoor air samples – Q1 2017;
- Submittal of Supplemental RIWP – Q1 2017;
- Access coordination for groundwater sampling – Q1 2017;
- Supplemental groundwater sampling – Q2 2017;
- Data analysis tasks (evaluation of VI risk, groundwater model, etc.) – Q1/Q2 2017; and
- Supplemental RI letter report – Q2/Q3 2017.

Should you have any questions or comments, please contact the undersigned at (856) 423-8800.

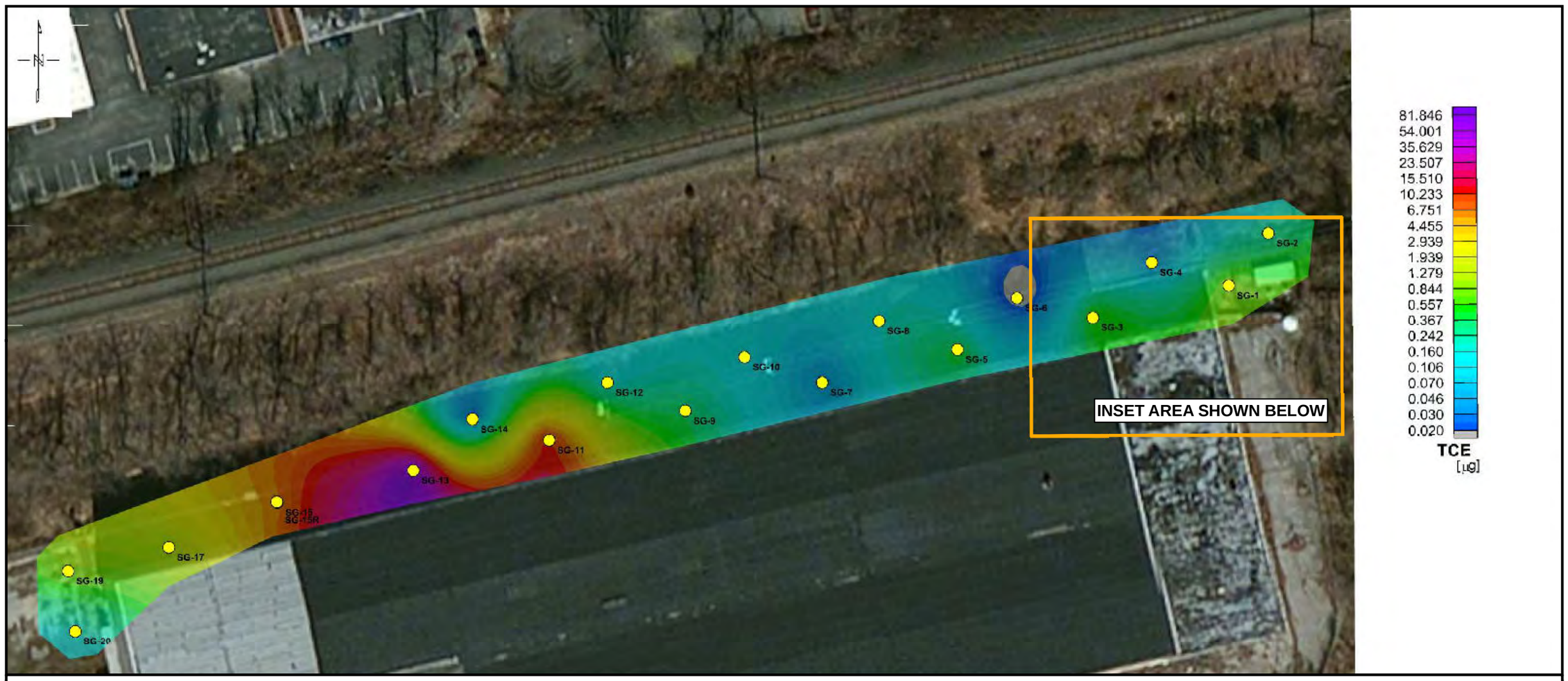
Sincerely,
ROUX ASSOCIATES, INC.

Justin Kowalkoski, P.G.
Senior Geologist

Greg Martin, P.G.
Vice President/Principal Hydrogeologist

cc: Richard Staron - PADEP
Anderson Hartzell - PADEP
Robert Schena - PADEP
John Nagel - East Whiteland Township, Manager
Jon Buzan - East Whiteland Township, EAC
Bishop Tube Project Team

FIGURES



Notes:
1. Soil screening data provided by Amplified Geochemical Imagic, LLC (AGI) in their August 29, 2014 report based on Roux Associates' May and August 2014 soil gas survey activities.
2. A minimum curvature surface was used to interpolate the data between sampling points. A minimum curvature surface is the smoothest possible surface that will fit the given data values within the defined survey area. The survey area was defined by AGI based on the distribution of available data.
3. Soil gas results reported in micrograms (µg).
4. Boring locations are approximate.

50 0 50 100 Feet

Legend

- Overburden Monitoring Well Location and Identification
- Bedrock Monitoring Well Location and Identification
- Roux Soil Boring Location with Laboratory Analytical Results for VOCs
- Baker Soil Boring Location with Laboratory Analytical Results for VOCs
- Drainage Swale
- Building Outline

Notes:
1. Service Layer Credits: ESRI, DigitalGlobe, GeoEye, Earthstar Geopgraphics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Layer Access Date: 12/2/2016.
2. Baker soil boring locations are based on the 2002, 2003, and 2008 Baker reports. Boring locations are therefore approximate.
3. Some Baker soil boring locations are also associated with SVOC, PCB and/or Metals laboratory analytical results.
4. Only Roux soil boring locations with laboratory analytical results for VOCs in soil are shown.
5. VOCs = Volatile Organic Compounds.
6. Soil data are not contemporaneous. Data depicted was collected between 2002 and 2015.

N

10 0 10 20 Feet

Title:

NORTHEAST CORNER SAMPLE LOCATIONS

FORMER BISHOP TUBE FACILITY
CHESTER COUNTY, PENNSYLVANIA

Prepared For:

BISHOP TUBE PROJECT TEAM

ROUX
ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: SSPR	Date: 12/2/2016	FIGURE
Prepared by: SSPR	Scale: 1:120	1
Project Mgr: JAK	Office: NJ	
File No: F1(CP)	Project: 0539.0003J000	

G:\PROJECTS-0810539 - Saul Ewing - SX\0003\PROJECT DATABASE\GIS\Letter Response to DEP\F1(CP)NortheastCorner.mxd

ATTACHMENT 1

SELECT SOIL BORING AND MONITORING WELL LOGS

Baker

Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339 BORING NO.: LAG-01
COORDINAT EAST: NORTH:
ELEVATION: SURFACE:

Rig: Powerprobe 9630	MC Sampler	Casing	Augers	Core Barrel	Date	Progress (Ft.)	Weather	Depth to Water (Ft.)
Size (ID)	1-5/8" I.D.				5/29/07	20.0	Sun 80°	NE*
Length	4'							
Type								
Hammer Wt.								
Fall								

Remarks: BKG - Background * perched zone @ 9.5-45'

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
BG/PS = Background/Point Source
ppm = parts per million

Depth (Ft.)		Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
1							0.6 Asphalt & base material sand, gravel silt & fine sand, brown, moist, cohesive.	
2			2.3			0.0		
3		S-1					2.5 wet 3.5'-4.5'	
4	4.0						4.3 limestone sand & gravel, white, grey	
5							silt, sand & clay, w/ rocks, brown, moist, low plastic. - fill.	
6			2182-184 VOA 185 SVOA 186 SO3			0.0		
7		S-2	LAG-01-05@ 5-6' 3.0					
8	8.0							
9								
10		S-3	2.7			0.0		

DRILLING CO.: AllProbe BAKER REP.: Brian Steffes
DRILLER: Greg Baker BORING NO.: LAG-01 SHEET 1 OF __

Baker
Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339
BORING NO.: LAG-01

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
ps/bg = point source/background

Depth (Ft.)		Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
11							Continued from Sheet 1	
12	12.0							
13								
14		S-4	2.5			0.0		
15								
16	16.0						15.4 vegetation, black organic soil @ 15.4-15.7	
17							Decomposed rock, clayey, micaceous moist	
18		S-5	2.7			0.0		
19							19.2	
20	20.0						Broken rock, dry to moist schistic, intact pieces are hard, grey-green	
21							Bottom of hole @ 20.0	
22								
23								
24								
25								
26								
27								
28								
29								
30								

DRILLING CO.: AllProbe
DRILLER: Greg Baker
BAKER REP.: Brian Steffes
BORING NO.: LAG-01 SHEET 2 OF 2

Baker

Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339 BORING NO.: LAG-02
COORDINAT EAST: NORTH:
ELEVATION: SURFACE:

Rig: Powerprobe 9630	MC Sampler	Casing	Augers	Core Barrel	Date	Progress (Ft.)	Weather	Depth to Water (Ft.)
Size (ID)	1-5/8" I.D.				5/30/07	24.0	sun 75°	15.5'
Length	4'							
Type								
Hammer Wt.								
Fall								

Remarks: BKG - Background east of N. UST.

