Draft Feasibility Study

FULTON AVENUE SUPERFUND SITE
OPERABLE UNIT 2

United States Environmental Protection Agency

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List of Acronyms and Abbreviations

µg/L	micrograms per liter
µm	micrometer
1,1-DCE	1,1-dichloroethene
AOP	advanced oxidation processes
APTIM	APTIM Federal Services LLC
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	contaminant of concern
COPC	contaminant of potential concern
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
DES	Design and Engineering Services
DVI	dual-valent iron
ELCR	excess lifetime cancer risk
EPA	United States Environmental Protection Agency
ERH	electrical resistance heating
FS	Feasibility Study
ft/d	feet per day
GAC	granular activated carbon
GCPIA	Garden City Park Industrial Area
GRA	General Response Action
HDPE	High Density Polyethylene
HDR EOC	HDR Environmental, Operations and Construction, Inc.
HDR-APTIM	HDR APTIM LLC
HHRA	Human Health Risk Assessment
HI	hazard index
IC	institutional control
ISCO	in-situ chemical oxidation
ISCR	in-situ chemical reduction
ISTD	in-situ thermal desorption
ISTT	in-situ thermal treatment
LTM	Long Term Monitoring
LNAPL	light non-aqueous phase liquid
MCL	Maximum Contaminant Level
MGD	million gallon per day
MNA	Monitored Natural Attenuation
NAPL	non-aqueous phase liquid
NAVD88	North American Vertical Datum of 1988

NCDOH	Nassau County Department of Health
NCDHPW	Nassau County Department of Health and Public Works
NCP	National Contingency Plan
NPDES	National Pollution Discharge Elimination System
NPL	National Priorities List
NYSDEC	New York State Department of Environmental Conservation
O&M	operation and maintenance
°C	degrees Celsius
OU	Operable Unit
OU1	Operable Unit 1
OU2	Operable Unit 2
P&T	pump and treat system
PAH	polycyclic aromatic hydrocarbons
PCE	tetrachloroethene
PDC	Potential Delineation Criteria
PDI	Pre-Design Investigation
POTW	publicly owned treatment works
PPE	Personal Protective Equipment
PRB	permeable reactive barrier
PRG	preliminary remediation goal
PWS	public water supply
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROI	radius of influence
SARA	Superfund Amendments and Reauthorization Act of 1986
SEE	steam-enhanced extraction
Site	Fulton Avenue Superfund Site
SSA	Sole Source Aquifer
SVE	soil vapor extraction
SWAP	Source Water Assessment Program
TBC	"to be considered"
TCE	trichloroethene
TCH	thermal conduction heating
TOGS	Technical and Operational Guidance Series
UIC	Underground Injection Control
USGS	United States Geological Survey
UV	ultraviolet
VC	vinyl chloride

VOC	volatile organic compounds
WAWNC	Water Authority of Western Nassau County
ZVI	zero valent iron

1 INTRODUCTION

This Feasibility Study (FS) for Operable Unit (OU) 2 (OU2) of the Fulton Avenue Superfund Site (the Site) has been prepared for the United States Environmental Protection Agency (EPA) by HDR APTIM LLC (HDR-APTIM). HDR APTIM LLC is a joint venture of HDR Environmental, Operations and Construction, Inc. (HDR EOC) and APTIM Federal Services LLC (APTIM). The FS is part of the Remedial Investigation/Feasibility Study (RI/FS) being performed by HDR-APTIM under Task Order Number 68HE0222R0007 of the EPA Design and Engineering Services (DES) Contract No. 68HE0318D0009. This current task order was issued in July 2022.

1.1 Purpose and Organization of the Report

This FS report has been prepared in accordance with EPA's Guidance for Conducting Remedial Investigations and Feasibility Studies under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) (EPA, 1988) and other applicable guidance as included in the list of references.

In accordance with the National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan (NCP) (EPA, 1994a), the relative performance of each alternative is evaluated using the nine criteria of the NCP as the basis for comparison. The purpose of the evaluation process is to determine which alternatives meet the threshold criteria of (1) overall protection of human health and the environment over both the long-term and short-term and (2) attainment of Applicable or Relevant and Appropriate Requirements (ARARs), unless a waiver is appropriate.

Section 121 of CERCLA requires that remedial actions completed under Section 104 or Section 106 of CERCLA be protective of human health and the environment and attain the levels or standards of control for hazardous substances, pollutants, or contaminants specified by ARARs (i.e., cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a National Priorities List [NPL] site) found in federal and state statutes, unless waivers are obtained. Non-promulgated "to be considered" (TBC) criteria or guidelines must also be considered.

Once the threshold criteria have been met, the remedial alternatives are evaluated in terms of their ability to provide the best balance with respect to the five NCP balancing criteria, including:

- Long-term effectiveness and permanence, to address how well a remedy protects human health and the environment after remedial action objectives (RAOs) have been met, including an assessment of residual risk, and the adequacy and long-term reliability of management controls.

- Toxicity, mobility, or volume reduction to assess the amounts of chemicals destroyed or treated and that remain at the site.
- Short-term effectiveness in the protection of human health and the environment during construction and remedial actions, including the length of time required to achieve protection, short-term reliability of remedial technologies, protection of workers and the community during construction, and disruption of neighboring areas.
- Implementability, considering the technical and administrative feasibility of each alternative, and availability of the products and services needed to execute the remedy. This also considers the ability to construct and operate remedial facilities, ease of undertaking additional remedial actions, ability to monitor remedial effectiveness, and ability to obtain approvals and Permit Equivalents.
- Cost evaluation of remedial alternatives, including both total long-term (operational) and short-term (construction) costs.

The modifying criteria, namely state and community acceptance of the remedial alternatives are evaluated based on formal comments received during the remedial project's comment period. Issues and concerns presented by stakeholders (e.g., government agencies, property owners, and community groups) will be addressed after the public comment period concludes.

The development and screening of each alternative includes the following six steps:

- Develop RAOs;
- Develop General Response Actions (GRAs);
- Identify volumes and areas where GRAs will be applied;
- Identify and screen technologies applicable to each GRA;
- Identify and evaluate technology process options to select representative process options for each technology; and
- Assemble combinations of selected process options into remedial alternatives.

Once the alternatives have been assembled, a detailed evaluation is completed. The purpose of the evaluation is to identify the advantages and disadvantages of each alternative. The detailed evaluation of alternatives consists of an individual analysis of each alternative against the evaluation criteria, and a comparative analysis among the alternatives to assess the relative performance of each alternative with respect to the evaluation criteria. This analysis is designed to provide decision makers with sufficient information to adequately compare the alternatives, select an appropriate remedy, and demonstrate satisfaction of the CERCLA remedy selection process in the Record of Decision (ROD).

This report comprises ten sections, summarized below:

- **Section 1 – Introduction:** provides general information on the purpose and organization of the FS Report, and the criteria and process involved in evaluating and selecting the remedial alternative(s) to be implemented.

- **Section 2 – Site Description:** includes a summary of history and background information and a description of the physical characteristics of the Site.

- **Section 3 – Remedial Investigation Summary:** provides a summary of the nature and extent of contamination; and results of human health risk assessment screening.

- **Section 4 – Remedial Goals and Remedial Action Objectives (RAO):** develops a list of RAOs and preliminary remediation goals (PRGs) that consider the contaminant characterization, results from the human health risk assessment screening, and compliance with ARARs and TBCs.

- **Section 5 – General Response Actions (GRA):** identifies the GRAs for each medium.

- **Section 6 – Identification and Screening of Remedial Technologies and Process Options:** provides an evaluation of the GRAs against the NCP criteria, the effectiveness in meeting RAOs, and the technical implementability and costs. Screening of technologies and process options for OU2 are also included.

- **Section 7 – Evaluation of Process Options:** evaluates the groundwater remediation process options retained after screening.

- **Section 8 – Development of Remedial Action Alternatives:** assembles the viable process option into remedial alternatives. This section also provides the preliminary design assumptions associated with the alternatives that were used to develop costs.

- **Section 9 – Detailed Evaluation of Remedial Action Alternatives:** provides a detailed description of the NCP criteria and evaluation of the individual remedial alternatives against the criteria. A comparison between the various remedial alternatives is also provided.

- **Section 10 – References:** provides a list of references used to prepare the FS.

2 SITE DESCRIPTION

2.1 Location and Description

The Fulton Avenue Superfund site comprises an area of groundwater contamination within the Towns of North Hempstead and Hempstead, Nassau County, New York (**Figure 2-1**). The EPA has designated two OUs for the Site: Fulton Avenue Superfund Site OU1 (Fulton OU1) and Fulton Avenue Superfund Site OU2.

Fulton OU1 includes a 0.8-acre property located at 150 Fulton Avenue, Garden City Park, Nassau County, all locations impacted by contamination released at the Fulton Property, and all other contamination impacting the groundwater and indoor air in the vicinity of the Fulton Property (EPA 2015). In 1986, the Nassau County Department of Health and Public Works (NCDHPW) conducted an investigation to find the source of Volatile Organic Compound (VOC) groundwater contamination impacting public water supply (PWS) wells located downgradient of Garden City Park Industrial Area (GCPIA). 150 Fulton Avenue in Hempstead, New York was identified as a potential source. In response, the New York State Department of Environmental Conservation (NYSDEC) added the 150 Fulton Avenue site to the registry of Inactive Hazardous Waste Disposal Sites. In 1998, the EPA placed the Site on the NPL under the CERCLA. During the 1998-2001 environmental investigation, a drywell in the parking lot of 150 Fulton Avenue was found to be the major source of groundwater contamination. Previous tenants of the property included a fabric cutting mill operating from approximately 1965-1974, which dry cleaned fabric using tetrachloroethene (PCE) (EPA 2015). As a result, the 0.8-acre property and associated groundwater contamination were designated Fulton OU1.

During the course of the RI, the groundwater data showed groundwater contaminated with trichloroethene (TCE) to the west of OU1. The EPA designated OU2 to investigate the TCE contamination as well as possible sources of TCE. OU2 is the subject of this FS.

2.1.1 Municipal Wells

A PWS well search was completed to locate municipal wells within a one-mile radius of OU2. The results (**Figure 2-2**) show seven PWS wells within a one-mile radius of the center of OU2. These include:

1) Village of Garden City - Well 9 (N-03881);
2) Village of Garden City - Well 13 (N-07058)
3) Village of Garden City - Well 14 (N-08339);
4) Franklin Square Water District - Well 1 (N-03603);
5) Franklin Square Water District - Well 2 (N-03604); and
6) Water Authority of Western Nassau County (WAWNC) - Well 57 (N-07649); and
7) Water Authority of Western Nassau County (WAWNC) - 57A (N-07650).

Groundwater analytical data from these wells show the presence of PCE, TCE, and cis -1, 2-Dichlorothylene (cis-1,2-DCE) in concentrations above either the NYSDEC or Federal Drinking

Water Standards. The concentration of TCE, PCE, and cis-1,2-DCE in these wells are shown on **Figures 2-3** through **2-9**.

Garden City Well 9 contains TCE and lesser amounts of PCE potentially from OU2. Garden City Wells 13 and 14 contain PCE and lesser amounts of TCE potentially from OU1. WAWNC wells 57 and 57A contain VOCs potentially from other sources. Franklin Square Well 1 contains TCE and lesser amounts of PCE. Franklin Square Well 2 contains only TCE below the NYSDEC and Federal Drinking Water Standards.

2.2 Land Use and Topography

Land use in the area of the OU2 plume is primarily residential with a small area of commercial land use in the northern area of OU2. Regional land use in and around the Site is shown in **Figure 2-10**.

OU2 lies in the Atlantic Coastal Plain physiographic province of Long Island, New York. Based on the United States Geological Survey (USGS) Lynbrook Quadrangle 7.5-minute topographic map, ground surface topography is relatively flat lying and ranges in elevation between 75 and 100 feet (NAVD88). The ground surface generally slopes to the southwest at a grade of less than 1 percent (USGS, 2023).

2.3 Geology

The geology of Nassau County, New York can generally be described as a thickening wedge of unconsolidated sediment overlying bedrock, that extends from Long Island Sound to the Atlantic Ocean. Bedrock generally consists of Precambrian crystalline igneous and metamorphic rock, including granite, schist, and gneiss. Bedrock is overlain by a sequence of upper Cretaceous age unconsolidated sedimentary deposits, of the Raritan and Magothy Formations, and Pleistocene age glacial deposits.

The Raritan Formation lies directly on the bedrock surface. The Raritan Formation consists of the basal Lloyd sand member and an upper Clay member, which is often referred to as the Raritan Clay. The Lloyd member range is approximately 300 feet thick and is composed of fine to coarse sand, gravel, discontinuous beds of sandy clay, and thin beds of lignite. The Clay member is approximately 200 feet thick and is composed of gray, white, red, and purple clay that is locally silty or sandy. Lignite and pyrite are also present.

The Magothy Formation lies unconformably above the Raritan and is approximately 400 feet thick. The Magothy Formation is composed of fine to medium sand with discontinuous lenses of coarse sand, sandy clay, silt, and clay. The lower 50 to 100 feet typically contains gravel. Lignite and pyrite are also present. Literature (Smolensky, et al., 1989) indicates that the contact between the base of the Magothy Formation and the top of the Raritan Clay is at or near -400 ft msl in OU2.

Pleistocene outwash deposits range in thickness from 30 to 100 feet and are composed of stratified, fine to coarse sand and gravel. **Figure 2-11** provides a plan view geologic map and

shows a generalized geologic cross section which depicts the distribution of the various formations in OU2.

2.3.1 Hydrogeology

Regional groundwater recharge occurs at and slightly north and northeast of OU2. The regional groundwater flow direction in the Magothy Aquifer can be inferred from the 2016 potentiometric surface map provided by the USGS (Como et al., 2018). Based on the potentiometric surface of the Magothy Aquifer, the groundwater flow direction at and downgradient of OU2 is to the southwest trending more to the south as groundwater flows through OU2 (**Figure 2-12**).

Groundwater in the shallow portions of the Magothy Aquifer in OU2 occurs as an unconfined aquifer. However, lenses of silt and clay, whose overlapping arrangement produces anisotropy ranging from approximately 36:1 to 120:1, cause a confining effect with depth (Isbister, 1966 and Reilly et al., 1983). The storativity of the Magothy Aquifer ranges from water table conditions (0.25) to confined conditions (0.0006) depending on the location and depth (Reilly et al., 1983). Hydraulic conductivity estimates for the regional Magothy Formation based on aquifer tests of permeable portions of the aquifer range from approximately 27 feet per day (ft/d) to 150 ft/d with an average of approximately 67 ft/d (Isbister, 1966). Variations in the horizontal and vertical hydraulic conductivity can occur locally due to the presence of lower or higher permeability materials such as silts, clays, or gravels. More recent studies contain average values of hydraulic conductivity for the Magothy Formation to be in the range of 35 to 90 ft/d (Cartwright, 2002; Misut and Feldman, 1996; Smolensky and Feldman, 1995). The horizontal hydraulic gradient in shallow portions of the Magothy Aquifer can range from 0.0001 to 0.001 feet per foot; however, the hydraulic gradient can be affected by hydraulic stresses such as local pumping, recharge basins, and remediation systems (Busciolano et al, 1998).

The Nassau/Suffolk Aquifer, which includes the upper glacial, Magothy, and Lloyd aquifers, was designated as a Sole Source Aquifer by the EPA in 1978. The Nassau/Suffolk Aquifer is considered the sole source of drinking water in Nassau County. There are seven public water supply wells within a one-mile radius of OU2.

2.3.2 Surface Water

There are no natural surface water bodies including rivers or creeks within a one-mile radius of the OU2 plume. There is a stormwater retention basin (i.e., recharge basin) located on Tanners Pond Road in OU2 (**Figure 2-13**). The retention basin is ephemeral and primarily holds water after rain events. It is anticipated that it could have a temporary impact on both horizontal and vertical groundwater flow in the immediate area of the basin. Additionally, there is a wetland area identified by the National Wetlands Inventory within the OU2 plume in the Garden City Country Club.

Groundwater in OU2 does not discharge to surface water. There are numerous rivers approximately two miles to the south of OU2.

3 REMEDIAL INVESTIGATION SUMMARY

The purpose of the OU2 remedial investigation (RI) was to investigate the nature and extent of the TCE contamination associated with OU2. HDR conducted field activities for the RI in five phases from 2011 to 2020, which are described in detail in the RI report, along with a more detailed summary of the results of each investigation and general discussions of the site conditions. The field activities culminated in Phase 5 which included two comprehensive rounds of groundwater sampling in 2019 that were used to develop the conceptual site model and risk assessment presented below.

3.1 Nature and Extent of Contamination

Multiple lines of evidence were used to identify the extent of the TCE-dominant groundwater contamination in OU2. These lines of evidence were used to:

- Distinguish TCE that was released to the environment from TCE that is from the biotic or abiotic degradation of PCE.
- Distinguish TCE in OU2 from other potential sources of TCE using groundwater flow direction as defined by the USGS groundwater flow mapping (Como et al, 2018).
- Distinguish TCE in OU2 from other potential sources of TCE using the mapped recharge areas of municipal wells in the Garden City area as defined by the Nassau County Department of Health (NCDOH) Source Water Assessment Program (SWAP).

Evaluating these lines of evidence led to six monitoring wells (MW-20C, MW-23C, MW-25A, MW-26F, MW-26G and N-11171) and one municipal water supply well, Garden City Well 9 (N-03881) that were determined to contain TCE-dominant concentrations and are considered with in the OU2 plume.

3.1.1 Groundwater Monitoring Well Sampling

Two rounds of groundwater sampling were conducted in August-September 2019 and December 2019 as part of the comprehensive Phase 5 groundwater sampling. The total distribution of wells covered an area much larger than OU2 to get a full perspective of the contamination and possibly identify OU2 source(s). Within the OU2 plume, the six monitoring wells and one public water supply well were sampled and analyzed for VOCs, metals (iron, manganese, and sodium), organic acids, and biodegradation indicator parameters in the comprehensive rounds.

3.1.1.1 Volatile Organic Compounds

VOCs were detected in all of the OU2 wells in both rounds of groundwater sampling in Phase 5. TCE and PCE were most frequently detected above the Potential Delineation Criteria (PDC) in Phase 5. A comparison of VOC data to the PDC is provided on **Table 3-1** and shown on **Figure 3-1**. Below is a summary of the VOCs with PDC exceedances in OU2 groundwater.

- TCE
    - Sample results in Round 1 within OU2 ranged from 0.37 to 79 µg/L with a maximum at N-03881, a median of 23 µg/L, and an average of 25 µg/L.
    - Sample results in Round 2 within OU2 ranged from 2.4 to 27 µg/L with a maximum at MW-25A, a median of 15 µg/L, and an average of 16 µg/L.
- PCE
    - Sample results in Round 1 within OU2 ranged from 0.52 to 42 µg/L with a maximum at N-03881, a median of 7.9 µg/L, and an average of 14 µg/L.
    - Sample results in Round 2 within OU2 ranged from 1.1 to 22 µg/L with a maximum at MW-25A, a median of 5.5 µg/L, and an average of 7.9 µg/L.
- cis-1,2-DCE
    - Sample results in Round 1 within OU2 ranged from 0.36 to 5.6 µg/L with a maximum at MW-26F, a median of 0.5 µg/L, and an average of 1.6 µg/L.
    - Sample results in Round 2 within OU2 ranged from 0.27 to 3.8 µg/L with a maximum at MW-26F, a median of 0.34 µg/L, and an average of 1.1 µg/L.

Analytical results from RI groundwater sampling indicate that TCE-dominant groundwater contamination is present in an area roughly 5,400 feet long north to south, extending from the area between Nassau Terminal Road and the Long Island Railroad line in the north, to an area between Farmount Blvd. and Dartmouth Street to the south. The width of the TCE-dominant area is roughly 2,500 feet, extending from the area between Adam Street and New Hyde Park Road to the west, to the western border of OU1 between Tanners Pond Road and Lee Road to the east. The southeastern portion of the plume extends approximately 500 feet east into the northwestern portion of the Garden City Country Club. The extent of the plume is shown on **Figure 3-1**.

There is not sufficient well density to provide a detailed vertical distribution of TCE-dominant groundwater. However, data indicate that TCE exceeds the PDC only in deep wells with screen depths ranging from 345 feet to 466 feet below ground surface (bgs). In general, data indicate that the TCE-dominant groundwater in OU2 is migrating primarily in the deeper portion of the Magothy Aquifer at depths between 300 feet and 500 feet bgs.

3.1.1.2 Metals

Iron, manganese, and sodium were detected throughout OU2 (**Table 3-1**). These metals, however, were determined not to be site-related contaminants in that they were not released to groundwater from the same source as the TCE.

Iron concentrations in OU2 wells ranged from 79 µg/L to 379,000 µg/L with the highest concentration at MW-23C. Manganese concentrations ranged from 1.5 µg/L to 2,170 µg/L in the OU2 wells (**Table 3-1**). Iron and manganese are naturally occurring in the Magothy Formation and can be solubilized by changing geochemical conditions (Brown, 1995).

Sodium concentrations ranged from 7,280 µg/L to 117,000 µg/L. Sodium is commonly found on Long Island resulting from urban runoff and stormwater recharge to the aquifer system.

3.2 Fate and Transport

The primary contaminants in OU2 are TCE and PCE. These chlorinated solvents are present as solutes (i.e. dissolved phase) in groundwater. As such, horizontal and vertical migration within and beyond OU2 will be with the general flow of groundwater. Investigations also indicate that the plume is migrating at depth within the Magothy Aquifer in OU2.

Advection is the most dominant transport process in the movement of these compounds in groundwater. The direction of advective movement is controlled by the horizontal and vertical hydraulic gradients within the aquifer. Horizontal hydraulic gradients within OU2 were generally southwest in direction and vertical hydraulic gradients were generally downward.

The average linear or seepage velocity in OU2 is estimated to be approximately 0.5 ft/d. This value represents the net advective movement on a large or sitewide scale. Advective movement on a more local scale is much more complex. Local changes in the direction and magnitude of both horizontal and vertical gradients result from pumping at water supply wells and recharge at stormwater retention basins in OU2. Vertically upward gradients were observed in proximity to operating water supply wells, and up to three feet of increased hydraulic head was observed in proximity to stormwater recharge basins during major precipitation events.

Variable rates of advection result in mechanical dispersion of the PCE and TCE. Effects of mechanical dispersion, however, in OU2 are expected to be minimal in the longitudinal and lateral direction of groundwater flow.

The presence of fine-grain silt and clay beds in the Magothy Aquifer appear to be limited and therefore, the effects of diffusion and back diffusion on the plume are expected to be limited.

The advective movement of PCE and TCE can be slowed or retarded by sorption to organic matter in the aquifer. The Magothy Aquifer generally has a low organic carbon content (f_{oc} less than or equal to 0.001) (ITRC, 2015). Under these conditions, the impact of retardation on the advective movement of PCE and TCE is expected to be limited.

There is mixed evidence of biotic transformation of PCE and TCE in OU2. The aquifer is under mildly reducing conditions, based on ORP levels measured during well sampling indicating that favorable redox conditions are present. Although the OU2 area is both recharged locally and is close to the hydraulic divide that represents the main recharge zone for the aquifer on Long Island, contamination was found in deeper portions of the aquifer where oxygen can be consumed along the longer flow path by the widespread presence of organic solvent contamination.

Only trace levels of cis-1,2-DCE, a byproduct of the reductive dichlorination of TCE were detected. However, vinyl chloride was not detected indicating that degradation is incomplete. This may be a result of limiting geochemical conditions in the aquifer resulting in degradation of TCE to a

limited degree.

Abiotic degradation may also be occurring as it appears that favorable redox conditions are present and soluble iron is present in the aquifer. However, neither analysis for acetylenes or iron speciation to identify the presence of reduced forms of iron (e.g. iron sulfides) was performed and it is not known if and to what degree abiotic degradation may be taking place.

As previously discussed, the presence of fine-grained silt and clay beds within the aquifer at OU2 is limited and the effects of diffusion and back diffusion are expected to be limited as well. Although chlorinated VOCs (CVOCs) have a high Henry's Law Constant and would readily be transferred from the aqueous phase into the gaseous phase through volatilization, volatilization is not expected to be a factor in the fate and transport of TCE and PCE in OU2 as contamination appears to be deep within aquifer, not at or near the water table or unsaturated zone. For the same reason, dilution from recharging precipitation is not expected to be a major factor in the fate and transport of TCE and PCE in OU2.

3.3 Risk Assessment Summary

The risk assessment performed as part of the RI was limited to a human health risk assessment (HHRA). An ecological risk assessment was not conducted because contaminated groundwater does not discharge to any surface water bodies within OU2. Since there are no groundwater discharges to surface water, exposure pathways are not complete, and ecological receptors are not exposed to contaminants from the Site.

Evaluation of potential cancer risks and noncancer hazards (resulting from the screening assessment) to future Site receptors from exposure to contaminant of potential concern (COPCs) in groundwater indicated that there are several primary COPCs, consisting of VOCs (TCE, PCE, and benzene) and metals (iron and manganese) in groundwater. These COPCs were further evaluated in the risk assessment. The concentrations of TCE, manganese and iron in groundwater contribute to the overall hazard and risk estimates, and exposure to these COPCs may result in potential adverse health effects.

The potential exposure scenarios considered in the HHRA included drinking water ingestion and dermal contact for future Site workers and future Site residents, and inhalation of volatile organics in groundwater while showering for future Site residents. Vapor intrusion into indoor air was not evaluated as the available soil vapor samples were located in areas of OU1 that are not near the TCE-dominant plume (OU2). Therefore, the soil vapor samples collected as part of this RI, are not considered to be representative of the soil vapor concentrations that might result from the TCE-dominant plume. In addition, the depth to contaminated groundwater exceeds 100 feet in all OU2 monitoring wells.

The baseline HHRA results indicate the potential for unacceptable excess lifetime cancer risk (ELCR) does not exceed the target risk range of $1x10^{-6}$ to $1x10^{-4}$ (one in a million to one in ten thousand); however, the noncancer hazard index (HI) exceeds unity (one), indicating there may be concern for potential noncancer effects mainly from TCE, iron, and manganese.

The total ELCR for a worker's exposure to COPCs in groundwater via tap water use from all pathways is $4.1x10^{-6}$ which is within the target risk range of $1x10^{-6}$ to $1x10^{-4}$ (one in a million to one in ten thousand). The ELCR for groundwater ingestion exposure is $4.1x10^{-6}$, with the primary contributor to risk being TCE. The ELCR for groundwater dermal exposure is $2.4x10^{-8}$ which is less than the target risk range of $1x10^{-6}$ to $1x10^{-4}$. The total noncancer HI is 2.9. The HI for groundwater ingestion is 2.9 and the primary contributor is iron, with a HQ of 1.8. The HI for groundwater dermal exposure is 0.005.

The ELCRs for a resident's exposure to COPCs in groundwater via tap water is 2.5x10-5 from the ingestion pathway, 3.5x10-6 from the dermal pathway, and 8.1x10-8 from the inhalation pathway for a receptor total of 3.0x10-5. These values are within or less than the target risk range of 1x10-6 to 1x10-4. The groundwater ingestion pathway contributes the majority (about 83%) to the risk total; the primary contributor is TCE. The total noncancer HI is 18 for an adult and 22 for a child. The groundwater inhalation and ingestion pathways contribute the most to these HIs with adult HIs of 10 and 8, respectively, and child HIs of 8 and 13, respectively. TCE is the primary contributor for all pathways, but iron and manganese both have HIs greater than one for the ingestion pathway. While included in the HHRA, these parameters are not considered to be site-related; detections of iron and manganese do not appear to be associated with the OU2 TCE. Thus, iron and manganese were not retained as chemicals of concern.

3.4 Contaminants of Concern

COPCs include contaminants that were identified in the HHRA with an elevated risk or hazard and contaminants that are considered potentially Site-related and/or exceeded federal and state drinking water and/or groundwater limits. COPCs were reviewed to determine which of them are actual contaminants of concern (COCs).

The OU2 COCs were determined to be PCE and TCE.

Iron and manganese were identified by the HHRA screening as COPCs, but were not carried forth as COCs as they are not considered Site-related, are regulated as secondary taste and quality contaminants, and are generally considered to be naturally occurring. Benzene was another COPC that was not retained as a COC. Its maximum detected concentration is less than the drinking water standard (1 µg/L). Additionally, benzene is commonly associated with petroleum products and not related to TCE and thus is not considered Site-related.

3.5 OU2 Plume Conclusions

The major conclusions of the OU2 RI are outlined below:

- The source(s) of the OU2 TCE has not been identified.
- Groundwater in the Magothy Aquifer in OU2 flows to the southwest and south.

- Groundwater contains VOCs, metals, and wet chemistry parameters above the PDC. However, only TCE and PCE have been retained as COCs.

- The OU2 groundwater plume extent is approximately 2,500 feet in width by 5,400 feet in length with a depth ranging from 250 to 450 feet at the northern edge of the plume and between 350 to over 500 feet at the southern edge.

- TCE within OU2 ranges in concentration from 0.37 ug/L to 79 ug/L with an average concentration of 21 ug/L and a median of 19 ug/L.

- Groundwater containing TCE has impacted one public water supply well (N-03881, Garden City Well 9). Groundwater extracted by this well is treated to below Federal/State maximum contaminant levels (MCLs) before distribution to customers.

- Groundwater containing TCE poses an unacceptable risk to human health under the future potable use scenario for future workers and future residents. Groundwater containing VOCs does not form a complete exposure pathway to potential ecological receptors.

4 REMEDIAL GOALS AND REMEDIAL ACTION OBJECTIVES

4.1 Applicable and Relevant and Appropriate Requirements and To Be Considered Criteria

Section 121(d) of the CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires federal and state ARARs be met. Subpart E, Section 300.400(g) of the NCP, identification of ARARs, describes the process to attain ARARs (EPA, 1986).

There are differences between the identification and analysis of applicable vs. relevant and appropriate requirements. Applicability is a legal and jurisdictional determination, while the determination of relevant and appropriate is based on professional judgment, considering the environmental and technical factors specific to a site.

To be applicable, a requirement must directly address the circumstances at the site. Applicable requirements are defined as “those cleanup or control standards, or other substantive environmental protection requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site” (55 FR 8814). Jurisdictional prerequisites of the requirement must be met for the requirement to be applicable and include: the party being subject to the law; the substances or activities must be under the authority of the law; the law must be in effect at the time activities occur; and the law requires, limits, or protects the type of activity in question.

There is greater flexibility in determining relevant and appropriate requirements. Determining relevant and appropriate requirements is a two-step process, requiring a determination first of relevance, where the requirement pertains to the type of remedial action being taken, location of the action, or chemicals and related conditions at the site. Second, a determination of whether it is appropriate focuses on the nature of the items, in question, characteristics of the site, circumstances of the release, and proposed remedial action. The requirement is appropriate if suited to the particular site. The facility action must comply with requirements that are determined to be both relevant and appropriate. Once a requirement is determined to be relevant and appropriate, it must be complied with as if applicable.

EPA has classified ARARs (applicable or relevant and appropriate) into three categories, depending on whether the requirement is triggered by the presence of a specific chemical, characteristics of a specific location, or a particular response action.

1. Chemical-specific ARARs are risk-based, numeric and narrative cleanup standards, e.g., Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act.

2. Location-specific ARARs are restrictions on the concentration of hazardous substances or on activities in environmentally sensitive areas, e.g., restrictions within floodplains, wetlands.

3. Action-specific ARARs are technology- or activity-driven requirements, resulting largely from provisions of Resource Conservation and Recovery Act (RCRA) and the Clean Water Act.

ARARs are promulgated, legally enforceable federal and state requirements. In contrast, TBC values include non-promulgated, non-enforceable criteria, advisories, guidance, and proposed standards generated by the federal or a state government. TBCs may assist in interpreting ARARs or determine PRGs when ARARs do not exist. Once a TBC is identified and becomes part of a Superfund ROD, it is enforceable within the context of the remedial action that is the subject of the ROD.

Screening criteria consisting of ARARs (promulgated standards) and TBCs (screening criteria) were used as benchmarks to evaluate the nature and extent of contamination. ARARs are summarized in **Table 4-1** and discussed in greater detail below.

4.2 Chemical-Specific ARARs and TBCs for Groundwater

Chemical-specific ARARs and TBCs for groundwater define acceptable exposure levels and therefore are used to establish the PRGs. Groundwater in Nassau County has been withdrawn for municipal, irrigation, and industrial purposes since the early twentieth century (Nemickas, 1989). PWS wells currently operate near the OU2 plume. The water quality standards listed in **Table 4-1A** are considered relevant and appropriate.

4.3 Location-Specific ARARs

Location-specific ARARs are requirements which set restrictions on activities within ecological resources such as floodplains and wetlands or which impact endangered species or historical resources. The location-specific ARARs listed in **Table 4-1B**, are considered in the screening and evaluation of various technologies and process options to restrict activities within or eliminate impacts to these resources.

The Nassau/Suffolk Aquifer is comprised of the upper glacial, Magothy, and Lloyd aquifers, was designated as a Sole Source Aquifer (SSA) by the EPA in 1978. This is considered the sole source of drinking water in Nasau County. Location-specific ARARs at OU2 include requirements to protect the SSA.

4.4 Action-Specific ARARs and TBCs

Action-specific ARARs are requirements which set controls and restrictions to particular remedial actions, technologies, or process options. These regulations do not define groundwater cleanup levels but do affect the implementation of specific remedial technologies. For example, although outdoor air has not been identified in the RI report as a contaminated medium of concern, air quality ARARs are listed below, because some potential remedial actions may result in air emissions of toxic or hazardous substances. These action-specific ARARs, listed in **Table 4-1C**, are considered in the screening and evaluation of various technologies and process options.

4.5 Preliminary Remediation Goals

Groundwater is the contaminated media to be remediated under OU2. Relevant and appropriate chemical-specific requirements with numerical standards include the EPA National Primary Drinking Water Standards (MCLs; 40 CFR Part 141.10), New York Surface Water and Ground Water Quality Standards (6 NYCRR Part 703.5) (NYSDEC), Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (NYSDEC Division of Water Technical and Operational Guidance Series [TOGS] 1.1.1), and New York State Department of Health Drinking Water Standards (10 NYCRR Part 5) (NYCRR, 2022). The most stringent among these standards were used to develop a PRG for each COC. **Table 4-2** provides the PRGs for groundwater COCs.

Even though PRGs are the ultimate concentration goals for site cleanup, site-specific situations and limitations may prevent the remedial action from achieving the PRGs in a reasonable time frame. These constraints are further discussed in Section 8.

4.6 Principal Threat Waste

The NCP establishes an expectation that EPA will use treatment to address the principal threats posed by a Site wherever practicable (NCP Section 300.430(a)(1)(iii)(A)). The "principal threat" concept is applied to the characterization of "source materials" at a Superfund Site. A source material is material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of contamination to groundwater, surface water, or air, or acts as a source for direct exposure. Contaminated groundwater generally is not considered to be source material; however, non-aqueous phase liquids (NAPL) in groundwater may be viewed as source material. Based on the groundwater sampling and detected contaminant concentrations, there are no principal threat wastes identified at the Site.

4.7 Remedial Action Objectives

RAOs are media-specific goals for protecting human health and the environment. They serve as the basis for developing remedial action alternatives and specify what the cleanup action will accomplish. The process of identifying the RAOs follows the identification of affected media and contaminant characteristics; evaluation of exposure pathways, contaminant migration pathways and exposure limits to receptors. The RAOs are based on regulatory requirements and risk-based evaluation, which may apply to the various remedial alternatives being considered for a site.

The following presents RAOs that have been developed to address human health risks based on the results of the OU2 RI and risk assessment:

- Prevent or minimize future exposure (via ingestion, dermal contact, and inhalation) to Site-related contaminants in groundwater at concentrations greater than Federal and State standards;

- Minimize the potential for further migration of groundwater containing Site-related contaminants at concentrations greater than Federal and State standards; and
- Restore the impacted aquifer to its most beneficial use as a source of drinking water by reducing Site-related contaminant levels to the Federal and State standards.

5 GENERAL RESPONSE ACTIONS

GRAs are broad types of activities that will potentially satisfy the RAOs. Following the development of GRAs, one or more remedial technologies and process options are identified for each GRA category. The technologies and process options remaining after screening in Sections 6 and 7 will be assembled into alternatives that are discussed in Section 8. The alternatives will focus on containing and/or remediating groundwater.

The GRAs for impacted groundwater include:

- No Action – The no action option GRA is included as a basis for comparison with the other groundwater remediation technologies. If no action is taken, the contaminants will remain in place and the RAOs will not be met.

- Institutional Controls (ICs) – Restricting the groundwater use through ICs would minimize exposure but would take no active measures to reduce the volume of contaminants in groundwater or prevent continued groundwater plume migration. Groundwater LTM would be required in conjunction with the maintenance of existing and /or implementation of additional ICs.

- Monitored Natural Attenuation (MNA) – MNA makes use of naturally occurring processes where dilution, volatilization, biodegradation, adsorption, and/or chemical reactions with subsurface materials reduce contaminant concentrations to acceptable levels over time. In accordance with EPA guidance (EPA, 1998), MNA is used in combination with source control and LTM to assure the effectiveness and protectiveness of the process.

- Containment – Containment options are often implemented to prevent or significantly reduce the migration of contaminants in groundwater. They can be used in conjunction with treatment technologies where restoration of the resource has been identified as an objective, as is the case for the Site. Containment solutions often require long-term operation, maintenance, and groundwater monitoring to evaluate system performance and effectiveness in achieving RAOs.

- Extraction – Groundwater extraction provides hydraulic control to prevent migration of dissolved contaminants. Groundwater extraction is typically combined with ex-situ treatment and discharge response actions to achieve the RAOs. Groundwater extraction response actions provide reduction in mobility and mass of contaminants by removing the contaminants from the subsurface using groundwater extraction wells. Extraction solutions often require long-term operation, maintenance, and groundwater monitoring to evaluate system performance and effectiveness in achieving RAOs.

- Treatment – Treatment of contaminants can be achieved either in-situ or ex-situ and includes several types of technologies that encompass biological, thermal, and physical/chemical treatment approaches.

- Biological – Bioremediation consists of stimulation of microorganisms to promote degradation of contaminants. Biological treatment is generally effective for organic contaminants.

- Thermal – Thermal treatment processes can be viable strategies to mobilize and remove or destroy contaminants in groundwater.

- Physical/Chemical – Physical/Chemical treatment processes can be used to destroy, separate, or immobilize contaminants in groundwater.

- Discharge – Disposal options for extracted groundwater can include discharge to a publicly owned treatment works (POTW), surface, or groundwater after treatment of the effluent to meet applicable discharge standards.

6 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

This section identifies and screens remedial technologies and process options potentially capable of addressing groundwater contamination and achieving RAOs at OU2. The screening process serves to identify feasible technology categories and technology process options that have the potential to achieve the goal of the GRAs.

For each GRA, potentially applicable technology types and process options were reviewed by screening them with respect to technical implementability using Site information regarding geology, contaminant concentrations, and distribution. The major factors that influence the technical implementability of remedial technologies in OU2 are the hydrogeologic characteristics, depth of contamination, and the residential and commercial density of the area. Results of the preliminary screening of technologies and process options identified for each GRA are discussed below.

Table 6-1 summarizes the technology identification and screening process for groundwater. The table is grouped by the GRA. Technologies that may be appropriate for addressing the contaminants were retained for further evaluation and are identified on the last column of **Table 6-1**. Technologies that were screened out and not retained for further analysis are designated as "Not Retained" in the last column of **Table 6-1**.

6.1 No Action

The no action process option has been retained as a basis for comparison with other groundwater remediation technologies, as required by the NCP. This option includes no future activities to contain or remediate contaminants in OU2, provides no treatment for contaminants or legal and administrative mechanisms for protection of human health and the environment beyond establishing cleanup criteria and recognizing those mechanisms that are in place (e.g., restrictions on well installation) under other state and/or federal environmental regulatory program (non-Superfund) authority. This option assumes that physical conditions at OU2 remain unchanged.

6.2 Institutional Controls

ICs are non-engineering measures, such as administrative and/or legal controls, which help minimize the potential for human exposure to contamination and/or protect the integrity of a remedy by limiting site or resource use. EPA guidance on choosing and implementing ICs (EPA, 2000) provides that:

- If the cleanup does not result in unrestricted use at a site, an IC may be appropriate.
- Consider life-cycle strengths, weaknesses, and costs for implementation, monitoring, and enforcement when choosing ICs.

- Provide early coordination with state and local governments that may be responsible for ICs.
- ICs are to be assessed as carefully as any other remedial alternative.
- Place ICs in ways to increase their reliability.
- Clearly state ICs' objectives in decision documents.
- Obtain written assurances from those responsible for implementing, monitoring, and enforcing ICs; select the best ICs available to protect human health and the environment.

ICs are generally to be used in conjunction with, not in lieu of, engineering measures such as treatment or containment. ICs can be used during all stages of the cleanup process to accomplish RAOs, and they should be used or implemented in series to provide overlapping protection from contamination. Examples include easements, potable well drilling prohibitions, and zoning restrictions. ICs could also include health and safety policies and procedures to limit exposure to groundwater contaminants during construction activities via local construction permit equivalent programs.

Performance monitoring would include a description of the ICs implemented or planned, verify IC implementation, and discuss the IC's ability to meet performance objectives going forward. Actual or pending changes in land or resource use/ownership that may impact the effectiveness of the ICs should also be included in a performance monitoring report.

ICs have been retained for further evaluation for use in combination with another remedial technology and process option(s).

6.3 Monitored Natural Attenuation

MNA relies on naturally occurring attenuation processes to achieve Site-specific RAOs within a reasonable time frame. Natural attenuation processes, which reduce contaminant concentrations in groundwater over time, include destructive (biodegradation and chemical reactions with other subsurface constituents) and nondestructive mechanisms (dilution, dispersion, volatilization, and adsorption). MNA is implementable and has been retained for further evaluation for use with other remedial technologies. MNA is always used in combination with LTM to assess the effectiveness and protectiveness of the process.

6.4 Long-Term Monitoring

Long Term Monitoring (LTM) involves periodic sampling and analysis of groundwater to monitor the effectiveness of the respective implemented remedy and or movement of contaminants. LTM alone would not be effective in reducing contamination levels within a reasonable timeframe. LTM must be implemented in conjunction with other remedial technologies to confirm that

contaminant degradation is proceeding at rates consistent with meeting cleanup objectives. LTM has been retained for further evaluation for use with other remedial technologies or process options.

6.5 Containment

Containment can be used to reduce contaminant mobility, but it does not directly reduce contaminant toxicity or volume. Containment can be achieved either through structural barriers filled with impermeable, semi-permeable, or permeable materials, depending on the contaminants at a Site as discussed in Sections 6.5.1 and 6.5.2 below.