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
BG/PS = Background/Point Source
ppm = parts per million

Depth (Ft.)		Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
1							0.8 Asphalt & granular base material	
2			2.4			4.8	silty clay & vy. fine sand, brown, moist, slight organic odor, low to non plastic. - fill	
3		S-1				19.3		
4	4.0							
5			2128-157 VOA 158 SVOA 159 Met.			39.1	increasing clay, plastic, moist - fill	
6			LAG-02-05 @ 5-6'					
7		S-2	2.0			2.6		
8	8.0							
9						7.1		
10						4.0		

DRILLING CO.: AllProbe BAKER REP.: Brian Steffes
DRILLER: Greg Baker BORING NO.: LAG-02 SHEET 1 OF 1

Baker
Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339
BORING NO.: LAG-02

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
ps/bg = point source/background

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
11	S-3	2.0				Continued from Sheet 1	
12 (12.0)						as above, occaissional asphalt piece, fill	
13	S-4	2.2			3.9		
14							
15					2.4		
16 (16.0)							
17	S-5	3.6	2128-190 VOA 191 SVOA 192 SOS; LAG-02-16 @ 16-17'		1.5	17.1 silt & sand w/ vegetation, dk gray	
18						18.5 silt & sand, micaceous, degenerated rock, moist	
19							
20 (20.0)							
21	S-6	-0-			0.4	lost sample - hand drilling @ 22-24' Bottom 2' of barrel wet upon removal, water came up to 15.5'	
22							
23							
24 (24.0)							
25						Bottom of hole @ 29.0'	
26						LAG-02-GW water sample	
27							
28							
29							
30							

DRILLING CO.: AllProbe
DRILLER: Greg Baker
BAKER REP.: Brian Steffes
BORING NO.: LAG-02 SHEET 2 OF 2

Baker
Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339 BORING NO.: LAG-03
COORDINAT EAST: NORTH:
ELEVATION: SURFACE:

Rig: Powerprobe 9630	MC Sampler	Casing	Augers	Core Barrel	Date	Progress (Ft.)	Weather	Depth to Water (Ft.)
Size (ID)	1-5/8" I.D.				5/30/07	20.0	sun 85°	7.75*
Length	4'						*upon removing rods	
Type								
Hammer Wt.								
Fall								

Remarks: BKG - Background East of southern UST location.

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
BG/PS = Background/Point Source
ppm = parts per million

Depth (Ft.)		Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
1							Asphalt & gravel base material 1.0	
2						0.4	silt & fine sand, w/ gravel & schist pieces, brown, moist - fill	
3		S-1	3.3			0.7		
4	4.0					2.2		
5						2.3	increasing clay, low to med. plastic, moist. - fill	
6								
7		S-2	2.1					
8	8.0					1.7		
9							moist to wet zone 9-10.0'	
10		S-3	2.3			0.1		

DRILLING CO.: AllProbe BAKER REP.: Brian Steffes
DRILLER: Greg Baker BORING NO.: LAG-03 SHEET 1 OF 2

Baker

Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)

SO NO.: 104339 BORING NO.: LAG-03

SAMPLE TYPE	DEFINITIONS
S = Split Spoon A = Auger	SPT = Standard Penetration Test (ASTM D1586)
T = Shelby Tube W = Wash	PID = Photo Ionization Detector Measurement
R = Air Rotary C = Core	MSL = Mean Sea Level
D = Denison P = Piston N = No Sample	ps/bg = point source/background

Depth (Ft.)		Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
11							Continued from Sheet 1	
12	12.0					0.0	wet zone above 12.0'	
13						0.0	mixed and variable silt, clay and sand w/ qtz gravel & schist pieces throughout, can't determine fill/native contact	
14		S-4	2.8					
15								
16	16.0					0.0		
17			2128-	198 VOA 199 SVOA 200 metals		2.1		
18			2.8					
19		S-5	LAG-03-16 @ 16-17'				harder drilling & rods veering At @ 20.0', so we terminate boring.	
20	20.0					0.5		
21							Bottom of boring @ 20.0	
22							LAG-03-GW & (water sample)	
23							LAG-03 GWD (duplicate)	
24								
25								
26								
27								
28								
29								
30								

DRILLING CO.: AllProbe BAKER REP.: Brian Steffes

DRILLER: Greg Baker BORING NO.: LAG-03 SHEET 2 OF 2

Baker
Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339 BORING NO.: LAG-04
COORDINAT EAST: NORTH:
ELEVATION: SURFACE:

Rig: Powerprobe 9630	MC Sampler	Casing	Augers	Core Barrel	Date	Progress (Ft.)	Weather	Depth to Water (Ft.)
Size (ID)	1-5/8" I.D.				5/30/07	19.0'	sun 87°	4.5'
Length	4'							
Type								
Hammer Wt.								
Fall								

Remarks: BKG - Background

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston
N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
BG/PS = Background/Point Source
ppm = parts per million

Depth (Ft.)		Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
1						0.4	1.0 Asphalt & brown gravel	
2			2.7				silty Clay and sand, brick pieces, brown, moist - fill	
3		S-1				0.8		
4	4.0							
5						0.0		
6			2.6					
7		S-2					wet zone @ 7.4-7.6'	
8	8.0					0.0		
9				21/28-209 VOA 210 SVOA 211 Metals		0.0		
10		S-3	2.7	LAG-04-11 @ 11-12'				

DRILLING CO.: AllProbe BAKER REP.: Brian Steffes
DRILLER: Greg Baker BORING NO.: LAG-04 SHEET 1 OF 2

Baker
Baker Environmental

TEST BORING RECORD

PROJECT: Bishop Tube (4-1-154)
SO NO.: 104339
BORING NO.: LAG-04

SAMPLE TYPE
S = Split Spoon A = Auger
T = Shelby Tube W = Wash
R = Air Rotary C = Core
D = Denison P = Piston N = No Sample

DEFINITIONS
SPT = Standard Penetration Test (ASTM D1586)
PID = Photo Ionization Detector Measurement
MSL = Mean Sea Level
ps/bg = point source/background

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	SPT	Lab ID	PID (ppm)	Visual Description	Elevation (Ft. MSL)
11					1.0	Continued from Sheet 1	
12 (12.0)						silty Clay w/ sand & schist pieces, moist, brown, plastic	
13					0.0		
14							
15	5-4	3.2				15.0	
16 (16.0)					0.1	decomposed rock - sandy, silty clayey w/ schist pieces	
17					0.4		
18	5-5	2.8					
19 (19.0)					0.5	refusal on weathered schist	
						Bottoming hole @ 19.0'	
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							

DRILLING CO.: AllProbe
DRILLER: Greg Baker
BAKER REP.: Brian Steffes
BORING NO.: LAG-04 SHEET 2 OF 2

Baker

Baker Environmental

DIRECT PUSH SOIL BORING LOG

PROJECT:	Bishop Tube Site	**BORING NO.:**	SSA05
SO NO.:	24300-116-0001	**SHEET NO.:**	1 of 1
TASK NO.:	03003	**ELEVATION:**	Not Surveyed

DRILLING INFORMATION

Drill Rig:	Truck-Mounted Geoprobe Direct Push Rig	**Weather:**	Sunny, Upper 80s - Lower 90s (ºF)
Orientation:	Vertical	**Date Started:**	August 01, 2001
Sampler Size:	2-inch ID	**Date Completed:**	August 01, 2001
Sampler Length:	4-feet	**Water Level 0 Hr.:**	
Direct Push Sampling:	0 to 14'	**Water Level 24 Hrs.:**	N/A
Solid Flight Auger Drilling:	N/A to		

Remarks: Contingency soil boring drilled in the solvent spill area to evaluate the horizontal and vertical extent of VOC, SVOC, PCB and metal concentrations in soils.

SAMPLE INFORMATION

Sample No.	Sample Depth	Testing Parameters
116-080101-S-SSA05A-14 116-080101-S-SSA05A-14-MS/MSD	1 to 4 feet 1 to 4 feet	Soil sample - to PADEP contract lab for TCL VOCs, TCL SVOCs, TCL PCBs and TAL metals
116-080101-S-SSA05A-34 116-080101-S-SSA05B-78	3 to 4 feet 7 to 8 feet	Soil sample - to the PADEP mobile lab for TCL VOCs

Depth (Feet)	Run No.	Amount Sample Recovery (Ft.,%)	Bottom Depth of Sample (Feet)	PID IN-SITU TESTING meter units	Visual Description	Graphic Log	Laboratory Sample No.
1, 2, 3, 4	1	2.8 70%	4.0	9999over	0 - 2' Gravel fill material in a silty topsoil matrix, dry 2 - 4' Silty clay, firm, some weathered rock, 10YR 4/4, moist		SSA05A (1' - 4') SSA05A-MS/MSD (1' -4') SSA05A (3' - 4')
5, 6, 7, 8	2	3.2 80%	8.0	251	4 - 14' Silty clay, firm, 20-30 mm gravel frags, 10YR 4/3, moist, wet at 14'		SSA05B (7' - 8')
9, 10, 11, 12	3	2.1 53%	12.0	12.6			
13, 14	4	0.7 35%	14.0	0.0	Refusal at 14'		
15, 16							

DRILLING CO.:	B.L. Myers Bros., Inc.	**BAKER REP.:**	David Fekete
DRILLER:	Paul	**BORING NO.:**	SSA05