Wastes can also be “contained” via their sequestration into a geological formation through deep well injection. Alternately, hydraulic containment, accomplished by installing a line of extraction wells and then pumping and treating groundwater can be employed to stop contaminated groundwater from migrating past a certain point in the subsurface. Once treated, the clean water can be discharged to groundwater or surface water or sent to a public sanitary sewer.

6.5.1 Physical Barriers

Physical barriers (e.g., slurry walls, grout curtains, and sheet pile walls) are used to slow groundwater flow, minimize migration of contaminated groundwater, divert contaminated groundwater from a drinking water intake, and/or provide a hydrodynamic barrier to enhance the efficacy of a hydraulic barrier (i.e., a groundwater pump & treat system). The following are commonly used physical barriers:

6.5.1.1 Slurry Wall

Slurry walls consist of a vertically excavated trench that is filled with a low permeability material to contain the contaminated groundwater. Most slurry walls are constructed of a soil, bentonite, and water mixture. A bentonite slurry is used for wall stabilization during trench excavation. A soil-bentonite backfill material is then placed into the trench (displacing the slurry) to create a cutoff or containment wall. Walls of this composition provide a barrier with low permeability and chemical resistance. Other wall compositions, such as cement/bentonite, pozzolan/bentonite, attapulgite, organically modified bentonite, or slurry/geomembrane composite, may be used if greater structural strength is required or if chemical incompatibilities between bentonite and Site contaminants exist. Slurry walls are typically placed at depths up to 100 feet in unconsolidated media and are generally 2 to 4 feet in thickness.

This technology is not feasible for OU2 because the groundwater contamination is up to 500 feet deep, below the practical limit to which a vertical barrier can be installed. The density of buildings, roads, and subsurface utilities within the footprint of the groundwater plume would also make the installation of a slurry wall impractical. Therefore, slurry walls will not be retained for further evaluation.

6.5.1.2 Grout Curtain

A grout curtain is another method that can be used to create a physical barrier to groundwater flow. A grout curtain (also called grouting) consists of the injection of one of a variety of special fluids (e.g., epoxy or sodium silicate) or particulate grouts (e.g., Portland cement), into the soil matrix under high pressure. Grouting reduces permeability and increases mechanical strength of the grouted zone. When carried out in a linear pattern, grouting can result in a curtain or wall that can be an effective barrier to groundwater flow. The advantage of grout curtain emplacement is the ability to inject grout through relatively small diameter drill holes at relatively deep depths. The main disadvantage of using grout curtains is the uncertainty that complete cutoff is attained.

This technology is not feasible for OU2 because the density of buildings, roads, and subsurface utilities within the footprint of the groundwater plume would make the installation of a grout curtain impractical. Therefore, grout curtains will not be retained for further evaluation.

6.5.1.3 Funnel & Gate

Impermeable sheet pile walls (funnel) are installed by driving sheet materials, typically steel, through unconsolidated materials with a pile driver or vibratory drivers to direct water to a permeable reactive barrier (gate) for treatment. This technology is not feasible for OU2 because the groundwater contamination is up to 500 feet deep, well below the practical limit to which a sheet pile can be driven. Therefore, funnel and gate will not be retained for further evaluation.

6.5.2 Hydraulic Barrier – Groundwater Extraction and Treatment

Hydraulic control may be achieved by controlling the direction of groundwater flow with pumping (extraction) wells. These extraction wells create points of low hydraulic head to which nearby groundwater flows. When groundwater is pumped from extraction wells, the groundwater potentiometric surface (or generally the groundwater level) is modified and results in changes to the groundwater flow directions near the well. By optimizing the locations of the extraction wells and adjusting the groundwater pumping rates, groundwater flow can be modified to prevent contaminated groundwater from migrating toward downgradient receptors.

The water that is extracted typically requires treatment and management. The treatment train is typically a series of physical, chemical, or biological processes, with ultimate discharge or disposal of the treated water (FRTR, 2002; EPA, 1994b).

Treatment processes typically evaluated or used in extraction and treatment systems (also known as pump and treat systems [P&T]) can include, but are not limited to:

- Adsorption
- Air stripping
- Oxidation

- Precipitation/Coagulation/Flocculation
- Separation

Treatment and monitoring of extracted groundwater is required in conjunction with a hydraulic control (i.e., P&T) option where restoration of the resource is a RAO, as is the case for this Site. Treatment processes are discussed in detail in Sections 6.6.3 and 6.6.4. The hydraulic barrier approach is an established technology with known design standards and performance. System design is straightforward, as extraction well positions and flow rates can be determined using groundwater modeling and field-testing methods. Water treatment requirements are also well-established.

Groundwater pumping is normally most effective in aquifers with high hydraulic conductivities. Data related to the hydraulic conductivity, concentration and areal extent of contamination, contaminant and soil properties, depth and seasonal fluctuation of the water table, and the depth, location, and pumping rates of any wells that are likely to be influenced by remedial activities at the Site are required in designing the P&T system.

This technology has been used at many sites and is technically feasible. The water that is extracted typically requires treatment and management. Containment via hydraulic barriers using groundwater extraction wells has been retained for further evaluation.

6.5.3 Deep Well Injection

Deep well injection (and sequestration) is a contaminated liquid disposal technology that uses injection wells to place and sequester untreated liquid waste into geologic formations that have little potential to allow migration of contaminants (FRTR, 2002).

Deep well injection is not typically completed in shallow (<1,000 foot deep) potable aquifers and would likely face regulatory hurdles under the Safe Drinking Water Act, Clean Water Act, and Underground Injection Control (UIC) Programs. There are likely to be community acceptance issues related to implementing this remedy as well, due to the location of OU2. Therefore, deep well injection has not been retained for further analysis.

6.6 Treatment

The Treatment GRA includes technologies that treat contaminants either in-situ or ex-situ and include biological, physical/chemical, and thermal methodologies.

6.6.1 In Situ Biological Treatment

6.6.1.1 Enhanced Bioremediation

In-situ bioremediation technologies employ engineered systems to heighten the effects of naturally occurring biodegradation. The engineered systems are designed to enhance

bioremediation and accelerate the natural biodegradation process by introducing nutrients, electron acceptors, heat, and/or contaminant-degrading microorganisms to the subsurface.

Depending on the COCs and the media, bioremediation may work through aerobic or anaerobic metabolism. In selecting a bioremediation technology, the COC, media, biological pathways of degradation, and site conditions must all be considered.

Technologies that involve the addition of supplemental microbes to the subsurface are referred to as bioaugmentation technologies. Microorganisms able to degrade specific contaminants (e.g., Dehalococcoides bacteria can degrade chlorinated solvents) are added where their type or numbers are insufficient to remediate the contamination. Microorganisms may be “seeded” from populations already present or be introduced from cultivated strains of bacteria designed to degrade specific contaminants. The addition of key nutrients (e.g., nitrogen and phosphorus) is used to supplement other bioremediation methods, so the availability of nutrients does not limit the effectiveness of the in-situ bioremediation.

Bacteria can use different electron acceptors (oxidized compounds) and donors (reduced compounds) in the three major oxidation pathways — aerobic respiration, anaerobic respiration, and fermentation. In-situ biological treatment can use all these pathways, and contaminant degradation may occur through direct metabolism, co-metabolism, or abiotic transformations that may result from biological activities. Supplemental electron donors are added as a reductant in the redox (coupled oxidation/reduction) reaction used by the degrading microorganisms, for example, hydrogen-containing or generating compounds. Electron acceptors add oxygen (for aerobic processes) or an anaerobic oxidant (e.g., nitrate) to support microbial processes that degrade the contamination (EPA, 2000).

The rate of bioremediation can be enhanced by increasing the concentration of oxygen (creating an aerobic condition) or adding a carbon substrate (under anaerobic conditions) to the groundwater. Oxygen enhancement can be achieved by either sparging air below the water table (discussed further in Section 6.6.2) or circulating oxygen releasing compound throughout the contaminated groundwater zone.

Under anaerobic conditions, a carbon nutrient or electron donor is circulated throughout the groundwater contamination zone to enhance the natural rate and process of bioremediation. In co-metabolism, the COC is degraded as a result of a side reaction. For example, microorganisms may be provided with a fuel source and just so happen to degrade other contaminants at the same time (e.g., TCE).

Enhanced biological treatment technologies can be implemented in different general configurations, including direct injection, groundwater recirculation, permeable reactive barriers (PRBs), thermal heating, and bioventing. The configurations include vertical and horizontal wells and/or trenches for both injection and extraction of groundwater, or injection amendments to support the biodegradation processes. Injections could be implemented at OU2 based on the Site-specific geologic conditions.

Enhanced biological treatment has been retained for further evaluation.

6.6.1.1 Phytoremediation

Phytoremediation is a set of processes that use plants to remove, transfer, stabilize, and/or destroy contamination in groundwater. Phytoremediation is generally limited to treating shallow groundwater with lower contaminant concentrations and requires a large area of land for remediation. Due to the deep groundwater contamination at OU2 and the amount of land required, phytoremediation is not an applicable technology.

6.6.2 In-Situ Physical/Chemical/Thermal Treatment

Physical treatment technologies are those that employ air, water, or other means to oxygenate, agitate, or flush contamination through the subsurface to enhance its removal. Chemical treatment options use various processes (e.g., ultraviolet [UV] radiation) to degrade contaminants. These physical and chemical treatment technologies are described below.

6.6.2.1 Air Sparging

Air sparging is a physical treatment that involves injecting air directly into the subsurface to volatilize contaminants from the liquid phase to the vapor phase for treatment or removal, and to enhance biodegradation of contaminants via the introduction of oxygen. It is effective in treating chlorinated solvent contamination such as TCE.

Air sparging uses commercially available equipment and is a relatively simple, lower cost technology. The equipment can be readily installed and may require minimal oversight, as no waste streams are generated and the technology is compatible with other technologies (e.g., soil vapor extraction [SVE] and bioventing). It does require careful design and operation and is best suited to sites with sandy soils and aquifer depths less than 50 ft bgs.

Injected air traverses horizontally and vertically in channels through the soil column, creating a subsurface “air stripper” effect that removes contaminants through volatilization. The injected air helps to flush, or sparge, the contaminants upward into the unsaturated zone where an SVE system is usually implemented in conjunction with air sparging to remove the generated vapor phase contamination in soil.

Given the widespread extent and depth of contamination well below the practical limit of air injections, air sparging has not been retained for further evaluation.

6.6.2.2 Bioslurping

Bioslurping is another physical treatment option that combines the two remedial approaches of bioventing and vacuum-enhanced free product recovery to address light non-aqueous phase liquid (LNAPL) contamination. Bioslurping is traditionally used to remediate contamination by

petroleum products with a LNAPL layer, which is not present at OU2. Therefore, bioslurping has not been retained for further evaluation.

6.6.2.3 In Situ Chemical Oxidation/Reduction

In situ chemical oxidation (ISCO) chemically converts contaminants to less toxic compounds that are more stable, less mobile, and/or inert. It involves injecting a solution of oxidizing agent into the subsurface via an injection well or using direct push borings to treat dissolved-phased contaminants. The oxidizing agents most commonly used are ozone, hydrogen peroxide, potassium permanganate, hypochlorite, zero valent iron (ZVI), chlorine, chlorine dioxide activated persulfate, and nanoscale ZVI. Matching the oxidant and in-situ delivery system to the COCs and the site conditions is a key factor in successful implementation and achieving performance goals.

Chemical oxidation has been used for more than 30 years for in-situ remediation of groundwater. ISCO can be a viable remediation technology as it is effective for mass reduction of organic compounds in groundwater, has a relatively rapid treatment time, and is implementable with commercially available equipment.

However, there are safety requirements for handling and administering large quantities of hazardous oxidizing chemicals, namely a need to monitor the fate and transport of the chemicals in the aquifer; and naturally occurring organic material in the formation that can consume large quantities of oxidant. Additionally, the injected solution can have a tendency to displace groundwater, react with natural organic matter, and only then react with contaminated groundwater. It also has the potential to displace the plume, increasing chemical migration. There are certain safety hazards involved in the use of the reagents, particularly in a densely developed area, including heat generation from the exothermic reaction generated in the treatment process, and the resulting potential for damage due to fire and explosion if not carefully managed.

Chlorinated solvents can also be degraded via reductive processes. In-Situ Chemical Reduction (ISCR) can use either ZVI or dual-valent iron (DVI) to facilitate the chemical reduction of these contaminants through the creation of low redox potential and production of hydrogen. ISCR can minimize the formation of “daughter products,” such as vinyl chloride and can overcome the “DCE stall”, where further dechlorination from DCE to vinyl chloride and ethane does not occur or does so very slowly.

In low oxidation/reduction potential or low oxygen subsurface environments, ISCR is particularly advantageous. Prior to implementing the ISCR technology, analyses of the treatment area (e.g., use for source removal or plume control), contaminant characteristics, presence of NAPL, remedial timeframe, potential environmental impacts (i.e., secondary plumes), and health & safety issues are required (Adventus, 2007).

ISCO and ISCR are both implementable in aquifers with high permeability that are contaminated with chlorinated solvents and have both been retained for further evaluation.

6.6.2.4 In-Situ Adsorption

In-situ adsorption is a process through which contaminants adsorb onto an injected material, such as colloidal activated carbon, thus minimizing the migration of dissolved phase contaminants. In-situ adsorption involves injecting very fine particles of activated carbon (1-2 µm diameter) suspended in water. Once in the subsurface, the injected material behaves as a colloidal material binding to the aquifer matrix and adsorbing contaminants from groundwater. Available in-situ adsorption products also claim to promote degradation of adsorbed contaminants.

Based the COCs affinity for adsorption and the high permeability aquifer allowing for injections this technology has been retained for further evaluation.

6.6.2.5 Thermal Treatment

In-situ thermal treatment uses heat to mobilize and recover contaminants. The only significant difference between the various methods is the way the heat is generated and transferred into the subsurface. The following are three thermal treatment technologies evaluated for the Site.

Steam-Enhanced Extraction: Steam-enhanced extraction (SEE) uses an alternating steam injection and vacuum extraction approach to remove NAPL and volatile and semi-volatile compounds from the subsurface. The steam injection displaces mobile liquids (groundwater and mobile NAPL) ahead of the advancing steam zone. NAPLs and liquids displaced by the injected steam are pumped from extraction wells. The NAPL and vapors containing the volatilized contaminants are captured by vacuum extraction wells installed within the unsaturated zone above the thermal wells. Once above ground, extracted groundwater and vapors are cooled and condensed. The concentrated contaminants are separated from the aqueous steam for recycling or disposal, and process vapors and water are treated before discharge.

Several SEE applications have been completed at large sites. Relatively new thermal treatment schemes involving combinations of SEE with thermal conduction heating (discussed below) seek to optimize the use of the lower-energy method (i.e., by enhancing electrical heating projects using steam injection). The close spacing of injection and extraction points necessary to recover contamination are not implementable for this project given the large treatment area and depth and the highly developed nature of the area. Therefore, SEE will not be retained for further evaluation.

Electrical Resistance Heating: Electrical resistance heating (ERH) involves installation of electrodes in the subsurface for thermal treatment of VOCs. Soil and groundwater are heated by the passage of electrical current between the electrodes. It is the resistance to the flow of electrical current that results in increased subsurface temperatures. The maximum target temperature with ERH is the boiling point of water. As the subsurface is heated, contaminants are volatilized, and soil moisture and groundwater are converted to steam. Vapors generated by ERH, along with contaminated condensate and entrained water, are captured using vacuum extraction wells installed in the unsaturated zone above the heater wells and then treated using activated carbon

or other methods at the surface.

Unlike SEE, ERH does not rely on fluid movement to deliver heat. ERH electrodes are constructed using readily available materials (e.g., steel pipe and sheet piling) and have been used to treat contamination to depths of 100 ft bgs (ESTCP, 2010). Similar to each of the thermal technologies, given the large area and depth of contamination, the high density commercial/residential area, and the fact that most of the VOCs are in the permeable fractions of the aquifer, this technology is not effective or implementable under these hydrogeologic conditions. Therefore, ERH will not be retained for further evaluation.

Thermal Conduction Heating: Thermal conduction heating (TCH), also known as in-situ thermal desorption (ISTD), is the simultaneous application of heat and vacuum to the subsurface to remove organic contaminants. Heat is applied by installing electrically powered heaters throughout the zone to be treated. The heat moves out into the geologic formation primarily via thermal conduction. The boiling of fluids in the aquifer matrix leads to steam formation. The steam is captured by the vacuum applied at each heater boring. TCH may be applicable for VOCs and for higher boiling point organics such as PCBs, polycyclic aromatic hydrocarbons (PAHs), and pesticides because it can heat the subsurface to temperatures exceeding 300 degrees Celsius (°C) assuming that the amount of water in the treatment area can be controlled, because water has a cooling effect on the treatment area. For the same reasons as SEE and ERH, this technology is not effective or implementable under these hydrogeologic conditions. Therefore, TCH will not be retained for further evaluation.

6.6.2.6 In-Well Air Stripping

With in-well air stripping, a physical treatment technology, air is injected into a vertical well that has been screened at two depths. The lower screen is set in the groundwater saturated zone, and the upper screen is set in the unsaturated zone. Pressurized air is injected into the well below the water table, aerating the water. The aerated water rises in the well and flows out of the system at the upper screen, inducing localized movement of groundwater into (and up) the well as contaminated groundwater is drawn into the system at the lower screen. VOCs vaporize within the well at the top of the water table, where the air bubbles are out of the water. The air injection removes volatiles and establishes a circulation pattern of oxygen-saturated water in the aquifer that may also enhance the biodegradation rate.

The contaminated vapors accumulating in the wells are collected via vapor extraction contained within the well. Vapor phase treatment typically occurs above grade. The partially treated groundwater is never brought to the surface; it is forced into the unsaturated zone, and the process is repeated as water follows a hydraulic circulation pattern or cell that allows continuous cycling of groundwater. As groundwater circulates through the treatment system in-situ, and vapor is extracted and treated, contaminant concentrations are reduced.

For effective in-well treatment, the contaminants must be adequately soluble and mobile so they can be transported by the circulating groundwater. In general, in-well air strippers are more

effective at sites containing high concentrations of dissolved contaminants with high Henry's Law constants. The radius of influence and groundwater flow regime around the well require careful consideration in design and operation of the system (FRTR, 2002). Site and system characteristics to be considered are similar to those for air sparging, described above.

In well air stripping, however, is limited by depths and typically only effective at depths less than 100 feet. Based on the depth limitation in-well air stripping has not been retained for further evaluation.

6.6.2.7 Passive/Reactive Treatment Barriers

Passive/Reactive Treatment Barriers are treatment barriers that combine physical and chemical treatment. They allow the passage of impacted groundwater while causing the degradation or removal of contaminants. One example, a PRB is a passive in-situ treatment zone that degrades contaminants as groundwater flows through it. The reactions within the PRB are dependent on pH, redox potential, contaminant concentrations, and other factors. The hydrogeology must be conductive, and a relatively shallow confining layer is needed to “key” into and thereby contain the system.

Passive/reactive treatment barriers can consist of a vertically excavated trench that is filled with a chemical or physical treatment material. Most PRBs are installed as either a funnel-and-gate or continuous trench. Chemical and treatment materials can also be injected into the aquifer to treat contaminated groundwater.

A PRB is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. PRBs may combine a passive chemical or biological treatment zone with subsurface fluid flow management. Treatment media may include ZVI, nanoscale ZVI, chelators, sorbents, or microbes. The contaminants will either be degraded or retained in a concentrated form by the barrier material. The barrier could provide permanent containment for relatively benign residues or reduce the volume of the more toxic contaminants for subsequent treatment.

Injections could be implemented at OU2 based on the Site-specific geologic conditions. The large area and depth of contamination, however, would require a dense arrangement of multi-depth injection points within the footprint of contamination to achieve RAOs. PRBs have been retained for further analysis.

6.6.2.8 In-Situ Flushing

In-situ flushing involves the injection of an aqueous solution, commonly through wells, into a contaminated zone. This may be within the vadose zone, the saturated zone, or both. The solution then flows through the contaminated zone and the resulting effluent is extracted downgradient where it is treated and discharged or injected back into the aquifer. The aqueous solution injected may contain surfactants or co-solvents.

In-situ flushing has been used with conventional P&T and other methods of remediation to enhance the solubility or mobility of the contaminants, thus accelerating the remediation process. This technology was developed to treat chemicals with low solubility, such as NAPL, that can remain in the vadose zone for decades, slowly dissolving into the groundwater plume. By increasing the solubility or mobility of these contaminants at the source, in-situ flushing can provide a faster, more efficient method for groundwater remediation (GWRTAC, 1997).

In-situ flushing would not be implementable due to the size and depth of the plume and the density of buildings, roads, and subsurface utilities within the footprint of the groundwater plume. In-situ flushing technology has not been retained for further analysis.

6.6.3 Ex-Situ Biological Treatment

The following ex-situ treatment technologies assume the pumping of impacted groundwater at the site, prior to treatment.

6.6.3.1 Bioreactors

Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors. Contaminated groundwater is circulated in suspended media, such as activated sludge, within an aeration basin. In attached systems, such as rotating biological contactors and trickling filters, microorganisms are established on an inert support matrix. Because of the diluted nature of the contamination in the OU2 groundwater, bioreactors will not be evaluated further.

6.6.3.2 **Constructed** *Wetlands*

Constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and fixate/remove metals and other contaminants from influent waters. Constructed wetlands requires shallow depth to water, nearby surface water, and a large area of land for remediation which is not available near OU2. Constructed wetlands has not been retained for further evaluation.

6.6.4 Ex-Situ Physical / Chemical Treatment

The following ex-situ treatment technologies are considered in conjunction with P&T technology, as they require the pumping of impacted groundwater to the surface prior to treatment.

6.6.4.1 Adsorption

The adsorption process consists of passing contaminated liquid through a sorbent media. Contaminants are adsorbed onto the media, reducing their concentration in the bulk liquid phase. Adsorption mechanisms are generally categorized as physical, chemical, or electrostatic adsorption. The most common adsorbent used is granular activated carbon (GAC).

Vapor phase GAC adsorption is a process where vapor/air stream from a treatment process like air stripping, SVE, and ISTT (FRTR, 2002) is sent through a series of canisters or columns containing activated carbon to which organic contaminants adsorb. When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be removed and regenerated at an off-site facility; or removed and disposed of off-site.

Adsorption is a viable technology for VOC treatment of groundwater and extracted vapors. Therefore, adsorption via GAC has been retained for further evaluation for liquid and vapor treatment in conjunction with air stripping and groundwater extraction and treatment.

6.6.4.2 Advanced Oxidation Processes

Advanced oxidation processes (AOP), including the use of UV radiation, catalytic oxidation, ozone, potassium permanganate, and/or hydrogen peroxide can destroy organic contaminants in groundwater and/or air. VOCs (e.g., TCE, PCE, and vinyl chloride [VC]) and 1,4-dioxane are rapidly destroyed in UV/oxidation processes. However, pretreatment of the vapor/air stream may be needed to minimize maintenance requirements of the oxidation treatment component.

If ozone is used as the oxidizer, an ozone destruction unit(s) may be required to treat off-gases resulting from treatment and where ozone gas may accumulate or escape, to avoid a safety hazard. AOPs can effectively treat the COCs and have been retained for further analysis.

6.6.4.3 Air Stripping

Ex-situ air stripping has been used in conjunction with P&T systems to enhance performance; it separates volatile organics from groundwater by increasing the surface area of the contaminated water exposed to air. Air stripping methods include packed towers, diffused, tray and spray aeration. The process as conducted in a packed tower involves spraying contaminated water over the packing in the column, with a fan moving air against the water flow and a sump under the tower to collect decontaminated water. Modifying packing configurations can increase VOC removal efficiency. For example, a low-profile air stripper packs a number of trays in a very small chamber to maximize air to water contact while minimizing space. Because of the significant space saved, these units enhance the practicability of ex situ air stripping.

Issues limiting the practicability and effectiveness of ex situ air stripping include: biological fouling, requirements for pumping and treatment of large volumes of water, moderate to high energy demands, and off-gases that require collection and treatment. Ex situ air stripping can effectively treat COCs and has been retained for further evaluation as an enhancement to P&T technology.

6.7 Discharge

Discharge technology options address the means of disposal and/or discharge of groundwater that has undergone some sort of remedial processing and is either safe to discharge to the environment as is, or requires further treatment to protect human health and the environment prior

to release to the air, water, or a sewer system. There is specific guidance and numerous regulatory requirements related to the disposal or discharge of CERCLA wastes or emissions.

The CERCLA Compliance with Other Laws Manual, Parts I and II (EPA 1989a, 1989b) provides an analysis of ARARs for Superfund Site discharges, including those related to compliance with the Clean Water Act and National Pollution Discharge Elimination System (NPDES) program for surface water and POTW discharges; the Safe Drinking Water Act and its drinking water (i.e., MCLs), UIC and SSA programs; as well as RCRA and air quality programs.

6.7.1 Surface Water

This option consists of discharging extracted and treated groundwater to surface water. This approach can be an effective and implementable discharge method where surface water standards can be met. There are no natural surface water bodies near OU2. Therefore, on-site discharge to surface water has not been retained for further evaluation.

6.7.2 Groundwater

This discharge technology involves injection of treated groundwater into the aquifer using recharge basins, infiltration galleries, or a series of injection wells in combination with groundwater extraction and treatment technologies.

A recharge basin allows treated water to seep through the ground surface in a controlled area. An infiltration gallery includes a subsurface network of perforated pipes in trenches that return the treated water to the subsurface above the water table. Recharge basins and/or galleries may be constructed to discharge water generated as a result of groundwater extraction and ex-situ treatment. Recharge basins and infiltration galleries have been retained for further evaluation.

Injection wells could also be used to pump treated water under pressure into the subsurface below the water table. Injection wells may be able to discharge water generated as a result of groundwater extraction and ex-situ treatment. The use of injection wells will be retained for further evaluation.

6.7.3 Off-Site Discharge to POTW

Off-site discharge to a POTW consists of discharging treated groundwater directly to a sanitary sewer line or transporting the water to an off-site POTW via tanker trucks. This approach can be an effective and implementable discharge method, where CERCLA aqueous waste discharge requirements can be met (EPA, 1990b; EPA 1991). In evaluating the potential discharge to a POTW, the waste stream proposed must be characterized qualitatively and quantitatively, to assure the ability to treat the waste stream and maintain compliance with the candidate POTW's Permit Requirements, and that treatment capacity is available. The POTW's compliance status, whether the conveyance to be used is a combined or separate sanitary sewer system, and other

factors are also to be considered. Off-site discharge to a POTW has been retained for further evaluation.

7 EVALUATION OF PROCESS OPTIONS

Groundwater remedial technologies were screened in Section 6 for potential applicability and implementability (**Table 6-1**). Technologies that successfully passed the screening process in Section 6 were assembled into process options, which were then evaluated based on effectiveness, implementability, and relative cost. These are described below:

- Effectiveness – Focuses on the effectiveness of process options to contain and/or treat dissolved phase concentrations in groundwater.
- Implementability – Evaluates technical and administrative feasibility of implementing the process option.
- Relative cost – Capital and Operation and Maintenance (O&M) costs are considered and based on engineering judgement. Process options are evaluated as to whether costs are low, medium, or high relative to other options within the same technology type.

Process options that cannot be effectively implemented due to site characteristics or other restrictions were eliminated from further consideration. An evaluation of the remedial technology options conducted for groundwater is presented in **Table 7-1**.

The groundwater process options retained for detailed analysis include no action, ICs , MNA, LTM, groundwater extraction and treatment, enhanced bioremediation, ISCO/ISCR, in-situ adsorption, PRBs, ex-situ adsorption, ex-situ AOPs, ex-situ air stripping, on-site discharge to groundwater, and off-site discharge to POTW.

The remedial technologies and process options are described in the subsections below.

7.1 No Action

The no action option will not meet the RAOs. There is no cost associated with this option. The no action option has been retained only to provide a basis for comparison with other active remedial process options, as required under CERCLA.

7.2 Institutional Controls

ICs, such as deed restrictions and well drilling restrictions, can be used as a strategy to address exposure to contaminated groundwater. This remedial option does not treat groundwater contaminants; therefore, it is considered only in concert with other technologies. The use of this option relies on future enforcement of groundwater restrictions.

Deed restrictions would not reduce the mass of contamination at OU2 but are effective at protecting human health by restricting future Site uses or activities that may result in direct contact with contamination. Future land use must be restricted via legal restrictions that require continued implementation to remain effective.

Well drilling restrictions may effectively meet RAOs from a human health standpoint through restriction of future Site uses or activities which may result in direct contact with contaminated groundwater. The migration and environmental impact of the contaminated groundwater would not be reduced. Implementation would be easy via the existing permitting processes. The cost to implement is low. Well drilling restrictions can be used in conjunction with other remedial process options and have been retained for further consideration.

Although ICs do not directly treat COCs, they have been retained for further evaluation. ICs limit exposure to COCs. ICs may be used in conjunction with other remediation technologies.

7.3 Monitored Natural Attenuation

MNA is considered technically implementable at sites where natural mechanisms can be demonstrated to minimize or prevent the further migration of groundwater contamination. Based on a review of groundwater sample results, there is little evidence of biologically driven natural attenuation at OU2 as there is little evidence of the presence of cis,1,2-DCE and VC and the MNA parameters are not favorable for biologically driven natural attenuation.

While some natural attenuation is likely happening in OU2, there is not enough evidence to indicate that the processes are proceeding to completion at a rate capable of reaching PRGs within a 30-year period throughout OU2. MNA has not been retained based on effectiveness.

7.4 Long-Term Monitoring

LTM can be used as a strategy to evaluate the groundwater plume over time. This remedial option does not treat groundwater contaminants; therefore, it is considered only in concert with other technologies. LTM measures would not reduce the toxicity and migration of contaminants or the extent of environmental impacts and would not reduce Site-related contaminant concentrations to protective levels.

LTM includes periodic sampling and analysis of groundwater. An LTM program provides an indication of the movement of contaminants and/or progress of remedial activities. LTM alone would not be effective in meeting the RAOs. It would not alter the effects of contamination on human health and the environment. However, it may be implemented in conjunction with other process options or as a potential contingency/alternative remedy to other remedial technologies. LTM could be easily implemented. Costs are low and are limited to those associated with sampling and analysis required for LTM.

Although LTM does not directly treat COCs, it has been retained for further evaluation. LTM provides insight into the movement of contaminants. LTM may be used in conjunction with other remediation technologies.

7.5 Hydraulic Containment via Groundwater Extraction and Treatment

Groundwater extraction and treatment can be effective in contaminant mass removal over a long timeframe and in establishing hydraulic control of the aquifer, which can reduce or prevent further migration of contaminants.

Extraction wells are effective in providing hydraulic control for sites where the hydrogeology is well understood and the pumping rate necessary to maintain hydraulic control is sustainable. Given the sandy lithology and higher hydraulic conductivity at OU2, hydraulic containment via P&T would be effective in removing contaminated groundwater and controlling migration of groundwater. The higher hydraulic conductivity, however, would require pumping at higher rates to contain groundwater resulting in a larger water treatment system

The materials, maintenance, and labor needed for hydraulic containment via a P&T system may be more substantial compared to other technologies. Contaminant mass removal may be slow due to the low solubility of organic compounds and slow desorption of contaminants; therefore, hydraulic containment via a P&T system may take longer to achieve remedial goals than other options. While hydraulic containment via a P&T system can help prevent plume migration and remove dissolved phase contaminants, costs for remediation can be significant.

Further site characterization beyond what was completed during the RI would be necessary to select targeted extraction well locations and screen intervals.

Hydraulic containment via P&T has a high capital cost and requires long term operation and maintenance. Although hydraulic containment via a P&T system may be a relatively expensive option, it has been retained for further evaluation due to its effectiveness in reducing COC mass and containing groundwater. Groundwater extraction and treatment has been retained for further analysis.

7.6 Enhanced Bioremediation

In-situ biological treatment can effectively treat groundwater by biostimulating indigenous bacteria populations through injection amendments. In addition to amendments, select strains of bacteria may be added to the subsurface to help treat some sites (bioaugmentation). Bacteria perform coupled oxidation/reduction (redox) reactions to live, and bioremediation exploits these reactions to remove contaminants from contaminated media (soil, air, or groundwater). Bacteria can use different electron acceptors (oxidized compounds) and donors (reduced compounds) in the three major oxidation pathways — aerobic respiration, anaerobic respiration, and fermentation. In-situ biological treatment can use all these pathways, and contaminant degradation may occur through direct metabolism, co-metabolism, or abiotic transformations that may result from biological activities.

Various bioremediation technologies can be used in-situ to treat groundwater without removing it from the subsurface. This approach reduces the cost of handling and associated environmental impacts as it does not require the removal of contaminated groundwater.

In-situ biological treatment is effective for a wide range of contaminants, including the COCs present within OU2. Bacteria strains that degrade TCE have been identified and widely studied. The effectiveness for this technology depends on other factors like the natural flow of groundwater through the injection transects and the amount of time needed to establish favorable conditions for biological degradation and the bacteria communities themselves. This may require multiple injections to develop those conditions and populations. Those timeframes are in addition to the time required for the bacteria to degrade the contaminants.

There are several implementability challenges associated with in-situ biological treatment at OU2. Given the depth of contamination, the amendments would need to be injected using permanent injection wells or direct push techniques as the target depth precludes emplacing this material in a trench. This approach would require a high density of injection points across more than 2,500 feet to a depth up to 500 ft bgs in a residential area, which would require public approval and right-of-way access. The residential areas also limit the ability to conduct injections in patterns other than transect lines. Underground injections require an UIC permit equivalency be acquired from the EPA, and bench and pilot testing would need to be completed to determine the radius of influence (ROI) and requirements for amendments and substrates.

The size and depth of the plume would result in high capital costs due to the high density of injection points across more than 2,500 feet in a residential area and injection to depths up to 500 ft bgs, as well as high O&M costs due to multiple injection rounds are anticipated. Enhanced bioremediation has not been retained for further evaluation based on its moderate effectiveness, poor implementability, and high cost.

7.7 In-Situ Chemical Oxidation/Reduction

Various ISCO/ISCR technologies can be used in-situ to treat groundwater without removing it from the subsurface. This approach reduces the cost of handling and associated environmental impacts, as it does not require the removal of contaminated groundwater.

ISCO/ISCR are effective for a wide range of contaminants, including the COCs present within OU2. COCs could be treated with oxidants, such as Fenton's Reagent and sodium persulfate, or reducing agents, such as ZVI. This technology is less effective to remediate the moderate to low (<100 ug/L) TCE concentrations at OU2. This technology depends on the natural flow of groundwater through the injection transects. Injection of these chemicals may impact neighboring PWS wells.

There are several implementability challenges, including safety challenges associated with using strong oxidizing or reducing agents with potentially high injection pressures in residential neighborhoods in OU2. A high density of injection points would be needed to span the more than

2,500-foot-wide groundwater contamination in a residential area. ISCO/ISCR would have to be injected to depths up to 500 ft bgs. Underground injections require an UIC permit equivalency be acquired from the EPA, and bench and pilot testing would need to be completed to determine the ROI, requirements for amendments, and the interaction of injected material with the naturally occurring metals in the aquifer.

This technology includes high capital costs due to the numerous injection points or installation of permanent injection wells to the target depth, the amount of injection material needed to treat the contaminants, and the time required to conduct the injections. This technology also includes high O&M costs due to the multiple injection rounds that may be required.

The large volumes of strong oxidizing agents required for ISCO used in a densely developed residential neighborhood and the high pressures required to inject this material to the required depths can create safety concerns. Both ISCO and ISCR have the same implementability challenge of requiring a high density of injection points would be needed across more than 2,500 feet in a residential area and injecting to depths up to 500 ft bgs. ISCO/ISCR has not been retained for further evaluation.

7.8 In Situ Adsorption

In-situ adsorption is a process through which contaminants within the plume adsorb onto an injected material, such as colloidal activated carbon, thus minimizing the migration of dissolved phase contaminants. In-situ adsorption involves injecting very fine particles of activated carbon (1-2 µm diameter) suspended in water. Once in the subsurface, the injected material behaves as a colloidal biomatrix binding to the aquifer matrix and adsorbing contaminants from the groundwater. Available in-situ adsorption products also claim to promote degradation of adsorbed contaminants.

Materials for injection that would sorb COCs are available and effective. This technology does not destroy or degrade the contaminants, but rather binds them so they cannot migrate further. This technology depends on the natural flow of groundwater through the injection transects.

The same implementability challenges as for the other injection process options exist for this technology, specifically a high density of injection points would be needed to span the more than 2,500-foot-wide groundwater contamination in a residential area and reach depths of up to 500 ft bgs. UIC permit equivalency be acquired from the EPA and bench and pilot testing would need to be completed to determine the ROI, requirements for injection materials, and the interaction of injected material with the naturally occurring metals in the aquifer.

This technology includes high capital costs due to the numerous injection points or installation of permanent injection wells to the target depth.

The large area and depth of contamination would require a dense arrangement of injection points within the footprint of the contaminated area to achieve RAOs. Even with a high density

of injection points, there is the potential for incomplete adsorption of the Site contaminants. This technology has not been retained for further evaluation.

7.9 Passive/Reactive Treatment Barriers

PRBs are treatment barriers that combine physical and chemical treatment. They allow the passage of impacted groundwater while causing the degradation or removal of contaminants. One example of a PRB is a passive in-situ treatment zone that degrades contaminants as groundwater flows through it. The hydrogeology must be conductive and a confining layer is needed to “key” into and thereby contain the system.

PRBs can consist of a vertically excavated trench or series of injection points that are filled with a chemical or physical treatment material. Based on the depth and size of the plume, a PRB at OU2 would be installed as a series of injection points. The in-situ treatment process options described above were all contemplated as a series of injection points or PRBs. The effectiveness of each treatment material was considered in those subsections, but ultimately the implementability and cost eliminated PRBs from further consideration, regardless of the material selected. PRBs are not retained for further evaluation. .

7.10 Ex Situ Treatment

Ex-situ treatment technologies were evaluated to potentially treat the contaminated groundwater recovered from a groundwater P&T system to discharge standards. Discharge standards will differ based on the type of discharge.

7.10.1 Adsorption

GAC is a porous media with extremely high internal surface area and is useful for the removal of taste and odor producing compounds, natural organic matter, certain VOCs, synthetic organic compounds, and disinfection byproduct precursors. GAC is a proven technology with high removal efficiency for many VOCs.

Carbon adsorption can effectively treat VOCs but in liquid and vapor phases. Activated carbon adsorption is implementable and a proven technology. The equipment and materials are readily available. This technology involves moderate capital and O&M costs. This process option has been retained for further analysis for both liquid and vapor phase treatment.

7.10.2 Advanced Oxidation Processes

AOPs, like UV with peroxide, can be used to treat organic contaminants that are not readily adsorbed or air stripped from groundwater, like VC. Groundwater passes through a reactor vessel where it is dosed with chemicals to create a strong oxidizing condition used to treat the organic contaminants.

This technology has been applied to groundwater for drinking water applications on Long Island and there are multiple vendors with AOP systems that could be used at OU2. This technology involves high capital cost and high O&M cost.

AOPs are effective at treating the COCs and potentially emerging contaminants like 1,4-dioxane. Based on the potential for 1,4-dioxane in the influent this technology has been retained.

7.10.3 Air Stripping

Air stripping is a physical mass transfer process that uses clean air to remove dissolved VOCs from water by increasing the surface area of the groundwater exposed to air. Commonly used systems include the countercurrent packed column, multiple chamber fine bubble aeration systems, venturi systems, and low-profile sieve tray air strippers.

In a countercurrent packed column, contaminated groundwater is sprayed through nozzles at the top of the column, flowing downward through packing materials. In a low-profile sieve tray air stripper, contaminated groundwater flows across the surface of a series of perforated trays. In both systems, clean air is forced into the system by a blower in a direction opposite to groundwater flow (e.g., from the bottom, flowing upward). In a multiple chamber fine bubble aeration system, contaminated groundwater flows through aeration tank chambers, and air is introduced at the bottom of each chamber through diffusers forming thousands of fine bubbles. As the fine air bubbles travel upward through the water, mass transfer occurs at the bubble/water interface. System efficiency increases with decreasing bubble diameters.

Air stripping would be effective in removing volatile contaminants from water. Air stripping is proven to successfully remove TCE and PCE from water, because of its high Henry's law constant. Most other contaminants have a moderate to high ease of stripping.

Air stripping is also implementable. Vendors and equipment are readily available to provide air strippers for groundwater VOC removal. It would be implemented as a treatment method with groundwater extraction and discharge. Air stripping has low capital and low O&M costs. This process option has been retained for further evaluation.

7.11 Discharge/Disposal

Once groundwater has been treated, it would be discharged. Potential discharge options for groundwater are evaluated below.

7.11.1 Groundwater

7.11.1.4 Recharge Basins

This discharge technology includes discharging treated water to existing retention or recharge basins for infiltration into the aquifer. There is an existing basin in OU2 at the intersection of Colonial Avenue and Tanners Pond Road. The retention basin is ephemeral and only holds water

after rain events. This basin can be evaluated for available capacity and for potential improvements to handle a continuous flow of treated groundwater effluent.

Discharge to an existing retention/recharge basin would require piping the treated water to the basin(s) which would require moderate capital and moderate O&M costs. If a new retention or recharge basin would need to be constructed, this discharge option would require high capital costs for land purchasing and moderate O&M costs. Discharge to existing retention/recharge basins to the shallow subsurface has been retained for further evaluation.

7.11.1.5 Aquifer Injection

This discharge technology involves injecting treated groundwater to an existing aquifer using a series of wells. Injection requires that the groundwater be treated to meet applicable groundwater standards prior to aquifer discharge. The effectiveness of this option relies on proper injection well design and construction, including adequate pipe sizing, proper placement of the wells, and reliable construction materials.

Discharging treated effluent to a series of injection wells can be easily and readily implemented, given that standard construction methods and materials would be utilized. Some implementability problems can arise during long term operation of injection wells, such as clogging of screen packs with precipitates or microbial fouling, particularly in high iron conditions. These can be overcome by proper removal of suspended solids and excess iron from the treated water, periodic chlorination of the injected water, and redevelopment and cycling (on and off) of wells.

This process option involves moderate capital and moderate O&M costs. Due to the high iron and manganese concentration in groundwater and the associated high O&M costs, this process option has not been retained for further evaluation.

7.11.2 POTW

This off-site discharge option consists of discharging treated groundwater directly to a sanitary sewer line or transporting the water to an off-site POTW via tanker trucks. Discharge to a POTW would require qualitative and quantitative characterization which would result in high O&M costs. Transporting the water to an off-site POTW via tanker trucks would also result in high O&M costs.

OU2 is located in the Nassau County Sewer District, with the local sewer authority of Garden City Village that operates as a sewer collection district. Sanitary sewer lines in the vicinity of OU2 would likely have to be improved to handle the additional treated effluent flow. Improving the existing sanity sewer system would result in high capital costs. Off-site discharge to POTW has not been retained for further evaluation.