Roux Associates, Inc.
Environmental Consulting
& Management

Well Log: MW-08-SB

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Active Remediation Services
Project Number:	0539.0003J000	**Drilling Method**	Geoprobe
Project Manager:	Justin Kowalkoski	**Development Method:**	Not Applicable
Date Started:	4/30/2015	**Date Completed:**	4/30/2015

Depth (ft BGS)	Well Construction	Profile	Lithology	Remarks	PID (ppm)
0			Tan SILTY SAND and GRAVEL (building materials). No staining. No odor. Dry.		0.0
					0.0
					0.0
					0.0
				14"/29"	
					0.1
					0.5
					2.9
					10.2
					14.9
				22"/48"	5.8
5					12.2
					22.1
					13.2
					7.8
					5.7
			Reddish Brown mixed with dark brown CLAY, little Gravel and coarse Sand (weathered bedrock and asphalt). No staining. Petroleum odor. Moist.	28.5"/48"	53.1
					27.4
					43.0
10					28.8
			Yellowish brown CLAY, little Gravel and coarse Sand (weathered bedrock, concrete, and asphalt). No staining. No odor.		244
					279
					196
					109
			Olive gray CLAYEY SILT and WOOD. No staining. Unidentified odor. Wet.	26"/42"	217.8
					54.0
					45.0
					11.6
					2.2
			Dark gray to dark brown SILTY CLAY and coarse SAND. No staining. No odor. Dry.		3.3
15					1.2
			Dark gray to dark brown GRAVEL, some Silty Clay. No staining. No odor. Wet.	Refusal at 15.5'	

BCM WELL DRILLING LOG

WELL NO:	MW-6		
SHEET	1 OF: 1		
PROJECT:	Bishop Tube, Frazer, PA	PROJECT NO:	00-5265-03
WELL LOCATION:	NE Corner of Building 8	DATE(S) DRILLED	7/15/87
DRILLING CONTRACTOR:	Thomas Keyes, Inc.	DRILLING METHOD	Hollow-Stem Auger
BORING DIAMETER:	8"	SAMPLING METHOD: N/A	SAMPLE INTERVAL: N/A
LOGGED BY:	P.J. Dressel	TOTAL DEPTH:	20.66'
SCREEN SIZE AND MATERIAL:	0.020" Slot 4" PVC	SCREENED INTERVAL:	10.66-20.66'
CASING SIZE AND MATERIAL:	4" PVC	CASED INTERVAL:	+2-10.66'
GRAVEL PACK SIZE:	No. 3 and No. 4 Gravel	PACKED INTERVAL:	8-20.66'
GROUT TYPE:	Cement and Bentonite Mix (10% Bentonite)	GROUTED INTERVAL:	0-6'
GROUTING METHOD:	Gravity	BENTONITE SEAL:	6-8'
DEVELOPMENT METHOD:	Centrifugal pump TIME: 1/2 hr	ESTIMATED YIELD:	<1 gpm
STATIC WATER DEPTH:	16.04' DATE: 7-13-87	REFERENCE:	Top of PVC
REMARKS:	Stickup = 16" to top of steel casing.		

LITHOLOGIC INTERVAL	SAMPLE INTERVAL	SPOON BLOWS	RECOVERY (IN.)	CLASSIFICATION OF MATERIALS
0-4'				FILL: Sand; gravel; asphalt; brown; moist.
4-12'				FILL: Silt; brown; moist; some lithic fragments.
12-14'				SAME: Wet.
14-15'				FILL: Silt; gray; wet; some lithic fragments; petroleum-like odor.
15-20.66'				FILL: Silt; brown; wet; some sand; some schist fragments.
20.66'				END OF BORING: AUGER REFUSAL

BCM WELL DRILLING LOG

WELL NO:	MW-8
SHEET 1 OF:	1
PROJECT: Bishop Tube, Frazer, PA	PROJECT NO: 00-5265-03
WELL LOCATION: East End of North Alleyway	DATE(S) DRILLED 7/16/87
DRILLING CONTRACTOR: Thomas Keyes, Inc.	DRILLING METHOD Hollow-Stem Auger
BORING DIAMETER: 8" / SAMPLING METHOD: N/A	SAMPLE INTERVAL: N/A
LOGGED BY: P.J. Dressel	TOTAL DEPTH: 18'
SCREEN SIZE AND MATERIAL: 0.020" Slot 4" PVC	SCREENED INTERVAL: 8-18'
CASING SIZE AND MATERIAL: 4" PVC	CASED INTERVAL: +2-8'
GRAVEL PACK SIZE: No. 3 and No. 4 Gravel	PACKED INTERVAL: 6-18'
GROUT TYPE: Cement and Bentonite Mix (10% Bentonite)	GROUTED INTERVAL: 0-4'
GROUTING METHOD: Gravity	BENTONITE SEAL: 4-6'
DEVELOPMENT METHOD: Centrifugal Pump / TIME: 1/2 hr.	ESTIMATED YIELD: <1 gpm
STATIC WATER DEPTH: 13.76' / DATE: 7-13-87	REFERENCE: Top of PVC

REMARKS: Stickup = 16" to top of steel casing.

LITHOLOGIC INTERVAL	SAMPLE INTERVAL	SPOON BLOWS	RECOVERY (IN.)	CLASSIFICATION OF MATERIALS
0-4'				FILL: Sand; gravel; moist.
4-6'				FILL: Silt; brown; moist; some lithic fragments.
6-8'				FILL: Silt; gray; moist; some sand; some lithic fragments. Brown.
8-12'				SAME.
12-18'				SAME: Wet.
18'				END OF BORING

WELL DRILLING LOG

BCM

WELL NO: MW-9	
SHEET 1 OF: 1	
PROJECT: Bishop Tube, Frazer, PA	PROJECT NO: 00-5265-03
WELL LOCATION: East End of North Alleway	DATE(S) DRILLED 8/11/87
DRILLING CONTRACTOR: Thomas Keyes, Inc.	DRILLING METHOD Air Rotary
BORING DIAMETER: 8/6" / SAMPLING METHOD: Cuttings	SAMPLE INTERVAL:
LOGGED BY: J.R. Ousey	TOTAL DEPTH: 63'
SCREEN SIZE AND MATERIAL: N/A	SCREENED INTERVAL:
CASING SIZE AND MATERIAL: 6" I.D.	CASED INTERVAL: +2-36'
GRAVEL PACK SIZE: N/A	PACKED INTERVAL:
GROUT TYPE: Cement	GROUTED INTERVAL:
GROUTING METHOD: Pressure	BENTONITE SEAL:
DEVELOPMENT METHOD: Surge and Airlift / TIME: 1/2 hr.	ESTIMATED YIELD:
STATIC WATER DEPTH: / DATE:	REFERENCE:

REMARKS: Air lifted and surged the completed well for 1/2 hour. Still slight-brown color to water when completed.

LITHOLOGIC INTERVAL	SAMPLE INTERVAL	SPOON BLOWS	RECOVERY (IN.)	CLASSIFICATION OF MATERIALS
0-4'				FILL: Colluvium, schist fragments.
4-8'				SAME.
8-16'				SAME.
16-20'				SAME: Water (perched) at 20'.
20-26'				SAPROLITE (WEATHERED SCHIST).
26-36'				MICA SCHIST: Hard; dry
36-46'				MICA SCHIST: Powdered; water at 46'.
46-63'				MICA SCHIST: Powdered; wet.

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MONITORING WELL CONSTRUCTION RECORD

PROJECT: **BISHOP TUBE SITE**

PROJECT NO.: 101128 Task 03009 | WELL NAME: **MW26**

COORDINATES: NORTHING: 10421.76 | EASTING: 10552.45

ELEVATION: SURFACE: 383.00

Rig: Air Rotary

Borehole Size	Start Date	End Date	Progress (ft)	Remarks
6-inch	1/8/2003	1/9/2003	Drill 31'-250'	Set 6-inch temporary casing 0'-31' on 01/08/2003.
15-inch	1/6/2003	1/7/2003	Drill 0'-31'	Set and grouted 12-inch casing on 01/08/2003.
12-inch	1/14/2003	1/14/2003	Drill 31'-85'	Set and grouted 8-inch casing on 01/14/2003.
8-inch Reaming	1/15/2003	1/15/2003	Drill 85'-250'	Ream 6-inch diameter hole to 8-inch diameter.
Well Construction	1/17/2003	3/3/2003	-	Well construction began 01/17/2003. Difficulty breaking bridge at 111'-118'.
Gauge Static Water Levels	3/21/2003	3/21/2003	-	A (17.68'), B (17.55'), C (16.56')

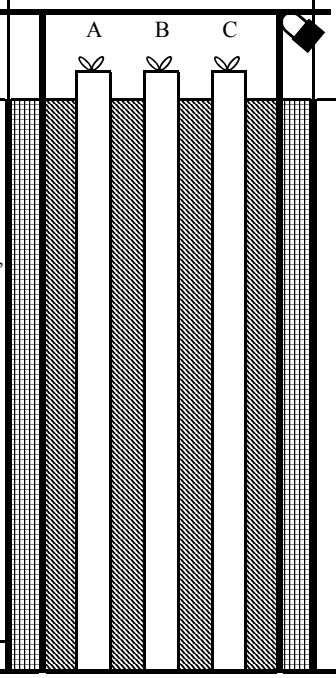
Remarks:

MW26 is a multi screened monitoring well with three separate screened intervals (A, B, & C). The well is located along at the northeast corner of Building #8 . PID background 0 meter units. Well completed at surface using a 3-foot stick-up of 8-inch diameter steel casing.