8 DEVELOPMENT OF REMEDIAL ACTION ALTERNATIVES

8.1 Description of Groundwater Alternatives

Preliminary groundwater remedial alternatives for OU2 have been developed by combining the remedial technologies and process options that have successfully passed the screening stage into a range of alternatives. Each alternative presented below considers the effectiveness, implementability, and cost. Detailed alternative evaluation, cost analysis, and comparison will be provided in Section 9.

Groundwater remedial treatment technologies were screened according to applicability, effectiveness, reduction in toxicity, mobility or volume of contaminants, and implementability in groundwater at OU2. Remedial alternatives for OU2 were developed based on the retained technologies and site-specific conditions as described above.

The technologies and groundwater process options retained for further analyses include:

- No Action
- ICs
- LTM
- Hydraulic Containment
- Ex-Situ Treatment
    - Adsorption
    - AOPs
    - Air Stripping
- Discharge
    - Groundwater (Recharge Basin)

The range of process options that meet the RAOs based on the screening results are summarized in **Table 8-1**. Based on the screening of remedial technologies and process options in Sections 6 and 7, the following remedial alternatives have been developed and are described in detail in the following subsections:

- Alternative 1 - No Action
- Alternative 2 – ICs with LTM
- Alternative 3 – Core of Plume Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

8.1.1 Alternative 1 – No Action

The No Action alternative is required by the NCP to be carried through the screening process. Under this alternative, no action would be taken to remediate the contaminated groundwater. This alternative would also not involve ICs. Contaminants present in the groundwater would remain in place.

The No Action alternative provides a baseline for comparison with other active remedial alternatives. Because no remedial activities would be implemented under the No Action alternative, long term human health would remain the same as those identified in the HHRA. There would be no capital, operations/maintenance, or monitoring costs, and no permitting or institutional legal restrictions needed, but this alternative would not meet any of the RAOs for groundwater.

8.1.2 Alternative 2 – ICs with LTM

ICs would restrict groundwater use or activities which might result in direct contact with contaminated groundwater until RAOs are met. The migration and environmental impact of the contaminated groundwater would not be significantly reduced. Due to the contaminated groundwater, ICs would be placed on OU2 to restrict future groundwater use that would expose users to contaminants at levels that may pose human health risks.

A pre-design investigation (PDI) would be conducted to determine the area requiring the ICs. This PDI would include installing two new monitoring wells (shown on **Figure 8-1**), a baseline groundwater sampling event (7 existing wells plus 2 new PDI wells for a total of 9 wells), and updated site surveying.

LTM would also be used as a basis for evaluating the terms of the ICs. LTM would also evaluate plume attenuation via natural processes. For cost estimating purposes, it is assumed that monitoring to evaluate contaminant levels would be conducted for a period of 30 years and would include the same 9 wells sampled during the PDI.

The timeframe for this alternative was estimated based on first-order decay rates for the OU2 wells calculated with data collected during the OU2 RI and previous investigations (**Figure 8-2**). TCE concentrations in well MW-20C are already below the PRG. Those decay rates indicate that wells MW-23C and MW-25A will reach PRGs in less than 20 years. Wells MW-26F, MW-26G, and N-11171 are monitoring wells located in the portion of OU2 where commingling with the OU1 plume has been observed. Well N-03881 is a PWS well also pulling in contamination from the OU1 plume. Based on that commingling those wells were not used in the estimation of this alternative's duration.

Based on this analysis and a safety factor, the plume would be estimated to remain above cleanup levels for approximately 30 years. This alternative would not meet all of the RAOs for groundwater but would result in restoring the aquifer to its beneficial use. Five-year reviews would be conducted.

8.1.3 Alternative 3 – Core of the Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Alternative 3 includes groundwater extraction and treatment in the highest concentration portion of the OU2 contaminated groundwater plume (herein called Core of the Plume) using P&T. The major components of Alternative 3 are:

- Installation of one groundwater extraction well in the down-gradient portion with the highest concentration of the OU2 contaminated groundwater plume;
- Treatment in a centralized plant consisting of metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and 1,4-dioxane treatment via AOP; and
- Discharge to groundwater via a recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.

Alternative 3 also includes the ICs and LTM, as described for Alternative 2 and a PDI. The PDI would include the activities described in Alternative 2 plus aquifer pump testing and pilot/treatability testing. This data would support the final extraction well construction design, the flow rates for hydraulic control, and the ex-situ treatment processes.

Alternative 3 includes one extraction well, which is shown on **Figure 8-3**. The extraction well would be installed to a depth determined during the design. For the purpose of this FS, the depth is based on the currently known information and assumed to be approximately 450 ft bgs. The groundwater extraction well is estimated to remove approximately 500 gpm (Grubb, 1993). The final flow rate would be determined during the design.

The typical treatment process would include metals removal, removal of VOCs by air strippers, vapor-phase GAC, liquid-phase GAC, and potentially 1,4-dioxane via AOP. A typical schematic of the proposed process treatment of the system is shown on **Figure 8-4**.

The treatment process anticipated for purposes of costing in the FS is described below; however, treatment requirements would be more fully determined during the remedial design.

- Water from the extraction well would be pumped to a treatment plant where it would be metered and then enter a metals removal process to remove iron and manganese.
- An air stripper would then be used for VOC treatment.
  - The vapors emitted from the air stripper would be treated by vapor-phase GAC. Process air heaters and blowers, along with the vapor-phase GAC are assumed as part of the air stripping system.
  - Liquid effluent from the air stripper would then pass through a liquid-phase GAC network. A lead-lag system would be used to allow continuous operation during GAC change-out periods.

- Liquid effluent from the GAC would then pass through treatment for reducing 1,4-dioxane concentrations. For the purpose of this FS, AOPs utilizing ozone with hydrogen peroxide are assumed for the removal of 1,4-dioxane in groundwater. Ozone with peroxide is known to accelerate the production of hydroxyl radicals, resulting in faster reactions. Due to the evolving nature of 1,4-dioxane ex-situ treatment, a final ex-situ treatment option will not be selected until the PDI or remedial design (RD) phase.
- After treatment, groundwater would be discharged to a discharge basin.

The treated water from the treatment plant would be discharged to groundwater via a recharge basin at the intersection of Colonial Avenue and Tanners Pond Road. The extraction well, treatment plant, and groundwater discharge would be at the property containing a recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.

O&M associated with the treatment system would include the following:

- Operational Labor: Includes labor for operating the treatment plant.
- Power (Extraction and Treatment): Includes power usage for the extraction pumps, air stripper blower(s), pump stations, duct heater, AOP unit(s), and operation of the treatment plant building.
- Material/Chemicals Usage: Includes costs for replacing/regenerating spent GAC, filter bags, metals pre-treatment agents, and chemicals for the AOPs.
- System Maintenance: Includes material and labor costs for system maintenance.
- Treatment Plant Monitoring: Includes material and labor costs for the collection of monthly process samples to verify the system is operating within the permissible limits.

Extracted groundwater would be conveyed via underground piping to the treatment plant and from the treatment plant to the discharge location. The conceptual design assumes the use of double-walled high density polyethylene (HDPE) piping to convey contaminated groundwater from the extraction well to the treatment plant and single-walled HDPE piping to convey treated water from the treatment plants to the discharge location. For the purpose of cost for this FS, it is assumed that approximately 3,500 linear feet of double-walled HDPE piping and approximately 50 linear feet of single-walled HDPE piping would be required for conveyance of the groundwater.

The P&T system would capture groundwater from the Core of the Plume. The downgradient portion of the plume would not be captured and would be sampled/analyzed to monitor reductions over time. LTM would be conducted to assess the degree of compliance achieved over time. ICs and LTM would be implemented as stated in Section 8.1.2.

The area treated would reach cleanup goals in 25 years and the down-gradient area not treated by the P&Tment system would concurrently attain goals in 30 years. Therefore, the total remediation time would be 30 years.

9 DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

This section presents the detailed evaluation of the remedial alternatives described in Section 8.0. The purpose of the evaluation is to identify the advantages and disadvantages of each alternative as well as key trade-offs among the alternatives. The detailed evaluation of alternatives consists of an individual analysis of each alternative against the evaluation criteria and a comparative analysis among the alternatives to assess the relative performance of each alternative with respect to the evaluation criteria.

9.1 Evaluation Criteria

The evaluation was based on criteria established under Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988). The nine evaluation criteria have been developed to address CERCLA requirements and to address the additional technical and policy considerations that have proven to be important for selecting among remedial alternatives. The evaluation criteria are as follows:

Overall Protection of Human Health and the Environment: This criterion is an evaluation of the alternative's ability to protect public health and the environment, assessing how risks posed through each existing or potential pathway of exposure identified in the human health risk assessment are eliminated, reduced, or controlled through removal, treatment, engineering controls, or institutional controls. The alternative's ability to achieve each of the RAOs is evaluated.

Compliance with ARARs: This criterion evaluates how the alternative complies with the ARARs, if an ARAR waiver is required, and the justification for a waiver, if needed.

Long Term Effectiveness and Permanence: Each alternative is evaluated for its long-term effectiveness after implementation. If contamination or treated residuals remain after the selected remedy has been implemented, the following items are evaluated:

- The magnitude of the remaining risks (i.e., will there be any significant threats, exposure pathways, or risks to the community and environment remaining);
- The adequacy of the engineering and institutional controls intended to mitigate the risk;
- The reliability of these controls; and
- The ability of the remedy to continue to meet RAOs in the future.

Should the results of this evaluation indicate concerns with the risks or reliability of the remedy, the utilization of technological enhancement, contingency, and/or alternative remedies may need to be considered.

Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment: The alternative's ability to reduce the toxicity, mobility, and/or volume of site contamination is evaluated. Preference should be given to remedies that permanently and significantly reduce the toxicity, mobility, or volume of the contamination at the site.

Short Term Impacts and Effectiveness: The potential short-term adverse impacts and risks of the remedy upon the community, workers, and the environment during the construction and/or implementation are evaluated. A discussion of how the identified potential adverse impacts to the community or workers at the Site will be controlled, and the effectiveness of the controls, should be presented. A discussion of engineering controls that could be used to mitigate short term impacts (e.g., dust control measures) is provided. The length of time needed to achieve the remedial objectives is also estimated.

Implementability: The technical and administrative feasibility of implementing each alternative is evaluated for this criterion. Technical feasibility includes such things as the difficulties associated with construction and the ability to monitor the effectiveness of the remedy. For administrative feasibility, the availability of the necessary personnel and material is evaluated along with potential difficulties in, for example, obtaining specific operating approvals or access for construction and implementation of the remedy.

Relative Cost: This criterion evaluates the estimated capital, operations, maintenance, and monitoring costs for each alternative. Relative costs are estimated and presented on a present worth basis.

State Acceptance: NYSDEC comments, concerns, and overall perception of the remedy are evaluated in a format that responds to all questions that are raised (i.e., a responsiveness summary).

Community Acceptance: The public's comments, concerns, and overall perception of the remedy are evaluated in a responsiveness summary.

The eighth and ninth criteria, State and Community Acceptance, will be evaluated following comments on the RI/FS report and the proposed plan, and will be addressed in preparing the ROD.

9.2 Individual Analysis of Remedial Alternatives

The individual analysis of the remedial alternatives with respect to the first seven criteria is presented below. A comparative analysis of the remedial alternatives is provided within **Table 9-1.**

9.2.1 Alternative 1 - No Action

Overall Protection of Human Health and the Environment – Alternative 1 would provide no control of exposure to contaminated groundwater and no reduction in risk to human health and

environmental impacts. This alternative would allow for the potential continued migration of contaminated groundwater downgradient of OU2.

Compliance with ARARs – Because no action would be taken, ARARs would not be met. Under the No Action alternative, chemical-specific ARARs would continue to be exceeded in the area of OU2.

Long Term Effectiveness and Permanence – No long-term management or controls for exposure are included in Alternative 1. Long term potential risks would remain unchanged under this alternative.

Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment – Alternative 1 would provide no reduction in toxicity, mobility, or volume of the contaminated groundwater.

Short Term Impacts and Effectiveness – Alternative 1 would not result in disruption of the OU2 area and therefore no additional risks would be posed to the community, workers, or the environment as no remedial actions would occur.

Implementability – There are no implementability concerns posed by this remedy as no remedial actions would be implemented.

Relative Cost – Because this is a no action alternative, the capital, O&M, and net present worth costs are estimated to be $0. The estimated cost for Alternative 1 is summarized in **Table 9-1** and **Appendix A**. Details of the cost estimate for Alternative 1 are provided in **Appendix A1**.

9.2.2 Alternative 2 – ICs with LTM

Overall Protection of Human Health and the Environment – Alternative 2 would provide overall protection of human health because the exposure pathways to human receptors would be eliminated by restrictions placed on the future use of groundwater within the area of groundwater contamination and through treatment and testing of municipal water supplies required by State and Federal drinking water programs.

Compliance with ARARs – Alternative 2 would be expected to achieve compliance with ARARs over approximately 30 years as natural processes attenuate the plume. LTM activities for Alternative 2 would be continued until the PRGs were met.

Long Term Effectiveness and Permanence – This alternative would provide long-term effectiveness and permanence as groundwater contamination would be attenuated via natural processes. The long-term effectiveness of this alternative would be assessed through routine groundwater monitoring and five-year reviews to verify restoration of the environment and that human health was not at risk. ICs are effective on a long term basis and rely on implementation and enforcement which has proven to be successful. The LTM program would be a reliable indicator on the contaminant concentrations in groundwater over time.

Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment – This alternative would address the contamination through natural attenuation processes. These processes would reduce the toxicity, mobility, and volume of the groundwater contamination over a period of time.

Short Term Impacts and Effectiveness – Site work would be limited to the installation of additional monitoring wells. Installation of wells would be performed without significant risk to the community. Through required training, Site workers would wear appropriate personal protective equipment (PPE) to minimize exposure to contamination and as protection from physical hazards.

Implementability – This alternative is technically implementable using conventional construction methods and equipment. No technical difficulties are anticipated for installation of monitoring wells and conducting LTM.

Relative Cost – The present worth cost of Alternative 2 is estimated to be $3,200,000. The capital cost is estimated to be $816,000 and the total present worth value of O&M and periodic costs is estimated to be $2,384,000. The capital cost is primarily the cost of installing two new monitoring wells. The estimated cost for Alternative 2 is summarized in **Table 9-1** and **Appendix A**. Details of the cost estimate for Alternative 2 are provided in **Appendix A2**.

9.2.3 Alternative 3 – Core of Plume Remediation and Discharge of Treated Water to Groundwater, ICs and LTM

Overall Protection of Human Health and the Environment – Alternative 3 would be protective of human health and the environment. It would limit the migration of the groundwater plume near the source but would not control the potential migration of contamination at the distal end of the groundwater plume. The downgradient portion of the plume would not be captured and would be sampled/analyzed to monitor reductions over time. This remedial alternative would prevent exposure to contaminated groundwater and restore groundwater quality eventually. LTM would be used to monitor containment and assess the operational time frame for the P&T system. ICs would be used to protect human health in the downgradient part of the plume.

Compliance with ARARs – Alternative 3 is expected to achieve compliance with ARARs over time. P&T, ICs and LTM activities for Alternative 3 would be continued until the PRGs were met. The P&T system would capture the core of the plume and would be expected to decrease contaminant concentrations in the groundwater over time. The downgradient portion of the plume would not be captured and would be sampled/analyzed to monitor reductions over time. LTM would be conducted to assess the degree of compliance achieved over time. Through the operation of the treatment system, this alternative would meet action-specific ARARs for discharge of treated groundwater to groundwater, and discharge of off-gas into ambient air.

Long Term Effectiveness and Permanence – This alternative is expected to be effective over time. P&T systems are a proven technology. VOCs would be permanently removed from the core

of the groundwater plume with air stripping and GAC processes. 1,4-dioxane would be permanently removed from the core of the groundwater plume with AOPs or equivalent processes. The long-term effectiveness of this alternative would be more successful at the area near the core of the plume and less effective at the downgradient portion. This alternative could negatively affect the long-term water supply potential of the aquifer given the current water use restrictions due to historical over-pumping in the area. The effectiveness would be assessed through routine groundwater monitoring and five-year reviews to verify the restoration of the environment and that human health was not at risk.

Reduction of Toxicity, Mobility, or Volume of Contamination through Treatment – This alternative would reduce the toxicity, mobility, and volume of the contaminants in the core of the groundwater plume through P&Tment of the contaminated groundwater. Once the contaminated groundwater was withdrawn from the aquifer, the water would be treated at the surface via an air stripping and carbon treatment process to address VOCs, as well as AOPs to specifically address 1,4-dioxane. Contaminants trapped on the GAC adsorption media would be destroyed during regeneration or disposed in accordance with applicable waste regulations. AOPs provide complete destruction and mineralization of many chlorinated solvents, including 1,4-dioxane. At the distal end of the groundwater plume, natural processes would reduce the toxicity and volume of the contaminants

Short Term Impacts and Effectiveness – Groundwater extraction systems are effective at controlling the migration of contaminated groundwater and removing contaminant mass from an aquifer. Extraction of contaminated groundwater to the surface for treatment increases the risks of contaminant exposure to workers, the community, and the environment. However, safety techniques including community air monitoring, traffic control plans, and street closure permits would be implemented during construction. In addition, alarmed monitoring equipment would be used to minimize risks from failures of treatment system components. A fence and other potential security measures would be installed around the treatment system facility to restrict access, discourage trespassers, and limit potential exposure.

The majority of the short-term impacts would be incurred during the construction of the extraction wells, conveyance piping, treatment plant, and discharge outfall. Increased traffic and noise would be expected during construction activities; however, noise and traffic control plans detailing standard work practices and engineering controls would be implemented to reduce impacts to the community to the extent possible.

Through required training, Site workers would wear appropriate PPE to minimize exposure to contamination and as protection from physical hazards.

Implementability – This alternative is technically implementable using conventional construction methods and equipment. Groundwater extraction and treatment is implementable as the technique uses well-established technologies and the equipment and services needed to install and operate the treatment system and to sample groundwater monitoring wells are commercially available. PDI, pilot testing, and property evaluation would be necessary to determine optimal well

placement, flow rates, and any required pre-treatment. Land acquisition would likely be required for the construction of the extraction well.

Cost – The present worth cost of Alternative 3 is estimated to be $38,624,000. The capital cost is estimated to be $12,766,000 and the total present wort value of O&M and periodic costs is estimated to be $25,858,000. The capital cost is primarily the cost of system construction. The estimated cost for Alternative 3 is summarized in **Table 9-1** and **Appendix A**. Details of the cost estimate for Alternative 3 are provided in **Appendix A3**.

9.3 Comparative Analysis of Alternatives

Table 9-1 summarizes the comparison of the three alternatives against the first seven criteria.

9.3.1 Overall Protection of Human Health and the Environment

Alternatives 2 and 3 would provide equal protection of human health because the exposure pathways to human receptors would be eliminated by restrictions placed on the use of groundwater within the area of groundwater contamination and through treatment and testing of municipal water supplies required by State and Federal drinking water programs.

9.3.2 Compliance with ARARs

Alternatives 2 and 3 would comply with ARARs equally as the exposure pathways to human receptors would be eliminated by restrictions placed on the use of groundwater within the area of groundwater contamination and through treatment and testing of municipal water supplies required by State and Federal drinking water programs.

Alternative 2 would comply with ARARs over a period of approximately 30 years as natural processes attenuate the plume. Alternative 3 would also comply with ARARs over a period of 30 years from active groundwater extraction, treatment, and discharge.

9.3.3 Long-Term Effectiveness and Permanence

Alternatives 2 and 3 would have similar long-term effectiveness and permanence as both alternatives would reduce the COCs to below the PRGs in a similar timeframe (30 yrs). The reduction of COCs through natural processes is considered an effective technology. Groundwater extraction and ex-situ treatment under Alternative 3 are also considered effective technologies for addressing groundwater contaminated with the COCs.

The adequacy and reliability of the institutional controls under Alternatives 2 and 3 are high and rely on implementation and enforcement through the state, which have proven to be successful. The long-term monitoring program that would be established for the alternatives would yield a reliable indication on the contaminant concentrations in groundwater.

Alternative 3 relies on commonly used treatment technologies to permanently destroy the contaminants once withdrawn from the aquifer. Following air stripping, any remaining contaminants trapped on the GAC adsorption media would be destroyed during regeneration. The AOP technology provides complete destruction and mineralization of many chlorinated solvents, including 1,4-dioxane.

9.3.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 3 would reduce the toxicity, mobility, and volume of contaminants in the aquifer by using extraction wells to remove contaminated groundwater and by providing surface treatment through air stripping, granulated active carbon, and AOP technologies. Alternative 2 would reduce the toxicity, mobility, and volume of contaminants in the aquifer through natural processes. Alternative 3 would remove the largest amount of COCs and would have the largest reduction in toxicity, mobility, and volume in the shortest period of time because it would target the portions of the plume with the highest COC concentration. Alternative 2 would reduce the next largest amount of COCs in the aquifer through natural processes.

Alternative 3 would reduce toxicity and volume due to the treatment processes and the distractive irreversibility of the treatment. Alternative 3 relies on commonly used treatment technologies to permanently destroy the contaminants once withdrawn from the aquifer. Following air stripping, any remaining contaminants trapped on the GAC adsorption media would be destroyed during regeneration or disposed of in accordance with applicable waste regulations. The AOP technology provides complete destruction and mineralization of many chlorinated solvents, including 1,4-dioxane.

9.3.5 Short-Term Effectiveness

Alternatives 2 and 3 would be effective in the short-term at removing or reducing contaminant mass from the aquifer. Alternatives 1 and 2 would result in the least number of short-term impacts due to no physical construction, as compared to the active alternative. Alternative 3 would have short-term impacts to the local communities due to the drilling of the extraction well, installation of underground conveyance piping, construction of the treatment plant, and development of discharge locations. These disruptions would be minimized through noise and traffic control plans, as well as community air monitoring programs during construction to minimize and address any potential impacts to the community, remediation workers, and the environment. The groundwater extraction system would induce a hydraulic gradient capturing COCs within days or weeks of system startup.

9.3.6 Implementability

While each of the remedial alternatives are technically feasible and implementable, the degree of difficulty is determined by specific construction activities that will need to occur in heavily

developed areas.

Alternatives 1 and 2 would be the easiest alternative to implement as there would be no physical construction of a remedial system. Alternative 3 would be the most difficult to implement as it would contain an extraction well and piping. It would require access to land (Recharge Basin) owned by Nassau County at the intersection of Colonial Avenue and Tanners Pond Road. This alternative would also cause disruptions to traffic within several areas to install underground conveyance piping between the extraction wells and the centralized treatment plant.

Although Alternative 3 would be somewhat difficult to implement in the heavily developed areas, the proposed extraction well would be constructed with well-established technologies, equipment, and services. The equipment and services needed to sample groundwater monitoring wells are commercially available. The ex-situ treatment technologies proposed under Alternatives 3 are commercially available technologies and are typically easy to install and operate. Additional PDI, pilot testing, and property evaluation would be necessary to determine optimal well placement, flow rates, and any required pre-treatment.

9.3.7 Cost

A comparative summary of the cost estimates for each alternative is presented in **Table 9-1**, and **Appendix A**. In summary, Alternative 1 would have no cost. Alternative 2 would have the lowest cost of the alternatives using ICs with LTM ($3.2M). Alternative 3 would be the highest cost ($38.6M) with the active remediation components including groundwater remediation with an extraction well, centralized treatment, and discharge of treated water to groundwater would have the highest cost.

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Table 3-1 Exceedances of PDC in OU2 - Phase 5 Groundwater Sampling
Fulton Avenue Superfund Site OU2
Garden City, New York

					Metals			VOCs		
				Analyte	Iron	Manganese	Sodium	cis-1,2-DCE	PCE	TCE
				CAS	7439-89-6	7439-96-5	7440-23-5	156-59-2	127-18-4	79-01-6
				PDC	300	300	20000	5	5	5
				Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Sampling Event:	Location:	Sample:	Sample Type:	Sample Date:	Result	Result	Result	Result	Result	Result
2019 08-09 Phase 5 GW Sampling	MW-20C	MW-20C-GW-405-20190903-0		9/3/2019	17800		57200			
2019 08-09 Phase 5 GW Sampling	MW-23C	MW-23C-GW-403-20190903-0		9/3/2019	379000 D	2170 D	33900			26 D
2019 08-09 Phase 5 GW Sampling	MW-25A	MW-25A-GW-345-20190905-0		9/5/2019	3820		21700		23 D	26 D
2019 08-09 Phase 5 GW Sampling	MW-26F	MW-26F-GW-410-20190905-0		9/5/2019	831		23800	5.6	17	17
2019 08-09 Phase 5 GW Sampling	MW-26G	MW-26G-GW-443-20190905-0		9/5/2019	402				7.9	23 D
2019 08-09 Phase 5 GW Sampling	N-03881	N-03881-GW-426-466-20190904-0		9/4/2019					42 D	79 D
2019 08-09 Phase 5 GW Sampling	N-11171	N-11171-GW-220-20190829-0		8/28/2019	28000		31800			
2019 12 Phase 5 GW Sampling	MW-20C	MW-20C-GW-405-20191209-0		12/9/2019	18000		37300			
2019 12 Phase 5 GW Sampling	MW-23C	MW-23C-GW-403-20191209-0		12/9/2019	13000		55600			12
2019 12 Phase 5 GW Sampling	MW-25A	MW-25A-GW-345-20191206-0		12/6/2019	2700				22	27
2019 12 Phase 5 GW Sampling	MW-26F	MW-26F-GW-410-20191209-0		12/9/2019	1200				14	15
2019 12 Phase 5 GW Sampling	MW-26G	MW-26G-GW-443-20191209-0		12/9/2019	1500		21700		5.5	25
2019 12 Phase 5 GW Sampling	MW-26G	MW-26G-GW-443-20191209-1	Duplicate	12/9/2019	1600					21
2019 12 Phase 5 GW Sampling	N-11171	N-11171-GW-220-20191206-0		12/6/2019	11000		23500		6.8	13

Abbreviations
VOCs: volatile organic compounds
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
CAS: Chemical Abstracts Service identifier
PDC: potential delineation criteria
ug/l: micrograms per liter

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Table 4-1A Chemical-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Media	Requirement	Citation	Description
Federal			
Groundwater/ Water	Safe Drinking Water Act	42 U.S.C. §§300f-300j-26	Drinking water standards, expressed as maximum contaminant levels (MCLs), which apply to specific contaminants that have been determined to have an adverse impact on human health.
Groundwater/ Water	USEPA National Primary Drinking Water Regulations	40 CFR §§ 141.1-141-861	Health-based standards for public drinking water systems. Also includes drinking water quality goals that are set at levels at which no adverse health effects are anticipated, with a safety margin.
State of New York			
Groundwater/ Water	NYSDEC - Derivation and Use of Standards and Guidance Values	6 NYCRR Part 702	Basis for derivation of water quality standards and guidance values to control toxic and other deleterious substances.
Groundwater/ Water	NYSDEC - Water Quality Standards and Classifications	6 NYCRR Part 703	Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations
Groundwater/ Water	NYSDEC - Division of Water - Technical and Operational Guidance Series - Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (1998)	NYSDEC TOGS 1.1.1	Compilation of ambient water quality standards and guidance values and groundwater effluent limitations for use where there are no standards or regulatory effluent limitations.
Water	NYSDEC - Sources of Water Supply – Standards of Raw Water Quality	10 NYCRR Part 170.4	Raw water quality standards to protect sources of water supply dedicated for present or future public beneficial use for domestic and municipal purposes.
Water	NYSDOH - Ambient Water Quality Standards and Guidance Values	2021 Addendum to June 1998 Division of Water TOGS 1.1.1	New water quality guidance values for emerging contaminants PFOA, PFOS, and 1,4-dioxane.
Water	NYSDOH - Sources of Water Supply - Standards of Raw Water Quality	NYSDOH Part 5, Subpart 5-1.51/52	Maximum contaminant levels, maximum residual disinfectant levels and treatment technique requirements.

Notes:
CFR - Code of Federal Regulations
MCLs - Maximum Contaminant Levels
NYCRR - New York Codes, Rules, and Regulations
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
PFOA - perfluorooctanoic acid
PFOS - perfluorooctane sulfonic acid

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Table 4-1B Location-Specific ARARs and TBCs
Fulton Avenue Superfund Site
Garden City, New York

Location	Title	Citation	Description
Federal			
Groundwater	Federal Protection of Sole Source Aquifer	40 CFR §§ 149, et seq.	Describes the criteria to define a sole source aquifer and states that programs to reduce or prevent the contamination of sole source aquifers must be implemented when it is reasonably likely that contamination of such aquifers will occur
Floodplains	Federal Emergency Management Agency Executive Order 11988 - Floodplain Management	FEMA EO 11988	Activities taking place within floodplains must be performed to avoid adverse impacts and preserve beneficial values
Floodplains and Wetlands	Floodplain Management and Protection of Wetlands	24 CFR §§ 55.1 et seq.	Regulation that implments FEMA EO 11988
Floodplains and Wetlands	USEPA Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR Part 6, Appendix A, Section 6	Requirements associated with actions that have impacts on floodplains or wetlands
Wetlands	National Environmental Policy Act Executive Order 11990 - Protection of Wetlands	NEPA EO 11990	Activities performed within wetlands areas must be done to avoid adverse impacts
Wetlands	National Environmental Policy Act of 1969, as amended	42 U.S.C. §§ 4321, et seq.	Act that implements NEPA EO 11990
Floodplains and Wetlands	Office of Solid Waste and Emergency Response - Policy on Floodplains and Wetlands Assessments for CERCLA Actions (2005)	OSWER 9280.0-02	Guidance for implementing executive orders 11988 and 11990
Wetlands	Office of Solid Waste and Emergency Response - Wetlands Protection at CERCLA sites (1994)	OSWER 9280.0-03	Guidance document to be used to evaluate impacts to wetlands at Superfund sites
Historic or Cultural Lands	National Historic Preservation Act	16 U.S.C. §§ 470, et seq and 36 CFR Part 800	Established Requirements for the identification and preservation of historic and cultural resources
Critical Habitat Areas	Endangered Species Act and Fish and Wildlife Coordination Act	16 U.S.C. §§ 661, et seq. and 16 USC. §§ 1531, et seq.	Actions must be taken to conserve critical habitat in areas where they are endangered or threatened species
Floodplains	Resource Conservation and Recovery Act (RCRA) Regulations - Location Standards	40 CFR Part 264.18	Regulates the design, construction, operation, and maintenance of hazardous waste management facilities within the 100-year floodplain.

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Table 4-1B Location-Specific ARARs and TBCs
Fulton Avenue Superfund Site
Garden City, New York

Location	Title	Citation	Description
State of New York			
Critical Habitat Areas	New York State Department of Environmental Conservation - Endangered and Threatened Species of Fish and Wildlife	6 NYCRR Part 182	Provides standards for the protection of threatened and endangered species.
Wetlands	New York State Department of Environmental Conservation - Freshwater Wetlands Permit Requirements	6 NYCRR Part 663.1-663.11	Defines the procedural requirements for any activities taking place within or adjacent to wetlands.
Floodplains	New York State Department of Environmental Conservation - Floodplain Management Criteria for State Projects	6 NYCRR Part 502	Provides floodplain management criteria.

Notes:
CFR - Code of Federal Regulations
EO - Executive Order
FEMA - Federal Emergency Management Agency
NEPA - National Environmental Policy Act
NYCRR - New York Codes, Rules, and Regulations
NYS - New York State
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
OSWER - Office of Solid Waste and Emergency Response
TOGS - Technical and Operational Guidance Series
U.S.C. - United States Code

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description
Federal			
Disposal of Hazardous Materials	Resource Conservation and Recovery Act - Identification and Listing of Hazardous Wastes	40 CFR Part 261	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 40 CFR Parts 260 to 266.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Hazardous Waste Determination	40 CFR Part 262.11	Describes methods for identifying hazardous wastes and lists known hazardous wastes.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Manifesting	40 CFR Part 262, Subpart B	Describes manifest requirements applicable to small and large quantity generators.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Recordkeeping	40 CFR Part 262.40	Describes record keeping requirements for generators.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Labeling and Marking	40 CFR Part 262 Subpart C	Specifies EPA naming, labeling and container requirements for off-site disposal of hazardous waste.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act - Land Disposal Restrictions	40 CFR Part 268	Restricts land disposal of hazardous wastes that exceed specific criteria. Establishes Universal Treatment Standards to which hazardous waste must be treated prior to disposal.
Generating Hazardous Materials	Resource Conservation and Recovery Act – Accumulation limitations	40 CFR Part 262.14	Allows generators of hazardous waste to store and treat hazardous waste at the generation site for up to 90 days in tanks, containers, and containment buildings without having to obtain a RCRA hazardous waste permit.

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description
Storage and Disposal of Hazardous Materials	Resource Conservation and Recovery Act - Treatment, Storage and Disposal of Hazardous Waste	40 CFR Parts 264/265/270	Specifies requirements for the operation of hazardous waste treatment, storage, and disposal facilities.
Transporting Hazardous Materials	US Department of Transportation - Hazardous Materials Transportation Regulations	49 CFR Parts 171-180	Establishes classification, packaging, and labeling requirements for shipments of hazardous materials.
Transporting Hazardous Materials	RCRA- Standards Applicable to Transporters of Applicable Hazardous Waste	40 CFR Part 263	Establishes the responsibility of off-site transporters of hazardous waste in the handling, transportation and management of the waste. Requires manifesting, recordkeeping and immediate action in the event of a discharge
Generating Air Emissions	Clean Air Act - National Primary and Secondary Ambient Air Quality Standards	40 CFR Parts 50.6 and 50.7	Establishes air quality standard for particles with an aerodynamic diameter less than or equal to a normal 10 micrometers (PM10) and 2.5 micrometers (PM2.5)
Generating Air Emissions	Clean Air Act - New Source Review and Prevention of Significant Deterioration Requirements	40 CFR Part 52 Subpart HH	New sources or modifications which emit greater than defined thresholds for listed pollutants must perform ambient impact analyses and install controls which meet best available control technology (BACT).
Generating Air Emissions	Clean Air Act - National Emissions Standards for Hazardous Air Pollutants (NESHAP)	40 CFR Part 61; 40 CFR Part 63	Source-specific regulations which establish emissions standards for hazardous air pollutants
Discharging Water	Clean Water Act - Effluent Guidelines and Standards; National Pollutant Discharge Elimination System (NPDES) Program	40 CFR Part 401; 40 CFR Parts 122, 124, and 125	Both on-site and off-site discharges from CERCLA sites to surface waters are required to meet the substantive Clean Water Act limitations, monitoring requirements, and best management practices. NPDES permits are required to discharge treated water to a surface water.
Re-injecting Water	Safe Drinking Water Act – Underground Injection Control Program	40 CFR 144, 146	Establish performance standards, well requirements, and permitting requirements for groundwater re-injection wells.
Remediation	Superfund Green Remediation Strategy	www.epa.gov/superfund/greenremediation/sf-gr-strategy.pdf	Provides the EPA's strategy to clean up hazardous waste sites in ways that use natural resources and energy efficiently and reduces negative impacts on human health and the environment.

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description
State of New York			
Treatment and Disposal of Hazardous Materials	New York State Department of Environmental Conservation - Standards for Universal Waste and Land Disposal Restrictions	6 NYCRR Part 374-3 6 NYCRR Part 376	These regulations establish standards for treatment and disposal of hazardous wastes.
Transporting Hazardous Materials	New York State Department of Environmental Conservation - Waste Transportation	6 NYCRR Part 364	Regulates the collection, transport, and delivery of regulated waste, originating or terminating at a location within this State.
Management of Hazardous Materials	New York State Department of Environmental Conservation - Hazardous Waste Management System – General	6 NYCRR Part 370	Provides definition of terms and general standards applicable to hazardous waste management systems.
Identification and Listing Hazardous Materials	New York State Department of Environmental Conservation - Identification and Listing of Hazardous Wastes	6 NYCRR Part 371	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 6 NYCRR Part 370 to 373, and 376.
Transporting Hazardous Materials	New York State Department of Environmental Conservation - Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities	6 NYCRR Part 372	Standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its recordkeeping requirements.
Generating Air Emissions	New York State Department of Environmental Conservation - Air Quality Standards	6 NYCRR Part 257	Standards promulgated to provide protection from the adverse health effects of air contamination; and are intended to protect and conserve the natural resources and environment and to promote maximum comfort and enjoyment and use of property consistent with the economic and social well-being of the community.
Discharging Groundwater	New York State Department of Environmental Conservation - State Pollutant Discharge Elimination System (SPDES)	6 NYCRR Part 750	Governs the discharge of any wastes into or adjacent to State waters that may alter the physical, chemical, or biological properties of State waters, except as authorized pursuant to a NPDES or State permit.
Discharging Groundwater	New York State Department of Environmental Conservation - Classifications - Surface Waters and Groundwaters	6 NYCRR Part 701	Defines discharge water quality requirements into water sources.
Discharging Groundwater	New York State Department of Environmental Conservation - Nassau County Waters	6 NYCRR Part 885	Defines the classifications and standards of quality and purity to all surface waters within the designated drainage basin on the Nassau County waters.
Discharging Groundwater	New York State Department of Environmental Conservation - Protection of Waters Program	6 NYCRR Part 608	Implements regulations that preserve and protect bodies of water including wetlands, lakes, rivers, streams, and ponds.
Decommissioning Groundwater Wells	New York State Department of Environmental Conservation - Groundwater Monitoring Well Decommissioning Policy	NYSDEC CP-43	Provides guidance on the decommissioning of groundwater monitoring wells.
Generating Air Emissions	New York State Department of Environmental Conservation - Prevention and Control of Air Contaminants and Air Pollution: Air Pollution Prohibited and Visible Emissions Limited	6 NYCRR Parts 200 and 211	Provides guidance on air pollution and visible emissions.

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description

Notes:

BACT - Best Available Control Technology
CFR - Code of Federal Regulations
NESHAP - National Emissions Standards for Hazardous Air Pollutants
NPDES - National Pollutant Discharge Elimination System
NSPS - New Source Performance Standards
NYCRR - New York Codes, Rules, and Regulations
NYS - New York State
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
RCRA - Resource Conservation and Recovery Act
TOGS - Technical and Operational Guidance Series

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Table 4-2
Preliminary Remediation Goals for Groundwater
Fulton Avenue Superfund Site OU2
Garden City, New York

Compounds of Concern	CAS Number	NYSDEC Part 703.5 Class GA (µg/L)	NYSDEC TOGS 1.1.1 Class GA (µg/L)	NYSDOH Part 5 Subpart 5-1 (µg/L)	Federal MCL (µg/L)	Primary Remediation Goal (µg/L)
VOLATILE ORGANIC COMPOUNDS (VOCs)						
Tetrachloroethylene (PCE)	127-18-4	5	5	5	5	5
Trichloroethylene (TCE)	79-01-6	5	5	5	5	5

Notes:
The Primary Remediation Goal is the minimum of the individual listed criteria.
(1) Criterion value is for total.
Abbreviations:
CAS = Chemical Abstracts Service
MCL = Maximum Contaminant Level (EPA 2009)
µg/L = micrograms per liter

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Table 6-1
Initial Screening of Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	No Action	No Action	No remedial action.	**Retained** - No Action is required for consideration by NCP.
Institutional Controls (ICs)	Not Applicable	ICs - Non-Engineering (Administrative/ Legal) Controls	ICs are non-engineering measures that help minimize the potential for human exposure to contamination and/ or protect the integrity of a remedy by limiting site or resource use.	**Retained** - ICs will be considered and developed in conjunction with all active remedial alternatives.
Monitored Natural Attenuation	Not Applicable	Not Applicable	Natural subsurface processes include destructive (e.g., biodegradation and chemical reactions with other subsurface constituents) and non-destructive (e.g., dilution, volatilization, biodegradation, adsorption, and chemical reactions) mechanisms that reduce contaminant concentrations to acceptable levels.	**Retained -** MNA is an implementable GRA and will be considered and developed in conjunction with other remedial technologies.
Long Term Monitoring	Not Applicable	LTM	Monitoring to assess movement of contaminants, remediation performance, and risk mitigation. Does not reduce contamination.	**Retained -** LTM will be considered and developed in conjunction with all active remedial alternatives.
Containment	Physical Barriers	Slurry Wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	**Not Retained** - The depth of groundwater contamination exceeds the practical limit for installing a slurry wall. Additionally, construction in densely populated area further limits implementability of this technology.
		Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes.	**Not Retained** - Construction in densely populated area limits the practicability of this technology.
		Funnel & Gate	Impermeable sheet pile wall (funnel) to direct water to a permeable reactive barrier (gate) for treatment.	**Not Retained** - The depth of groundwater contamination exceeds the practical limits for driving sheeting into the aquifer.
	Hydraulic Barrier	Groundwater Extraction and Treatment	Consists of pumping groundwater from an aquifer to remove dissolved phase contaminants and/or achieve hydraulic containment of contaminated groundwater to prevent migration, with subsequent treatment and disposal/discharge.	**Retained -** Groundwater extraction and treatment will be developed as a remedial alternative for OU2.
	Deep Well Injection	Geologic Sequestration	Waste disposal technology using injection wells to place untreated liquid waste into geologic formations that have little potential to allow migration of contaminants.	**Not Retained** - Geologic conditions, regulatory hurdles under the Underground Injection Control (UIC) and other environmental programs, community acceptance issues, hinder technical implementability at OU2.