WELL INFORMATION

Construction Details			Elevations	Diameter (in.)	Top Depth (Ft.)	Bottom Depth (Ft.)
Portland Cement Grout - 1' to 31.5'		Steel Casing	383.00 Ground Surface	12	0	31.5
Portland Cement Grout - 1' to 85'		Steel Casing	386.18 Stick-up	8	+3	85
Bentonite Seal - 0'-88'	A	Well Casing --Schedule 40 PVC	385.94 Top of PVC	2	+3	90
# 2 Morie Sand - 88'-111'		Well Screen --20-Slot, Sch. 5 Stainless (Type 304)			90	100
Bentonite/Grout Seal - 111'-174'	B	Well Casing --Schedule 40 PVC	385.95 Top of PVC	2	+3	176
# 2 Morie Sand - 174'-198'		Well Screen --20-Slot, Sch. 5 Stainless (Type 304)			176	186
Bentonite Seal - 198'-219'	C	Well Casing --Schedule 40 PVC	385.94 Top of PVC	2	+3	222
# 2 Morie Sand - 219'-235'		Well Screen --20-Slot, Sch. 5 Stainless (Type 304)			222	232

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.) 383.00
					8" Diameter Steel Casing Stickup at Surface		
1					0'-3' - Limestone gravel and soil (fill from the construction of Building #8).		
2							
3					3'-10' - Clayey silt, brown (10 YR 4/3), moist, firm; rock and gravel fragments (2-5 mm).		
4							
5				0 units			
6							
7							
8							
9							
10					Match to Sheet 2		



DRILLING CO.: Uni-Tech Drilling Company, Inc. | **BAKER REP.:** David Fekete and Peter Farrand

DRILLER: Jim Evans | **WELL NO.:** MW26

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MONITORING WELL CONSTRUCTION RECORD

PROJECT: **BISHOP TUBE SITE**

PROJECT NO.: 101128 Task 03009 WELL NAME.: **MW26**

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DEFINITIONS
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SSD = Site Specific Datum

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 1		
11					10'-20' - Clayey silt, brown (10 YR 4/3), moist, firm; rock and gravel fragments (2-5 mm).		
12							
13							
14							
15				0 units			
16							
17							
18							
19							
20							
21					20'-26.5' - Clayey silt, brown (10 YR, 4/3), wet, loose; rock fragments (2-5 mm); some weathered rock. Water encountered at approximately 20'.		
22							
23				0 units			
24							
25		**PACKER TEST INTERVAL #1**					
		From 27 to 37 Feet					
26		Groundwater - Yield 10 gpm.					
		116-011303-GW-MW26-PT05			**TOP OF ROCK @ 26.5'**		
27		1,1-DCE -	20.9 ug/L		26.5'-30' - Calcareous schist, weak red (2.5 YR, 5/2), weathered; angular cuttings; calcite and quartz fragments (2-5 mm).		
		cis-1,2-DCE -	482 ug/L				
28		trans-1,2-DCE -	3.6 ug/L	0 units			
		PCE -	7.3 ug/L				
29		1,1,1-TCA -	148 ug/L				
		TCE -	1,290 ug/L				
30		VC -	34.4 ug/L		Match to Sheet 3		

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DRILLER: Jim Evans **WELL NO.:** MW26

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MONITORING WELL CONSTRUCTION RECORD

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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
				0 units	Continued from Sheet 2		
31							
32					15-inch diameter borehole drilled to 31.5'. 12-inch diameter steel casing set to 31.5' and grouted using a mixture of Portland Type II cement and 5% bentonite.		
33							
34					12-inch diameter hole drilled to 85'.		
35					31.5'-47' - Calcareous schist, highly weathered; angular cuttings; calcite and quartz fragments (2-5 mm).		
36							
37					31.5' - Water bearing zone encountered, 10 gpm.		
38							
39				0 units			
40							
41							
42							
43							
44							
45	**PACKER TEST INTERVAL #2 From 45 to 55 Feet**						
46	No yield. No sample collected.				46'-47' - Void.		
47							
48				0 units	47'-50' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm);		
49					some angular schist fragments (2-5 mm).		
50					Match to Sheet 4		

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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 3		
51					50'-62' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm); some angular schist fragments (2-5 mm).		
52							
53							
54							
55							
56				0 units			
57							
58							
59							
60							
61		**PACKER TEST INTERVAL #3 From 60 to 70 Feet** No yield. No sample collected.					
62							
63					62'-72' - Calcareous schist, highly weathered; angular cuttings; calcite and quartz fragments (2-5 mm).		
64							
65							
66				0 units			
67							
68							
69							
70					Match to Sheet 5		

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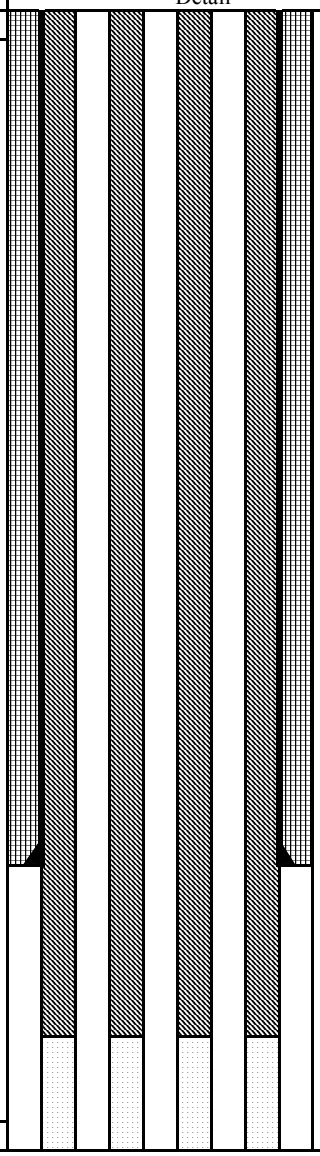
Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 4		
71				0 units			
72					72'-82' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm); some angular schist fragments (2-5 mm).		
73							
74							
75							
76							
77				0 units			
78							
79							
80							
81							
82							
83					82'-92' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm); some angular schist fragments (2-5 mm); some pyrite.		
84							
85					12-inch diameter borehole drilled to 85'. 8-inch diameter steel casing set to 85' and grouted using a mixture of Portland Type II cement and 5% bentonite. 8-inch diameter borehole drilled to 250'.		
86				0 units			
87							
88							
89							
90					Match to Sheet 6		



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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
	PACKER TEST INTERVAL #4				Continued from Sheet 5		
91	**From 90 to 100 Feet**			0 units			
92	Groundwater - Yield 0.5 gpm, pumped dry.						
	116-011303-GW-MW26-PT04				92'-110' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm); some angular schist fragments (2-5 mm); some pyrite.		
93	1,1-DCE -		19.8 ug/L				
	cis-1,2-DCE -		469 ug/L				
94	trans-1,2-DCE -		3.5 ug/L				
	PCE -		16.7 ug/L				
95	1,1,1-TCA -		129 ug/L				
	TCE -		1,780 ug/L				
96	VC -		34.3 ug/L				
97							
98							
99							
100							
101				0 units			
102							
103							
104							
105							
106							
107							
108							
109							
110					Match to sheet 7		

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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 6		
111					110'-132' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm); some angular schist fragments (2-5 mm); some pyrite.		
112							
113							
114							
115							
116							
117							
118							
119	**PACKER TEST INTERVAL #5 From 118 to 128 Feet** No yield. No sample collected.				Well construction - annular space from 118' to 163' filled with Portland Cement.		
120				0 units			
121							
122							
123							
124							
125							
126							
127							
128							
129							
130					Match to Sheet 8		

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DRILLER: Jim Evans **WELL NO.:** MW26

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MONITORING WELL CONSTRUCTION RECORD

PROJECT: **BISHOP TUBE SITE**

PROJECT NO.: 101128 Task 03009 WELL NAME.: **MW26**

SAMPLE TYPE	**DEFINITIONS**
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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 7		
131				0 units			
132					132'-152' - Calcareous schist, weak red (2.5 YR, 5/2), slightly weathered; calcite and quartz fragments (2-5 mm); some angular schist fragments (2-5 mm); some pyrite.		
133							
134							
135							
136							
137							
138							
139							
140							
141				0 units			
142							
143							
144							
145							
146							
147							
148							
149							
150					Match to Sheet 9		

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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 8		
151				0 units			
152					152'-162' - Calcareous schist, slightly weathered; abundant white calcite (2-5 mm).		
153							
154							
155							
156							
157				0 units			
158							
159							
160							
161	**PACKER TEST INTERVAL #6** **From 160 to 170 Feet** Groundwater - Yield 6-7 gpm. 116-011303-GW-MW26-PT03						
162	1,1-DCE - 22.2 ug/L				162'-170' - Calcareous schist, slightly weathered; some white calcite.		
163	cis-1,2-DCE - 511 ug/L trans-1,2-DCE - 4.2 ug/L						
164	PCE - 35.1 ug/L 1,1,1-TCA - 145 ug/L				Well construction - annular space from 163' to 174' filled with bentonite.		
165	TCE - 3,320 ug/L VC - 35.5 ug/L						
166				0 units			
167							
168							
169							
170					Match to Sheet 10		

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DRILLER: Jim Evans **WELL NO.:** MW26

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MONITORING WELL CONSTRUCTION RECORD

PROJECT: **BISHOP TUBE SITE**

PROJECT NO.: 101128 Task 03009 WELL NAME.: **MW26**

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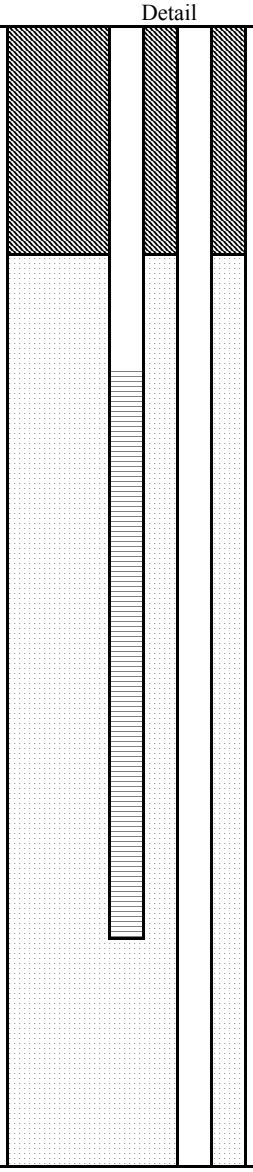
Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 9		
171					170'-177' - Calcareous schist, slightly weathered; some white calcite.		
172							
173							
174				0 units			
175							
176							
177	**PACKER TEST INTERVAL #7 From 176 to 186 Feet**				177'-187' - Possible fracture; schist, highly weathered; abundant rock fragments (calcite, quartz, and others) (5-10 mm).		
178	Groundwater - Yield 6-7 gpm. Slight solvent odor from sample.						
179	116-011303-GW-MW26-PT02						
180	1,1-DCE - 96.5 ug/L						
181	cis-1,2-DCE - 340 ug/L						
182	trans-1,2-DCE - 2.2 ug/L			0 units			
183	PCE - 627 ug/L						
184	1,1,1-TCA - 210 ug/L						
185	TCE - 176,000 ug/L						
186	VC - 10.6 ug/L						
187					187'-190' - Calcareous schist, slightly weathered; some white calcite.		
188				0 units			
189							
190					Match to Sheet 11		



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MONITORING WELL CONSTRUCTION RECORD

PROJECT: **BISHOP TUBE SITE**

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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 10		
191					190'-202' - Calcareous schist; abundant quartz and white calcite rock fragments (5-10 mm).		
192							
193							
194							
195							
196	**PACKER TEST INTERVAL #8 From 195 to 205 Feet** No yield. No sample collected.			0 units			
197							
198							
199							
200							
201							
202							
203					202' - Possible fracture; schist, highly weathered; abundant rock fragments (calcite, quartz, and others) (5-10 mm), possibly from fracture located at 177'-187'.		
204							
205					202'-210' - Calcareous schist; abundant quartz and white calcite rock fragments (5-10 mm).		
206				0 units			
207							
208							
209							
210					Match to Sheet 12		

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DRILLER: Jim Evans **WELL NO.:** MW26

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MONITORING WELL CONSTRUCTION RECORD

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PROJECT NO.: 101128 Task 03009 WELL NAME.: **MW26**

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Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 11		
211					210'-222' - Calcareous schist; abundant quartz and white calcite rock fragments (5-10 mm).		
212							
213							
214							
215							
216				0 units			
217							
218	**PACKER TEST INTERVAL #9** **From 217 to 227 Feet** Groundwater - Yield 10 gpm. Slight solvent odor from sample. 116-011303-GW-MW26-PT01						
219							
220	1,1-DCE - 19.7 ug/L						
221	cis-1,2-DCE - 454 ug/L; trans-1,2-DCE - 3.3 ug/L						
222	PCE - 54.2 ug/L; 1,1,1-TCA - 122 ug/L						
223	TCE - 22,700 ug/L; VC - 29.4 ug/L				222'-232' - Calcareous schist, weathered; possible fracture; strong solvent odor.		
224							
225							
226				572 units			
227							
228							
229							
230					Match to Sheet 13		

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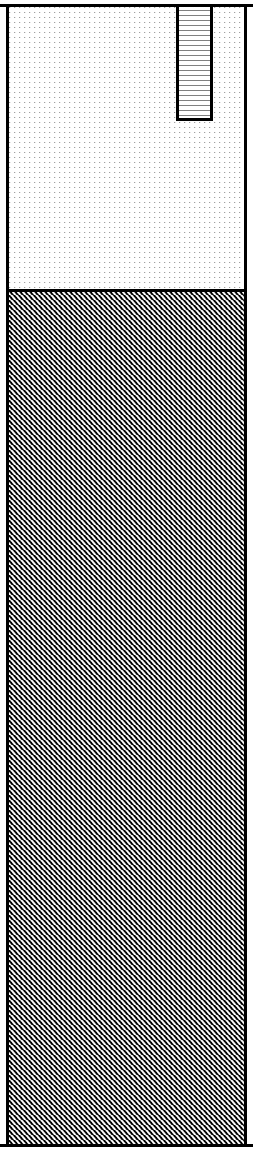
PID = Photo Ionization Detector Measurement
SSD = Site Specific Datum

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continued from Sheet 12		
231				0 units			
232					232'-250' - Calcareous schist; abundant quartz and white calcite rock fragments (5-10 mm).		
233							
234							
235					Well construction - annular space between 235' and 250' filled with bentonite.		
236							
237							
238							
239							
240							
241				0 units			
242							
243							
244							
245							
246							
247							
248							
249							
250					**END OF DRILLING @ 250'**		



DRILLING CO.: Uni-Tech Drilling Company, Inc. **BAKER REP.:** David Fekete and Peter Farrand

DRILLER: Jim Evans **WELL NO.:** MW26

Baker

Baker Environmental

MONITORING WELL CONSTRUCTION RECORD

PROJECT: **BISHOP TUBE SITE**

PROJECT NO.: 101128 Task 03009 WELL NAME.: **MW26**

SAMPLE TYPE	**DEFINITIONS**
S = Split Spoon A = Auger T = Shelby Tube W = Wash R = Air Rotary C = Core D = Denison P = Piston N = No Sample	SPT = Standard Penetration Test (ASTM D1586) PID = Photo Ionization Detector Measurement SSD = Site Specific Datum

Depth (Ft.)	Sample Type & No.	Sample Rec. (Ft.,%)	Lab Sample ID No.	PID meter units	Visual Description	Well Installation Detail	Elevation (Ft.)
					Continue from Sheet 14		
					End drilling 6-inch diameter borehole on 01/09/2003. Packer testing performed in 6-inch diameter borehole on 01/13/2003. Geophysical well logs (Temperature, Specific Conductance, Caliper, Gamma Ray, Spontaneous Potential, and Resistivity log suite) performed by Earth Data, Inc. in 6-inch diameter borehole on 01/10/2003. Borehole reamed out to 8-inch diameter on 01/15/2003. Well construction performed during period from 01/17/2003 to 03/03/2003.		

DRILLING CO.: Uni-Tech Drilling Company, Inc. **BAKER REP.:** David Fekete and Peter Farrand

DRILLER: Jim Evans **WELL NO.:** MW26

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& Management

Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
0		Flushmount manhole with locking J-plug		Asphalt.	
				Light brown SAND, trace Gravel.	12.0
5		Preliminary DTW from Approximate Ground Surface		Brown SANDY CLAY, some Gravel.	44.5
		DTW (A) = 17.45		Orange brown SILT, some coarse Sand and Clay, trace Gravel. No odor. NOTE: Thin metal strip at 4' bgs. Piece of brick at 6' bgs.	75.9
10		DTW (B) = 17.10		Orange brown with reddish orange mottling CLAY and SILT, some coarse Sand and Gravel, trace large Cobble. Plant decay odor from 8' to 12' bgs. Moist.	9.6
				Olive gray SILT and dark gray ORGANIC MATTER. Plant decay odor. Moist.	5.0
15		2" diameter PVC riser		Olive gray and yellowish brown CLAY, little coarse Sand and small roots. Plant decay odor. Moist.	5.6
20				Light gray and olive gray mottle with yellowish orange CLAY, some Boulder/Gravel/coarse Sand/roots. Plant decay odor. Moist.	48.5
				Gray, tan, and orange brown GRAVEL, some coarse Sand, little olive gray and orange brown Silt.	42.3 19.6 15.0
25				Orange brown-light brown CLAY, some coarse Sand, trace Gravel. No odor. Moist.	29.6
30				Dark to light brown and orange brown SILTY fine SAND, trace coarse Sand and Gravel. No odor. Moist. NOTE: Leached zone consisting of white to light gray brittle coarse to medium SAND in pockets and bands from 23.5' to 24.5' bgs.	0.0
				Light gray GRAVEL- to BOULDER-sized Phyllite (trace small pyrite). Trace oxidation. No odor. Moist.	3.0
35				Dark brown-olive gray with trace reddish brown fine to coarse SAND, some Gravel-sized Phyllite. No odor.	
40				Light gray BOULDER to GRAVEL-sized Phyllite in olive gray to light gray SILT and fine SAND matrix. No odor.	0.6
45				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace small pyrite. Few calcite and trace quartz veins (1/2" to 1 1/4") causing medium to high deformation locally. Thin (<1cm), near-vertical bedding planes. Not competent (gravel to to small boulder).	0.6
50					0.6
55					0.4