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Table 6-1
Initial Screening of Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment	In Situ Biological Treatment	Enhanced Bioremediation	Process to accelerate the natural biodegradation process by introducing nutrients, electron acceptors, and/or competent contaminant-degrading microorganisms to the subsurface.	**Retained -** Enhanced bioremediation will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		Phytoremediation	Set of processes that use plants to remove, transfer, stabilize and / or destroy contamination in groundwater.	**Not Retained** - Based on the depth of groundwater contamination at OU2 and amount of land area needed for phytoremediation make technology not implementable.
	In-Situ Physical/ Chemical/ Thermal Treatment	Air Sparging / Soil Vapor Extraction (SVE)	Injected air traverses horizontally and vertically in channels through the soil column, creating a subsurface “air stripper” that removes contaminants by volatilization. SVE is used to extract and treat the contaminated air.	**Not Retained** - The groundwater contamination is below the practical limit for air sparging.
		Bioslurping	Combines the two remedial approaches of bioventing and vacuum-enhanced free-product recovery.	**Not Retained** - Bioslurping is traditionally used to remediate contamination by petroleum products with a LNAPL layer, which is not present at OU2.
		ISCO/ISCR	Chemically converts contaminants to less toxic compounds that are more stable, less mobile, and/or inert via either chemical oxidation or reduction reactions.	**Retained** - Both ISCO and ISCR are effective at treating COCs and will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		In Situ Adsorption	In-situ adsorption involves the injection of very fine particles of activated carbon into a subsurface contaminated zone. Contaminants are adsorbed onto treatment media and degraded by reactive amendments, reducing their concentration.	**Retained -** In-situ adsorption will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		Thermal Treatment	Thermal treatment technologies such as steam enhanced extraction (SEE), thermal conductive heating (TCH), electrical resistivity heating (ERH), and thermal conduction heating (TCH) work by introducing heat into the aquifer/ formation to destroy the organic contaminants present.	**Not Retained** - The plume size and depth is too large and deep to effectively implement these technologies. Additionally, construction in densely populated area limits the practicability of this technology.
		In Well Air Stripping	Air is injected into a vertical well that has been screened at two depths.	**Not Retained** - In Well Air Stripping is not implementable based on the depth limitation of the technology compared to the depth of contaminated groundwater at OU2.
		Passive/Reactive Treatment Barriers	Use of PRBs consisting of iron with a bulking agent to treat groundwater contaminated with chlorinated solvents. A PRB is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. Use of horizontal wells could also deliver reagents to contaminated areas.	**Retained -** Passive/Reactive Treatment Barriers will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		In Situ Flushing	In situ flushing involves the injection of chemicals like surfactants into a subsurface contaminated zone. The solution then flows through the contaminated zone and the resulting effluent is extracted downgradient where it is treated and discharged.	**Not Retained** - This technology would not be implementable given the size and depth of the plume and the densely populated area.

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Table 6-1
Initial Screening of Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (Continued)	Ex-Situ Biological Treatment	Bioreactors	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors.	**Not Retained** - Bioreactors are not applicable because of the diluted nature of contamination in the groundwater at OU2.
		Constructed Wetlands	The constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and fixate / remove metals and other contaminants from influent waters.	**Not Retained** - Constructed wetlands requires a large area of land for remediation which is not available near OU2.
	Ex-Situ Physical/ Chemical Treatment	Adsorption	Organic contaminants are adsorbed onto treatment media, reducing their concentration.	**Retained** - Ex-situ adsorption using GAC will be further evaluated as part of a groundwater extraction and treatment system.
		Advanced Oxidation Processes	Strong oxidizing chemicals or processes are used to destroy organic contaminants.	**Retained** - Advanced Oxidation Processes will be further evaluated as part of a groundwater extraction and treatment system.
		Ex Situ Air Stripping	Mass transfer of volatile contaminants from water to air.	**Retained** - Ex situ air stripping will be further evaluated as part of a groundwater extraction and treatment system.
Discharge/ Disposal	On-Site Discharge	Surface Water	Extracted water discharged to surface water	**Not Retained** - This technology requires nearby surface water for discharge which is not available at OU2.
		Groundwater	Extracted water treated and/or discharged into injection well or infiltration basin.	**Retained** - Groundwater discharge has been retained for use at OU2.
	Off-Site Discharge	POTW	Extracted water pre-treated and/or discharged to POTW.	**Retained** - POTW has been retained for use at OU2.

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Table 7-1
Detailed Screening of Remedial Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness (RAOs, COCs, Impacts to HHE, Reliability)	Implementability (Technical & Administrative)	Relative Cost	Screening Comment
No Action	No Action	No Action	COCs in groundwater are left untreated.	**Poor.** Not effective, because no active measures are taken to address the COCs.	**High.** Technically implementable; however, No Action can't be selected under CERCLA.	**None.**	**Retained** per NCP.
Institutional Control (ICs)	Not Applicable	ICs - Non-Engineering (Administrative/ Legal) Controls	Exposure pathways are controlled by administrative controls.	**Moderate.** Requires administrative measures to limit exposure to contaminated groundwater. Institutional Controls are an effective supplement to remedial alternatives.	**High**. Readily implementable under EPA guidance (EPA 540-F-00-005)..	**Low.**	**Retained** in conjunction with other GRAs.
Monitored Natural Attenuation (MNA)	Not Applicable	MNA	Destructive and non-destructive natural mechanisms that reduce contaminant concentrations.	**Moderate.** MNA relies on natural attenuation processes to achieve the applicable standards	**Moderate.** Implementing an MNA program is technically and administratively achievable. However, must demonstrate effectiveness prior to implementation.	**Low.**	**Not Retained** as evaluation of site contaminants and conditions has shown little evidence of biologically driven natural attenuation.
Long Term Monitoring (LTM)	Not Applicable	LTM	Evaluates groundwater conditions over time.	**Moderate.** Requires administrative measures to limit exposure to contaminated groundwater. Institutional Controls are an effective supplement to remedial alternatives.	**High**. Readily implementable under EPA guidance (EPA 540-F-00-005).	**Low.**	**Retained** in conjunction with other remedies that treat the groundwater.
Containment	Hydraulic Containment	Groundwater extraction and treatment	Hydraulic containment is the process of prohibiting further migration of contaminants by capturing groundwater.	**High.** Hydraulic containment is a widely accepted and implementable remedy especially at sites where hydrogeology is well understood and pumping rates are achievable.	**High.** This technology is technically and administratively implementable.	**High.** Capital costs include installation of extraction wells and treatment plant equipment.	**Retained** for containment of OU2 plume. Will be combined with ex-situ treatment and discharge technologies as a groundwater extraction and treatment system.
Treatment	In Situ Biological Treatment	Enhanced Bioremediation	Enhanced bioremediation modifies environmental conditions to encourage microorganisms to destroy or detoxify organic contaminants in the environment.	**Moderate.** While bacteria will readily degrade COCs, the groundwater conditions are not conducive to biological degradation. Amendments would be required to create more favorable conditions. Those amendments could negatively affect nearby municipal water supply.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due to moderate effectiveness and significant implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood.
	In-Situ Physical/ Chemical/ Thermal Treatment	ISCO/ISCR	These processes convert the COCs to less toxic compounds via either chemical oxidation or reduction reactions.	**Low**. Can treat site COCs but not as effective at treating low concentration plumes. May negatively affect nearby municipal water supply.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due poor effectiveness at treating low concentration plumes, implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood. Safety concerns regarding chemical handling in residential neighborhoods also excludes this process option.
		In Situ Adsorption	Chemicals injected into subsurface to adsorb contaminants as groundwater flows through the injection transect.	**Moderate.** Effective at binding site COCs to prevent further migration. Does not chemically alter the contaminants.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due to implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood and potential for incomplete adsorption of COCs.
		Passive/Reactive Treatment Barriers	This process allows groundwater to passively migrate through treatment media to recover COCs.	**Moderate**. Passive/Reactive Treatment Barriers rely on passive treatment to achieve applicable standards. Effective at reducing low COC concentrations. May negatively affect nearby municipal water supply.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due to implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood.

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Table 7-1
Detailed Screening of Remedial Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

Treatment (continued)	Ex Situ Physical/ Chemical/ Thermal Treatment	Adsorption	Organic contaminants are adsorbed onto treatment media, reducing their concentration.	**High**. Adsorption using GAC to treat the vapor-phase contaminants is highly effective at destroying the organic contaminants resultant from the ex situ air stripping operations at the Site.	**High.** This technology is technically and administratively implementable.	**Moderate.** High capital and O&M costs are associated with this technology.	**Retained** for liquid-phase treatment and vapor-phase treatment of the air stripper off gas.
		Advanced Oxidation Processes	Advance oxidation processes use hydroxyl radicals, which are powerful oxidizers, to sequentially oxidize organic contaminants to carbon dioxide, water, and residual chloride	**High.** AOP is one of only a few technologies with commercial viability to treat 1,4-dioxane	**High.** This technology is technically and administratively implementable.	**High.** High capital and O&M costs are associated with this technology.	**Retained** for potentially treating emerging contaminants, if needed.
		Air Stripping	Mass transfer of volatile contaminants from water to air.	**High.** Ex situ air stripping is a highly effective, safe and reliable means for treating the dissolved phase organics present in the Site groundwater. Additional treatment technologies will be required to treat the vapor-phase contaminants resulting from the air stripper.	**High.** This technology is technically and administratively implementable.	**Low.** Low capital and O&M costs are associated with this technology.	**Retained** as the primary ex situ groundwater treatment alternative.
Discharge/Disposal	Discharge	Groundwater	Extracted water treated and discharged to groundwater via recharge basin.	**High.** Discharge to groundwater via injection or infiltration will be an effective method for disposal of treated groundwater.	**High.** This technology is technically and administratively implementable.	**Moderate.** Capital costs could be high if land acquisition is necessary, but an existing recharge basin could be evaluated for use	**Retained** for groundwater discharge.
			Extracted water treated and discharged to groundwater via injection wells.	**Moderate.** Dependent on the formation's ability to receive water. Wells can foul over time.	**High.** This technology is technically and administratively implementable.	**Moderate.** Capital costs include installation of injection wells	**Not retained** as more effective option available
		POTW	Extracted water pre-treated and/or discharged to POTW.	**High.** Discharging to a sewer main would be effective for disposal of treated groundwater.	**Moderate.** This technology is technically implementable, but would require the sewer district to approve the discharge.	**High.** High capital costs are associated with upgrade to the sewer lines.	**Not retained** as more effective option available

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Table 8-1
Summary of Remedial Technologies and Process Options
Fulton Avenue Groundwater Contamination Superfund Site OU2
Garden City, New York

General Response Actions	Technology	Process Options
No Action	No Action	No Action
Institutional Control	ICs	Non-engineering, administrative/legal controls
Long Term Monitoring	LTM	LTM
Containment	Hydraulic Containment	Groundwater extraction and treatment
Treatment	Ex-Situ Treatment	Adsorption
		Advanced Oxidiation Processes
		Air Stripping
Discharge/Disposal	Discharge	Recharge Basin

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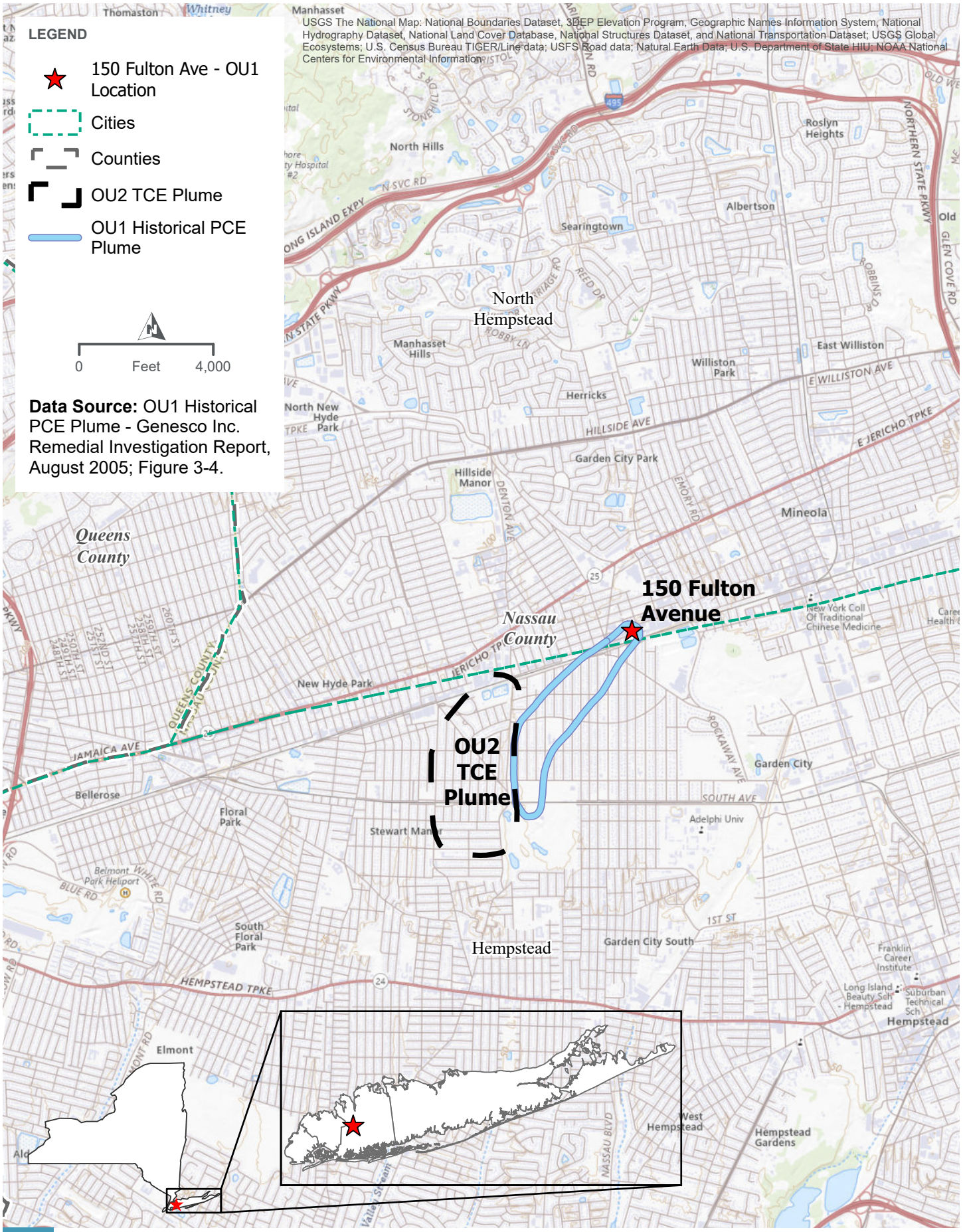
Table 9-1
Comparative Analysis of Remedial Alternatives
Fulton Avenue Superfund Site OU2
Garden City, New York

Alt. No.	Alternative Name	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Permanence	Reduction of Toxicity, mobility or Volume of Contamination thru Treatment	Short Term Impacts and Effectiveness	Implementability	Cost Effectiveness	
1	**No Action**	- Will not meet any of the RAOs.	- Will not comply.	- Contaminants remain in the environment and may transform into other compounds. - Magnitude of potential risks will be unchanged.	- Does not reduce toxicity, mobility or volume of contamination present in the contaminated groundwater.	- Does not result in disruption of operations or pose a short term threat to public health or the environment. - No remedial timeframe is associated with this alternative.	- No technical or administrative difficulties or constraints.	Capital Cost: Total O&M Present Value: Total Present Value Cost:	$ - $ - $ -
2	**ICs with LTM**	-This alternative is protective of the public health by eliminating exposure pathways to contaminated groundwater. -Will meet RAOs by preventing human exposure pathways to contaminants.	-Will comply with ARARs and PRGs will be achieved over a time period of about 30 years. - Natural processes are assumed to achieve RAOs over time.	-COCs would be reduced over time by natural attenuation processes.	-This alternative would reduce the toxicity, mobility, and volume over time as natural processes attenuate the plume.	-Minimal short term impacts, associated with monitoring well installation and sampling.	-This alternative is readily implmentable.	Capital Cost: Total O&M Present Value: Periodic Costs Present Value: Total Present Value Cost:	$ 816,000 $ 1,952,000 $ 432,000 $ 3,200,000
3	**Core of Plume Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM**	-This alternative is protective of the public health and the environment. -Will meet RAOs by preventing human exposure pathways to contaminants, minimizing the migration of contaminated groundwater, and eventually restoring the impacted aquifer to its most beneficial use as a source of drinking water by active remediation in the most contaminated portion of OU2 through a combination of active remediation and ICs.	-Will comply with ARARs and PRGs will be achieved over time, about 30 years. - Active treatment and natural processes are assumed to achieve RAOs.	-Permanent reduction in groundwater contamination from active groundwater remediation area.	-This alternative will provide a reduction in toxicity and volume of the contaminants in groundwater by extracting and treating groundwater from the most contaminated portion of the plume.	-Short term impacts during construction including installation of the extraction well and conveyance piping. Construction of the GWTP and rehabilitation of the recharge basin would also have short term impacts. This would include increased traffic, noise, clearing, grubbing, and site work.	-This alternative is technically implementable using conventional construction methods and equipment. -Potential land acquisition and property access required for construction of extraction well and easements for the conveyance piping, GWTP, and recharge basin could pose challenge. -Services and materials for implementation of this alternative are readily available.	Capital Cost: Total O&M Present Value: Periodic Costs Present Value: Total Present Value Cost:	$ 12,766,000 $ 24,731,000 $ 1,127,000 $ 38,624,000



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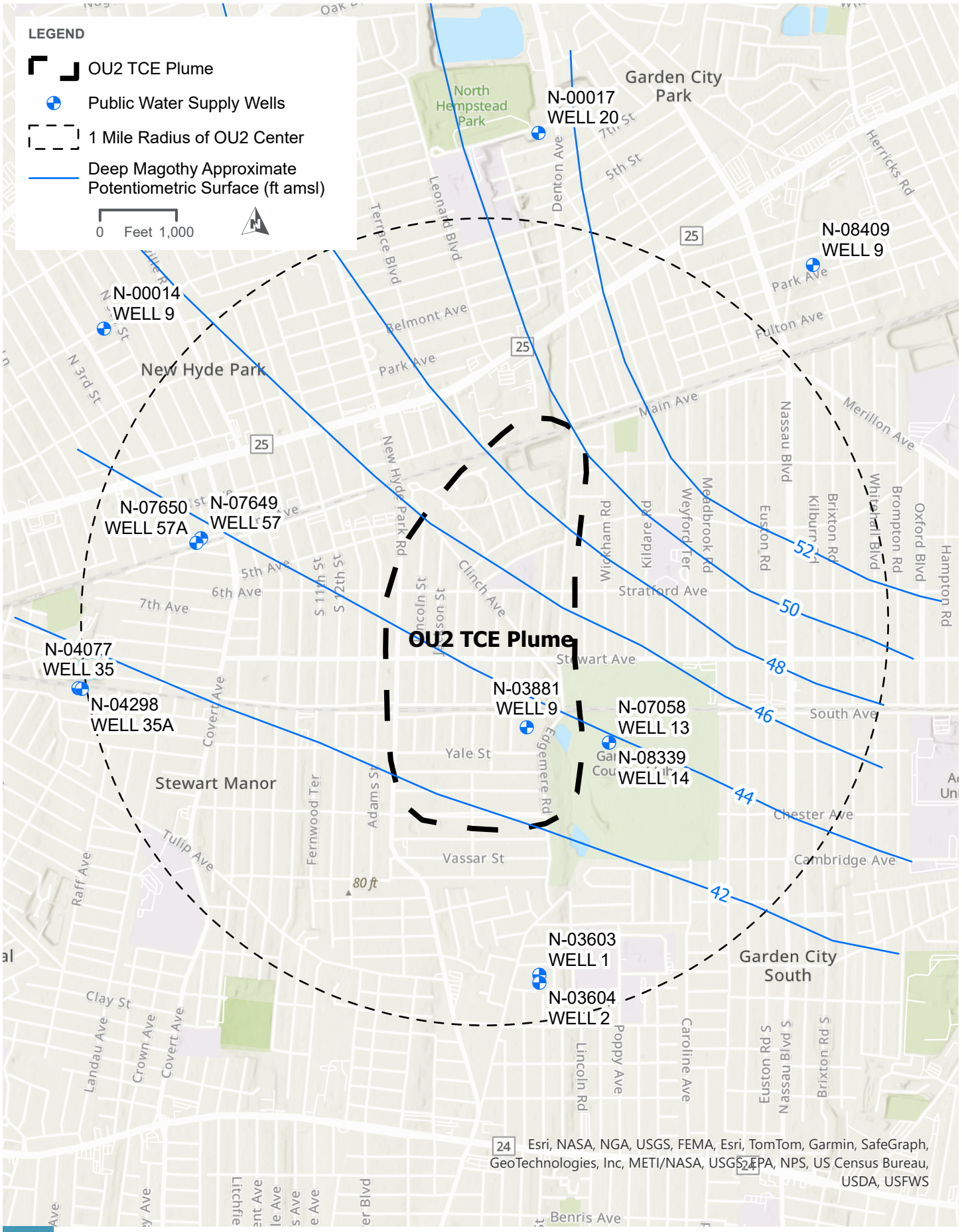
SITE LOCATION MAP