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Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
60				Void.	1.3
65				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace small pyrite. Few calcite and trace quartz veins (1/2" to 1 1/4") causing medium to high deformation locally. Thin (<1cm), near-vertical bedding planes. Not competent (gravel to to small boulder).	1.6
70					3.9
75				Void.	
80				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace medium to small pyrite. Few calcite and trace quartz veins (1/2" to 1 1/4") causing medium to high deformation along locally. Thin (<1cm), near-vertical bedding planes. Competent.	2.1
85					2.4
90					1.6
95					1.5
100				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace medium to small pyrite. Trace calcite and trace quartz veins causing low deformation locally. Thin (<1cm), near-vertical bedding planes. Competent.	2.3
105					2.7
110					1.5
115					2.8

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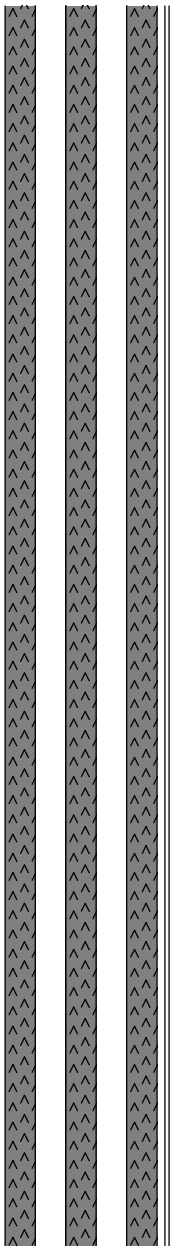
Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
120					1.9
125					2.4
130					2.4
135					1.8
140				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small to large pyrite. Few calcite and trace quartz veins (1/4" to 1 1/2", trace 5") causing high deformation locally. Thin (<1cm), near-vertical bedding planes. Competent.	2.8
145					2.7
150					0.8
155					0.5
160					0.6
165					0.4
170					1.6
175				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace small pyrite. Few calcite and trace quartz veins (1" to 4"). Thin (<1cm), near-vertical bedding planes. Not competent (1" to 5").	4.0

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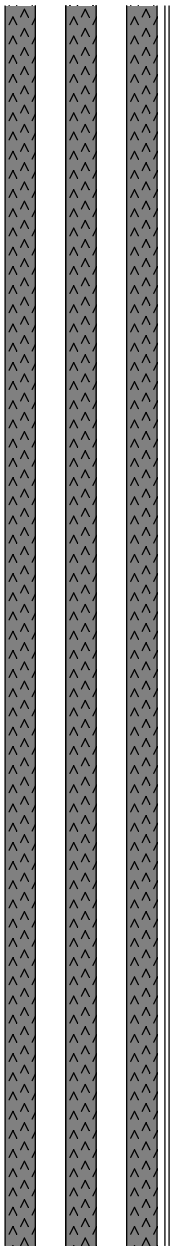
Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
180				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Infrequent small pyrite. Few calcite and trace quartz veins (1/2" to 1 1/2", trace 4") causing high deformation locally. Thin (<1cm), near-vertical bedding planes. Moderately competent (many breaks along bedding).	1.9
185					1.6
190					1.1
195					1.2
200					1.2
205					2.2
210					5.9
215					8.1
220					19.5
225				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace small pyrite, trace muscovite. Few calcite and trace quartz veins (1/2" to 1 1/2", trace 4") causing moderate deformation locally. Thin (<1cm), near-vertical bedding planes. Not competent (1/4" to 2", rounded).	18.7
230				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Few calcite veins (1/4"). Thin (<1cm), near-vertical bedding planes. Competent.	NM
235				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Few calcite and trace quartz veins (1/4"). Thin (<1cm), near-vertical bedding planes. Not competent (1/4" and greater sheets, broken along bedding).	NM

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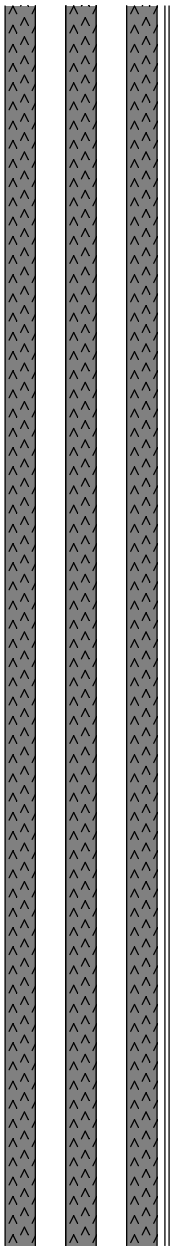
Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
240					NM
245					NM
250				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite, trace muscovite. Trace calcite and quartz veins (1/4" to 1/2"). Thin (<1cm), near-vertical bedding planes. Little iron staining at breaks and coincident with embedded minerals. Moderately competent (few breaks along bedding).	2.8
255					2.7
260					2.0
265				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small to medium pyrite. Few calcite and quartz veins (1/4" to 2"), especially at 266.5' bgs. Thin (<1cm), near-vertical bedding planes. Some iron staining at breaks and coincident with embedded minerals. Competent.	1.1
270					0.7
275				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small to medium pyrite. Few calcite and quartz veins (1/4" to 2"), especially thick (2 1/2" to 4") at 179 to 289' bgs and 303 to 305' bgs. Thin (<1cm), near-vertical bedding planes. Competent.	2.6
280					0.7
285					4.5
290					2.7
295					1.9

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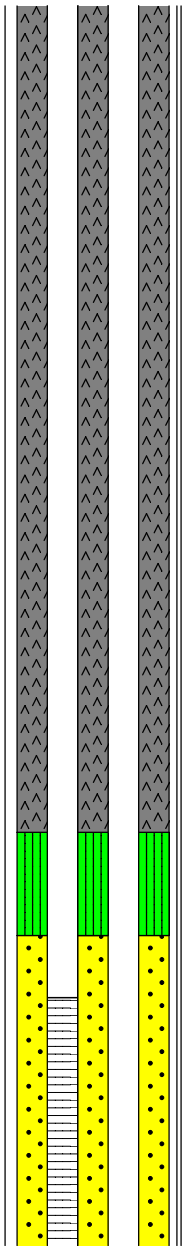
Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
300					1.1
305					4.7
310				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Thin (<1cm), near-vertical bedding planes. Some iron staining coincident with embedded minerals. Competent.	5.3
315				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Thin (<1cm), near-vertical bedding planes. Not competent (2" to 1' long pieces of phyllite, broken along bedding).	16.9
320				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small to medium pyrite. Some calcite and quartz veins (1" to 2"), especially at 320' and 323' bgs, causing moderate deformation locally. Thin (<1cm), near-vertical bedding planes. Iron staining at 321' bgs. Competent.	0.0
325					2.3
330					2.7
335					4.2
340					2.1
345					4.0
350					4.6
355					38.8

Roux Associates, Inc.
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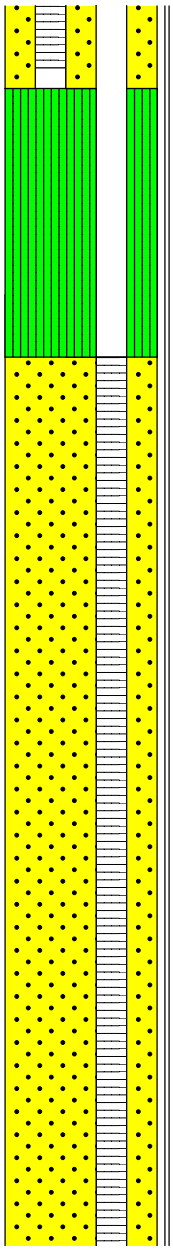
Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
360, 365, 370, 375, 380, 385, 390, 395, 400, 405, 410, 415		 Bentonite; #5 Sandpack; MW-75B (374'-419' bgs)		Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small to medium pyrite. Few calcite and quartz veins (1" to 2") causing moderate deformation locally. Thin (<1cm), near-vertical bedding planes. Competent.	32.8 5.9 21.6 23.7 52.7
				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Few small to medium pyrite. Few calcite and quartz veins (1/2" to 1 1/2") between 385' and 392' only, causing deformation locally. Thin (<1cm), near-vertical bedding planes. Not competent (1/4" to 1" to 1' flat pieces broken along phyllite bedding).	27.2 881.4 1067 1507 1027
				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Trace small pyrite. Trace calcite veins (1/4"). Thin (<1cm), near-vertical bedding planes. Competent.	962.1 1707
				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small to medium pyrite.. Thin (<1cm), near-vertical bedding planes. Not competent (2" to 3" flat pieces broken along phyllite bedding).	125.7
				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Few calcite and quartz veins (1/4" to 2") causing moderate deformation locally. Thin (<1cm), near-vertical bedding planes. Iron staining at 422' bgs. Competent.	488.9

Roux Associates, Inc.
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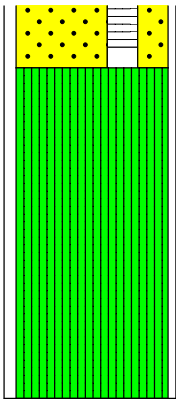
Well Log: MW-75 A/B

Project:	Former Bishop Tube Site	**Logged By:**	Sara Papamarcos
Site Location:	East Whiteland Township, PA	**Drilling Company:**	Cascade Drilling, LP
Project Number:	0539.0003J000	**Drilling Method**	Sonic
Project Manager:	Justin Kowalkoski	**Development Method:**	Air
Date Started:	7/24/2014	**Date Completed:**	8/15/2014

Depth (ft BGS)	Acoustical Televiewer	Well Construction	Profile	Lithology	PID (ppm) and Remarks
420					75.5
425				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Few calcite and quartz veins (1/4" to 2") causing moderate deformation locally. Thin (<1cm), near-vertical bedding planes. Not competent (2" flat pieces broken along phyllite bedding).	112.3
430				Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Few calcite and quartz veins (1/4" to 2") causing moderate deformation locally. Thin (<1cm), near-vertical bedding planes. Competent.	2000 over 2000 over
435		End of borehole @ 436' bgs		Medium gray PHYLLITE (interbedded carbonate and non-carbonate material). Small pyrite. Few calcite and quartz veins (1/4" to 2"). Thin (<1cm), near-vertical bedding planes. Not competent (1" to 3").	2000 over

July 6, 2018

Dustin Armstrong
Environmental Cleanup Program
PA Department of Environmental Protection
2 East Main Street
Norristown, Pennsylvania 19401

Re: Former Bishop Tube Site
Response to DEP's June 28, 2018 Letter Regarding
June 15, 2018 Monthly Progress Report

Dear Mr. Armstrong:

On behalf of the Bishop Tube Project Team ("BT Team"), Roux Associates, Inc. ("Roux Associates") submits this letter in response to the Pennsylvania Department of Environmental Protection's ("DEP") June 28, 2018 letter, which provided comments on several ongoing activities related to the former Bishop Tube Site ("Site"), and requested the following:

- Provide an Addendum to the previously filed Discharge to Surface Water Work Plan ("DSWWP Addendum") responding to DEP's comments on the original DSWWP and provide a schedule for completion of this work;
- Provide a schedule for completion of a second round of groundwater sampling;
- Provide (with the next monthly progress report) analytical data not previously provided to the DEP;
- Provide a plan and schedule for "completing the delineation of groundwater contamination resulting from the [former] Bishop Tube Site";
- Provide an evaluation of the use of modeling; and
- Provide a schedule for completion of a Supplemental Remedial Investigation Report ("Supplemental RIR").

Responses to the above items are provided below.

Provide DSWWP Addendum and Schedule for Completion
The DSWWP Addendum was sent to DEP on July 2, 2018; we await DEP's review and approval. Groundwater, first round of surface water and sediment sampling outlined in the DSWWP Addendum is tentatively scheduled for the week of July 16, 2018, to occur concurrently with other groundwater sampling activities (see below). Actual start date is contingent upon the timing of DEP's approval of the July 2, 2018 DSWWP Addendum[1], the nature of any comments from DEP, weather[2] and access

[1] It was Roux's intent to call DEP to determine if DEP would be able to review and comment/approve the DSWWP Addendum to allow the July 16, 2018 start date, but in light of DEP's June 28 letter, we provide this more formal response in writing.
[2] As noted in DEP's approval of the DSWWP, the low-flow surface water sampling event will be completed during a period with no precipitation in the 48-hour period prior to sampling. The second round of surface water sampling will be conducted during high flow conditions within the first 30 minutes (or as soon as practicable) of a storm

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California ■ Illinois ■ Massachusetts ■ New Jersey ■ New York ■ Texas

approvals. Regardless, we expect this field work to be completed before the end of July 2018 (with the second round of surface water sampling completed by the end of August, subject to weather). Should there be a need to adjust the schedule we will advise DEP. Surface water sampling requested by DEP consists of one low flow and one high flow event. Scheduling of the surface water sampling events will thus be based on DEP's response and the weather.

Provide Schedule for Completion of Second Round of Groundwater Sampling
A second round of groundwater sampling is currently scheduled for the week of July 16, 2018. Since this work is to occur concurrently with the DSWWP Addendum sampling activities, the actual start date is subject to the same conditions as above. We expect this field work to also be completed before the end of July 2018. As discussed in more detail below, the sampling program will include supplemental VOC analyses to assist in interpretation of results from the first round of sampling.

Provide Analytical Data Not Previously Provided to DEP
Roux has previously provided DEP with aqueous packer testing results, first round of groundwater sampling results and indoor air sampling results. We are not aware of analytical data not yet submitted to DEP. Should DEP have specific analytical data that it believes it does not have, please advise and we will provide.

Provide DEP with a Plan and Schedule for Groundwater Delineation
The BT Team has evaluated the groundwater analytical results from the packer testing and first round of sampling conducted in March 2018 for the newly constructed monitoring wells and piezometers. As noted by DEP, these preliminary results indicated that tetrachloroethene ("PCE") and trichloroethene ("TCE") were detected at levels exceeding the Residential and Non-Residential Used Aquifer Medium Specific Concentrations ("MSCs") in monitoring wells MW-81 and MW-82A located on the 50 Morehall Road property. Although not noted by DEP, the preliminary results from first round of groundwater sampling from monitoring wells MW-83 and MW-84d (cluster) located on the 49 Lancaster Avenue property and from the piezometers north of Little Valley Creek ("LVC") were below MSCs. A second confirmatory groundwater sampling event is necessary and is scheduled to occur the week of July 16, 2018, subject to the conditions discussed above.

Assessment of the preliminary analytical results indicate the following:

- Delineation of chlorinated volatile organic compounds ("CVOCs") in the direction of 49 Lancaster Avenue (i.e., transport along predominant bedrock strike orientation) is complete, subject to confirmatory data from the second round of groundwater sampling.
- Delineation of CVOCs to the north of LVC is complete, subject to confirmatory data from the second round of groundwater sampling.
- The exceedances of MSCs for PCE and TCE, subject to confirmatory data from the second round of groundwater sampling, require further assessment as to the source of the CVOCs found beneath the 50 Morehall Road property. Simple inspection of these data shows an approximate 1 to 1 ratio of PCE to TCE. This ratio is substantially higher than, and different from, the ratios commonly observed for this Site. Specifically, the relative proportions of PCE are notably elevated on the 50 Morehall Road property. Based on these results the second round of groundwater sampling will include the sampling activities previously approved by DEP and will be supplemented by the sampling of additional wells and the inclusion of compound specific isotope analysis ("CSIA") for volatile organic compounds ("VOCs") in select monitoring wells. These supplemental data are expected to assist in source determination. Upon receipt and interpretation of these data, a recommendation will be made to DEP as to whether further

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event with greater than 0.1 inches of precipitation and at least 72-hours after the previous 0.1 inches of precipitation.

delineation is warranted related to "groundwater contamination resulting from the [former] Bishop Tube Site" or whether an alternate source unrelated to the Site is evident.

The Plan requested by DEP for delineation of CVOCs observed on 50 Morehall Road has a necessary pre-requisite step of source determination, which is presented herein. Our plan is to sample 28 wells for VOCs and based upon review of the VOC results, we anticipate CSIA for up to 25 wells[3]. A list of the wells to be sampled, which is expanded beyond the previously approved sampling for the newly-installed monitoring wells, is provided on attached Table 1. Until these data are received and interpreted, it is not feasible to plan for further delineation activities. If the CSIA results indicate a source other than the former Bishop Tube Site, then delineation of CVOCs observed on 50 Morehall Road would not be the responsibility of the BT Team and the RI activities for groundwater delineation would be complete. Assuming the field sampling is completed before the end of July 2018, it is anticipated that the VOC and CSIA results will be reported to DEP in August and December, respectively[4].

Provide an Evaluation of the Use of Modeling

The DEP has asked for "an evaluation of the use of modeling with the existing data." There has already been extensive discussion between the BT Team and DEP regarding the scientific validity of both numerical (e.g., MODFLOW/MT3D) and analytical (e.g., BIOCHLOR) fate and transport modeling methods. As has been previously communicated, analysis of existing data using either of these methods is not compatible with the observed complex hydrogeologic conditions and the extended operational history of the Site. As was communicated to DEP in correspondence dated May 13, 2016, December 15, 2016, February 6, 2017, and April 24, 2017, the BT Team reiterates its prior conclusion that a high degree of uncertainty is inherent with such model analyses, rendering output with little or no value. We are unaware of any changes in site conditions or modeling methods which would alter our previous exhaustive consideration of this subject.

As was expressed previously to DEP, the BT Team is willing to employ a linear regression assessment using empirical groundwater data to complete the groundwater delineation for the Site. This approach necessarily employs certain simplifying assumptions, but if this modeling method were acceptable to DEP, then the BT Team is willing to revise/update the previous linear regression assessment to incorporate the most current data. The proposed methodologies have previously been provided to DEP in the above cited documents. However, before completing this revised assessment, the CSIA results would still be needed to determine whether CVOCs found on 50 Morehall Road are potentially sourced from the Site, and whether these data need to be incorporated into the assessment. If it is determined that the CVOC conditions beneath 50 Morehall Road are sourced from the former Bishop Tube Site, the BT Team will provide a Plan for delineation through completion of supplemental linear regression analyses or collection of empirical groundwater data from supplemental sentinel monitoring well(s).

Provide a Schedule for Completion of a Supplemental RIR

The status of completion of the supplemental RI activities is significantly dependent upon the results derived from implementation of the DSWWP Addendum and the expanded groundwater sampling program. Should these supplemental RI activities produce results that do not indicate the need for any additional field investigative activities, a reasonable estimate for submission of a Supplemental RIR would be the end of Q1 2019. Should the supplemental RI activities produce results that indicate the need for additional field investigative activities, an updated schedule can be prepared based on the anticipated duration of the supplemental field activities.

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[3] The exact wells to be analyzed using CSIA methods cannot be determined until the compounds present and their concentrations are established from the VOC results.

[4] The analytical laboratory conducting the CSIA work has advised that it has a 120-day turnaround time. Roux Associates contacted other potential laboratories to conduct the CSIA work, but none were able to complete the necessary 2D and 3D CSIA work on chlorine, carbon and hydrogen atoms.

Should you have any questions or comments, please contact either of the undersigned at (856) 423-8800.

Sincerely,

ROUX ASSOCIATES, INC.

Justin Kowalkoski, P.G.
Senior Geologist

Gregory D. Martin, P.G.
Vice President/Principal Hydrogeologist

cc: Richard Staron - PADEP - E-mail
Bonnie McClennen - PADEP - E-mail
Bishop Tube Project Team - E-mail

Table 1. Revised Groundwater Sampling Plan. Former Bishop Tube; Chester County, Pennsylvania.

Well ID	Sampling for VOCs (Previously Approved by DEP)	Sampling for VOCs (Revised List)	Sampling for CSIA (Revised Analysis)
MW-15		x	x
MW-25C		x	x
MW-26C		x	x
MW-27B		x	x
MW-28B		x	x
MW-32	x	x	x
MW-44B		x	x
MW-51B		x	x
MW-53A		x	x
MW-56		x	x
MW-58A		x	x
MW-59A		x	x
MW-61		x	x
MW-63		x	x
MW-64		x	x
MW-72		x	x
MW-75B		x	x
MW-77		x	x
MW-79A		x	x
MW-80C		x	x
MW-81	x	x	x
MW-82A	x	x	
MW-82B	x	x	x
MW-83	x	x	
MW-84A	x	x	
MW-84B	x	x	x
PZ-8	x	x	x
PZ-9	x	x	x

Notes:
VOCs = Volatile organic compounds.
DEP = Pennsylvania Department of Environmental Protection.
CSIA = Compound-specific isotope analysis.
x = Sampling proposed.
Wells identified for CSIA may be adjusted based on VOC results.

November 2, 2018

Dustin Armstrong
Environmental Cleanup Program
PA Department of Environmental Protection
2 East Main Street
Norristown, Pennsylvania 19401

Re: Bishop Tube Site
Concluding Remedial Investigation Activities

Dear Mr. Armstrong:

On behalf of the Bishop Tube Project Team ("BT Team"), Roux Associates, Inc. ("Roux Associates") submits this letter in response to the Pennsylvania Department of Environmental Protection's ("DEP") October 19, 2018 letter. In accordance with Paragraph 5g of the Amended Consent Order and Agreement ("COA") dated August 4, 2009, this response constitutes the BT Team's written response to DEP's request, with clarifications described below.

- **RI Schedule – GW Delineation Complete** - The BT Team believes that the schedule requested by DEP for submission of the Supplemental Remedial Investigation Report ("RIR") can be met if no additional data collection other than that previously outlined as part of DEP-approved work plans is required. More specifically, if the compound-specific isotope analysis ("CSIA") data, coupled with other lines of evidence, achieve plume delineation, then we expect to submit the Supplemental RIR on or about March 31, 2019, as noted in Roux Associates' August 9, 2018 letter to DEP and the BT Team's last 3 progress reports. We do not currently anticipate that receipt/review of the CSIA data (Jan/Feb 2019) and collection of a second round of surface water samples (anticipated Nov 2018), will affect the March 31, 2019 RI due date.
- **RI Schedule – GW Delineation Not Complete** - To the extent CSIA data, coupled with other lines of evidence, do not achieve plume delineation to PADEP's satisfaction, then we do not believe that DEP's schedule or technical approach is feasible.[1] It is not reasonable or appropriate for DEP to require the delineation of contamination in groundwater via modeling when the licensed professional geologist responsible for certification of the Supplemental RIR has concluded such a model could not precisely delineate the extent to which CVOC contamination that originated from the Site is exceeding MSCs.[2] The BT Team has clearly and repeatedly communicated its position that modeling, for the purpose of plume delineation, at this Site will produce results that are unreliable.[3] DEP has not provided a meaningful response to counter our technical position regarding the validity of modeling for this Site. The BT Team has incurred substantial cost and effort to generate factual groundwater data. While we share DEP's wish for prompt completion of the Supplemental RIR, this is not a reason to compromise the technical integrity of the Site investigation. To the extent DEP's objective is to employ "fate

[1] Notwithstanding whether the results would be reliable, completion of a complex model would take far longer than the 60 days from approval of a written work plan as suggested by DEP. A cursory review of available Baker invoices indicates it invoiced DEP for groundwater modeling services over at least a 10-month period. We further note that even after this 10-month period, the results of this model were nowhere near representative of the Site conditions that were later determined through physical Site investigation activity and the collection of empirical data.

[2] In DEP's User's Manual for the Quick Domenico Groundwater Fate-and-Transport Model (v. No.3b, 2/28/14), the DEP states: "Fate-and-Transport analyses [modeling, in this context] involve interpretations of hydrogeological conditions and they require the oversight of a licensed professional geologist. The environmental professional who submits a model to DEP is entirely responsible for using it correctly, selecting appropriate input parameter values, properly justifying his or her methods, and adequately documenting the work."

[3] The BT Team respectfully disagrees with DEP's characterization of prior communication regarding modelling as "circular". The BT Team has consistently expressed the importance of collecting reliable, empirical groundwater data to delineate the extent of groundwater contamination.

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California ■ Illinois ■ Massachusetts ■ New Jersey ■ New York ■ Texas

and transport analysis" to establish the approximate downgradient extent of single-digit parts per billion contaminants in groundwater, the linear regression approach previously proposed would be as reliable as any modeling effort and could be completed in a more timely manner.[4] The BT Team is suggests a meeting with DEP after receipt and interpretation of the CSIA results to discuss required actions.

- **FS Schedule** - Standard environmental industry practice is to commence a Feasibility Study ("FS") after completion of an RI. Since submission of the August 2015 RIR, the DEP has required substantial, sequential, additional investigation and has not determined that the RI for this Site is complete. Field work is still ongoing, including an investigation the DEP is conducting in 5 areas of the Site in November 2018. Nevertheless, because the FS scope, workplan and screening memorandum have been defined and approved by DEP[5], the BT Team agrees to set aside standard practice to address PADEP's request. Roux Associates will resume FS activities, in parallel with preparation of the Supplemental RIR, with the objective of submission of the FS Report within 45 days of submission of the Supplemental RIR.
- **Miscellaneous Items -** The BT Team requests clarification of DEP's comment (pg.2, para.3): "Also, note, two rounds of synoptic groundwater quality data are necessary to characterize the contaminant plume." DEP is fully aware of the scope of investigations for this Site and has conducted prior review and approval of all work plans. If DEP has specific groundwater sampling in mind that it believes the BT Team should be conducting, please advise immediately so that this issue can be resolved without need for modification to the schedule commitments above.

The BT Team has been and remains interested in completing its obligations under the COA. To ensure we do not give cause for DEP's citing of Paragraph 6 of the COA related to potential future 30-day notice of termination procedures, we request a written response to this letter. The BT Team is also willing to participate in a conference call or meeting if deemed beneficial by DEP.

If you have any questions or comments regarding the above, please call the undersigned at (856) 423-8800.

Sincerely,

ROUX ASSOCIATES, INC.

Gregory D. Martin, P.G.
Vice President/Principal Hydrogeologist

cc: Mr. Nagel - East Whiteland Township – E-mail
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Ms. Iddings, Esq. - PADEP - E-mail
Bishop Tube Project Team - E-mail

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[4] As described in DEP's Technical Guidance Manual (June 8, 2002, pg. IV-3), "... the regulations governing Act 2 use the term 'fate and transport analysis' as opposed to 'fate and transport model'. This particular distinction was made because it will not always be necessary to run an analytical or numerical quantitative 'fate and transport model' to achieve a standard."

[5] See previously submitted July 29, 2016 Feasibility Study Work Plan ("FSWP"), December 15, 2016 FSWP Addendum, DEP letter dated January 11, 2017 providing FSWP Addendum approval, March 31, 2017 Preliminary FS Screening Memorandum, and DEP letter dated April 21, 2017 providing comments on these documents. The preparation of the FS will continue following these established communications.