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-1



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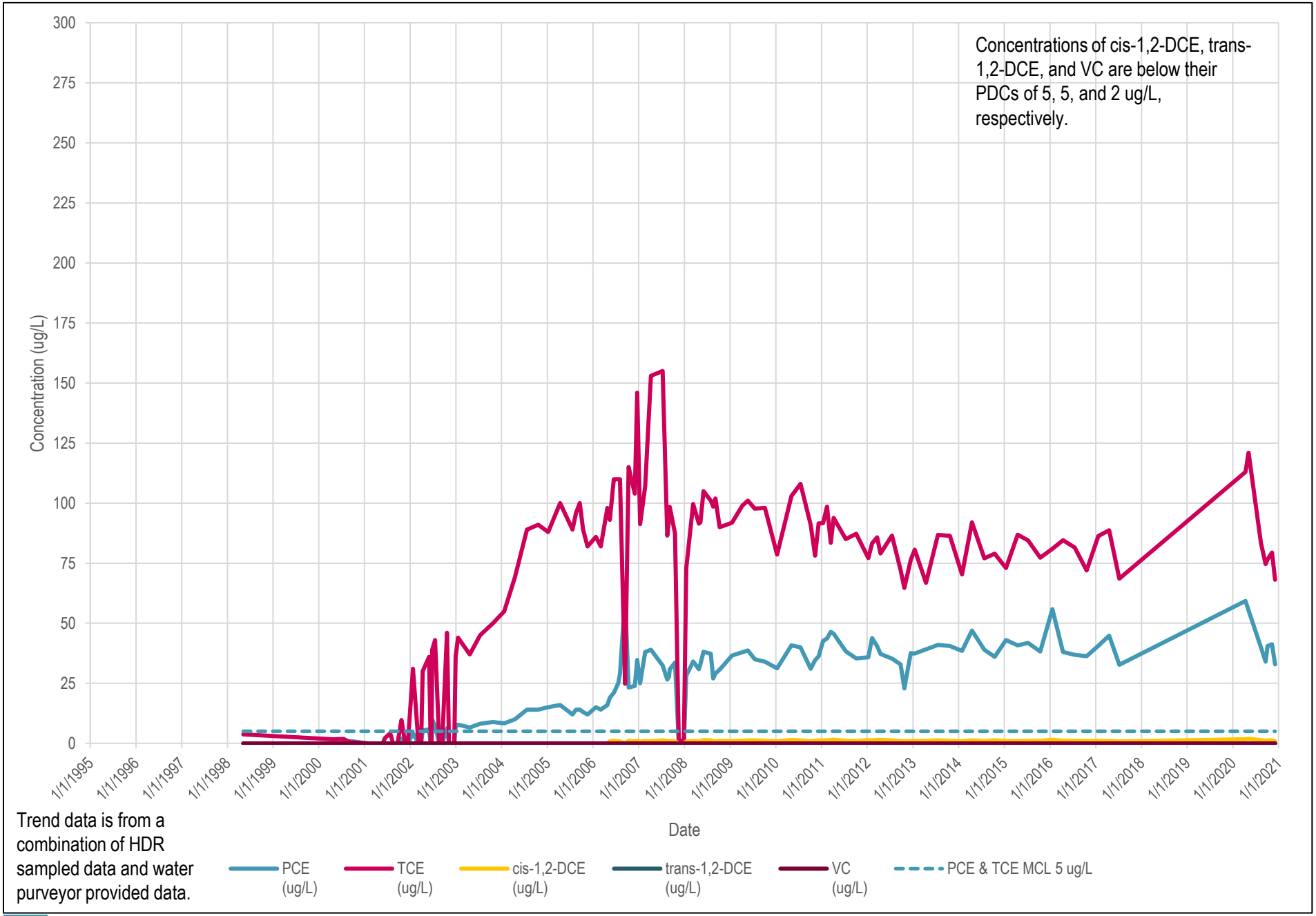
NEARBY PUBLIC WATER SUPPLY WELLS

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-2

N-03881 (Garden City Well 9)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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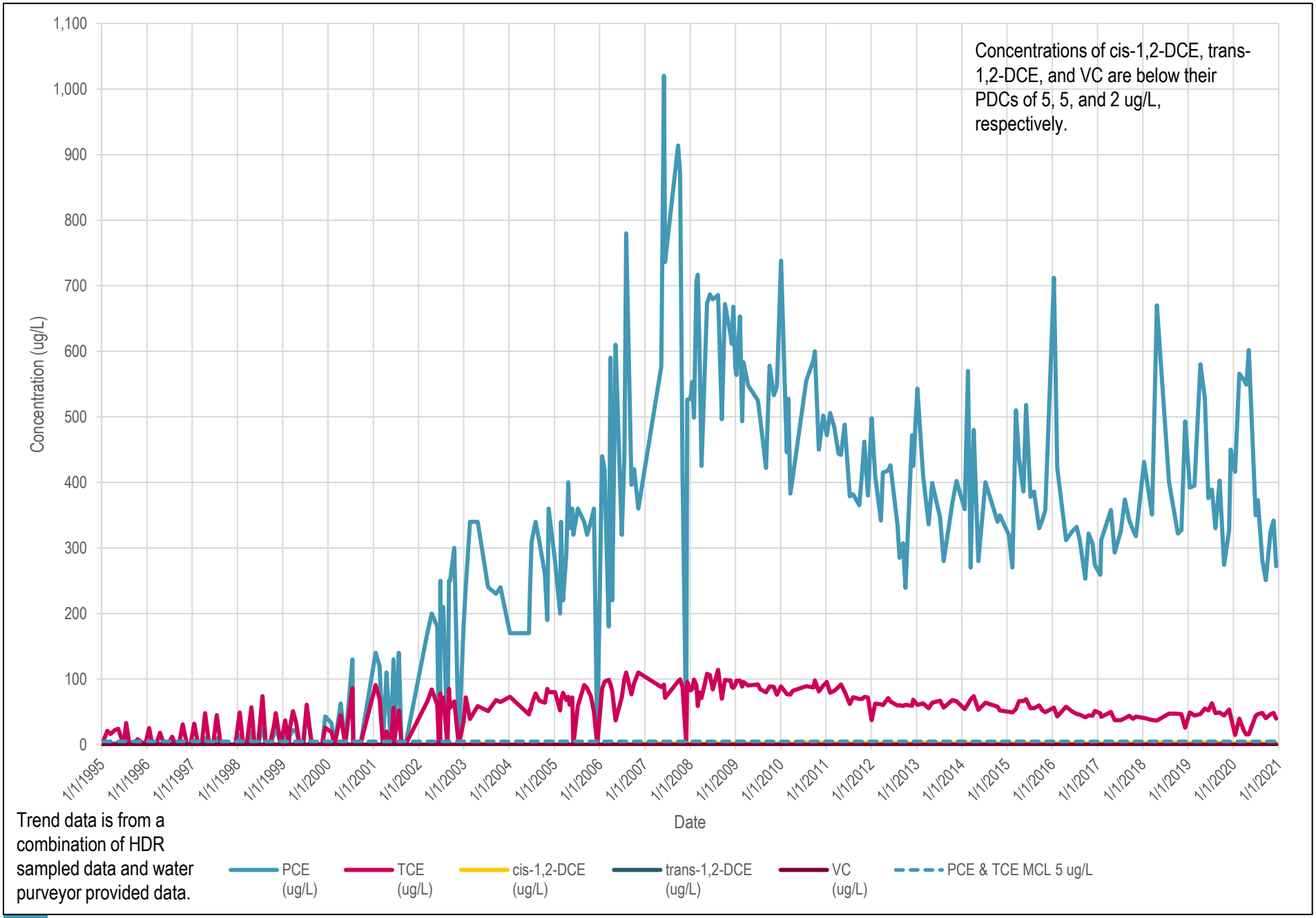
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-03881
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-3
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-07058 (Garden City Well 13)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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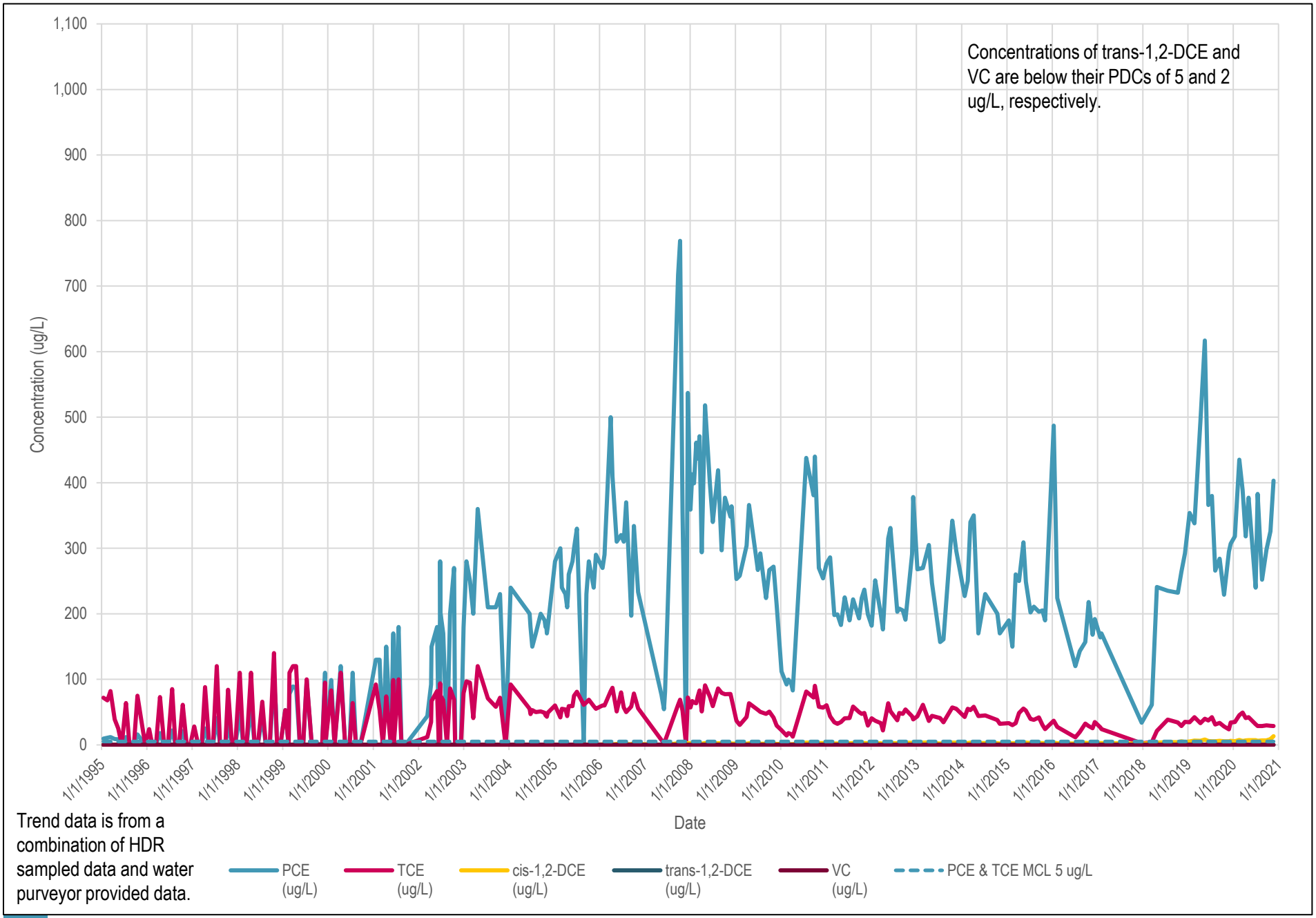
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-07058
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-4
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-08339 (Garden City Well 14)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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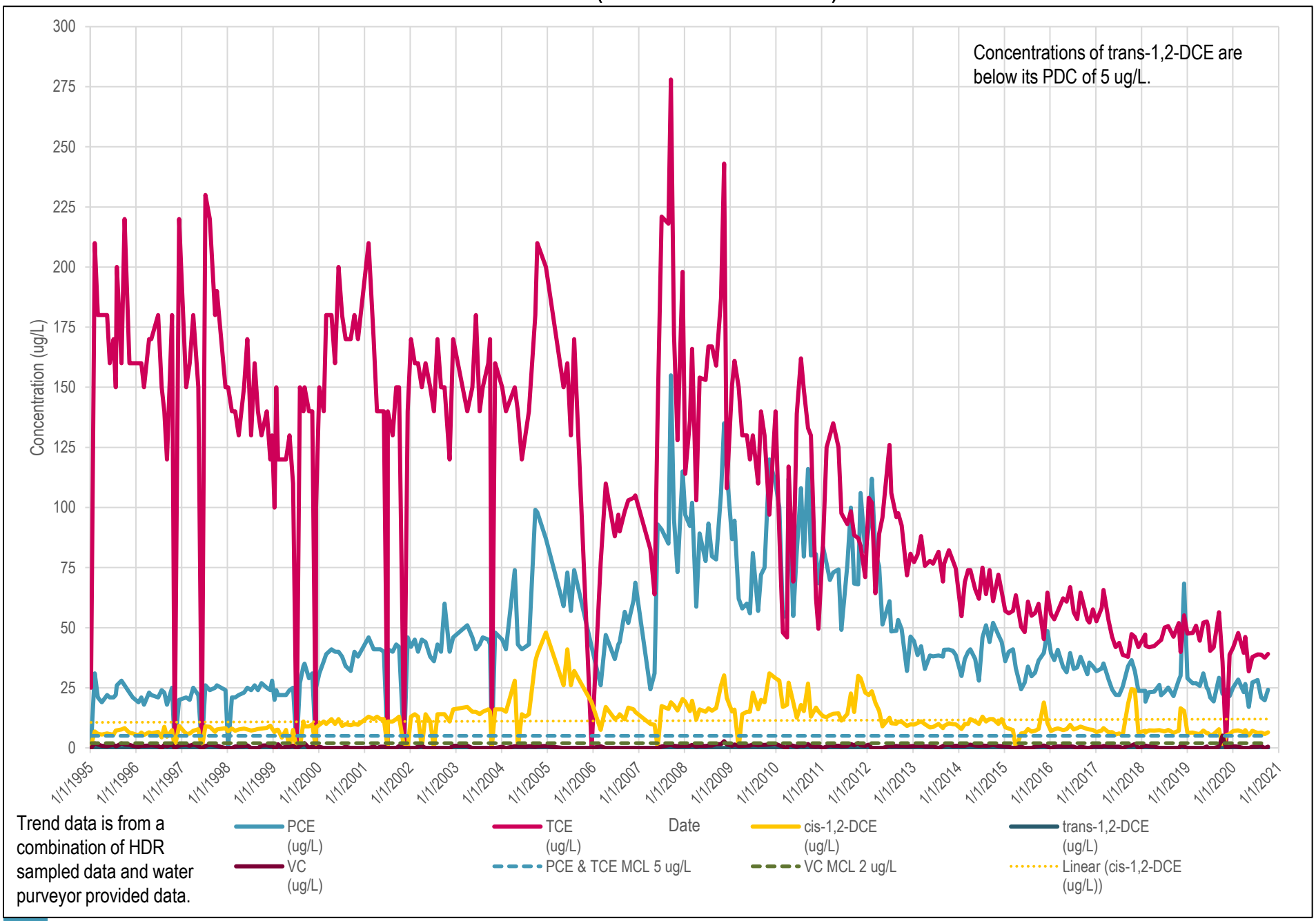
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-08339
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-5
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-07649 (WAWNC Well 57)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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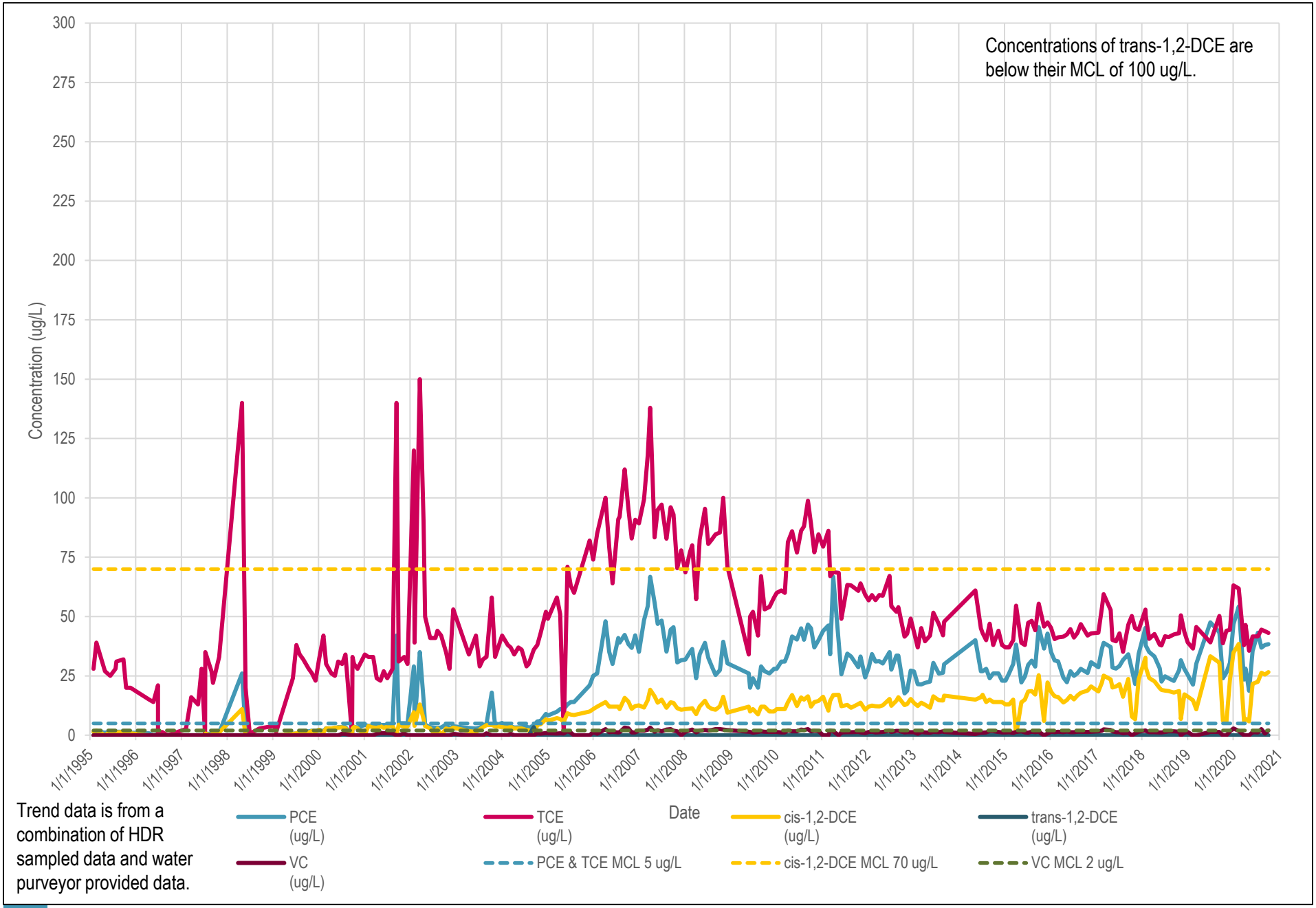
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-07649
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-6
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-07650 (WAWNC Well 57A)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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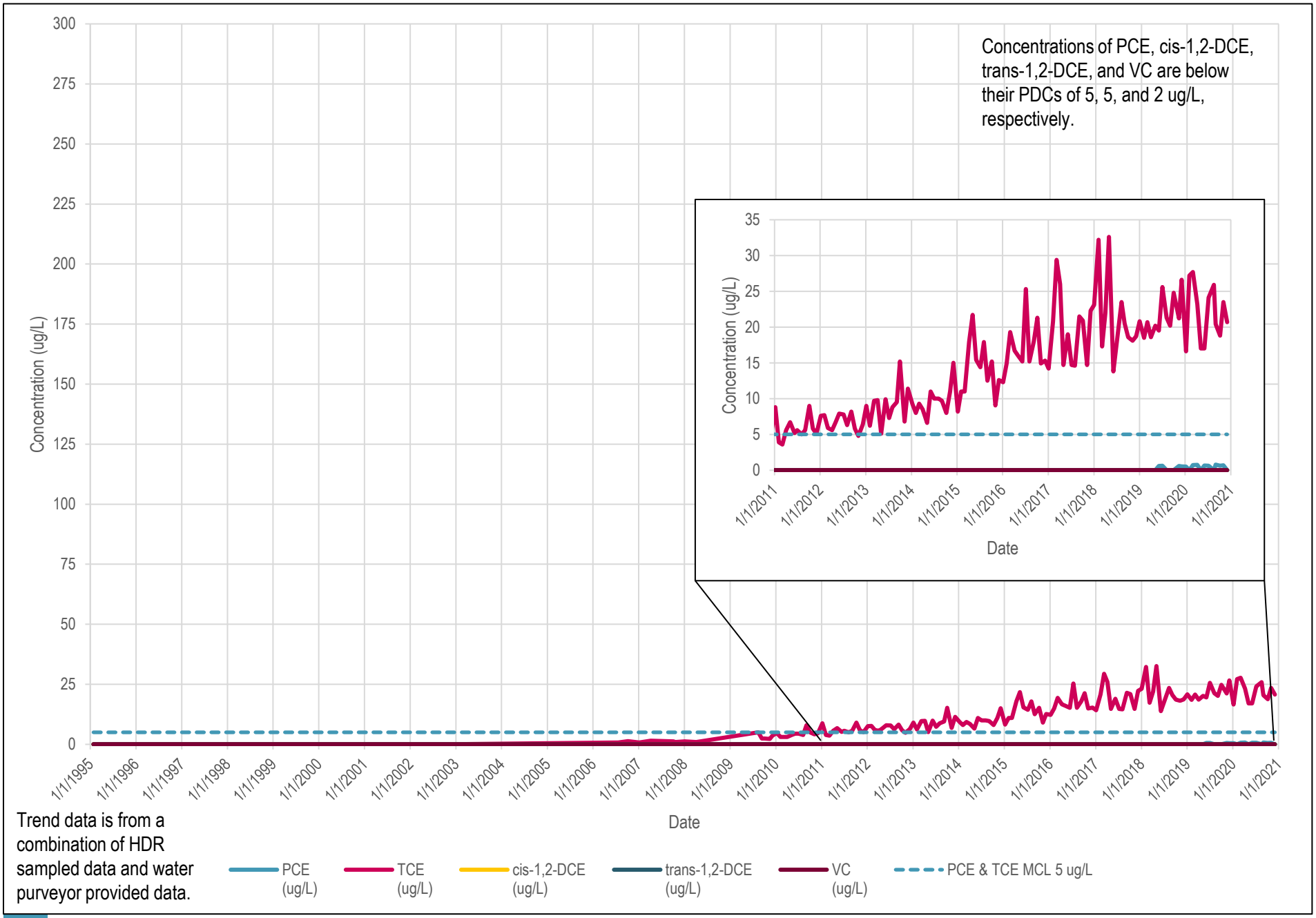
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-07650
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-7
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-03603 (Franklin Square Well 1)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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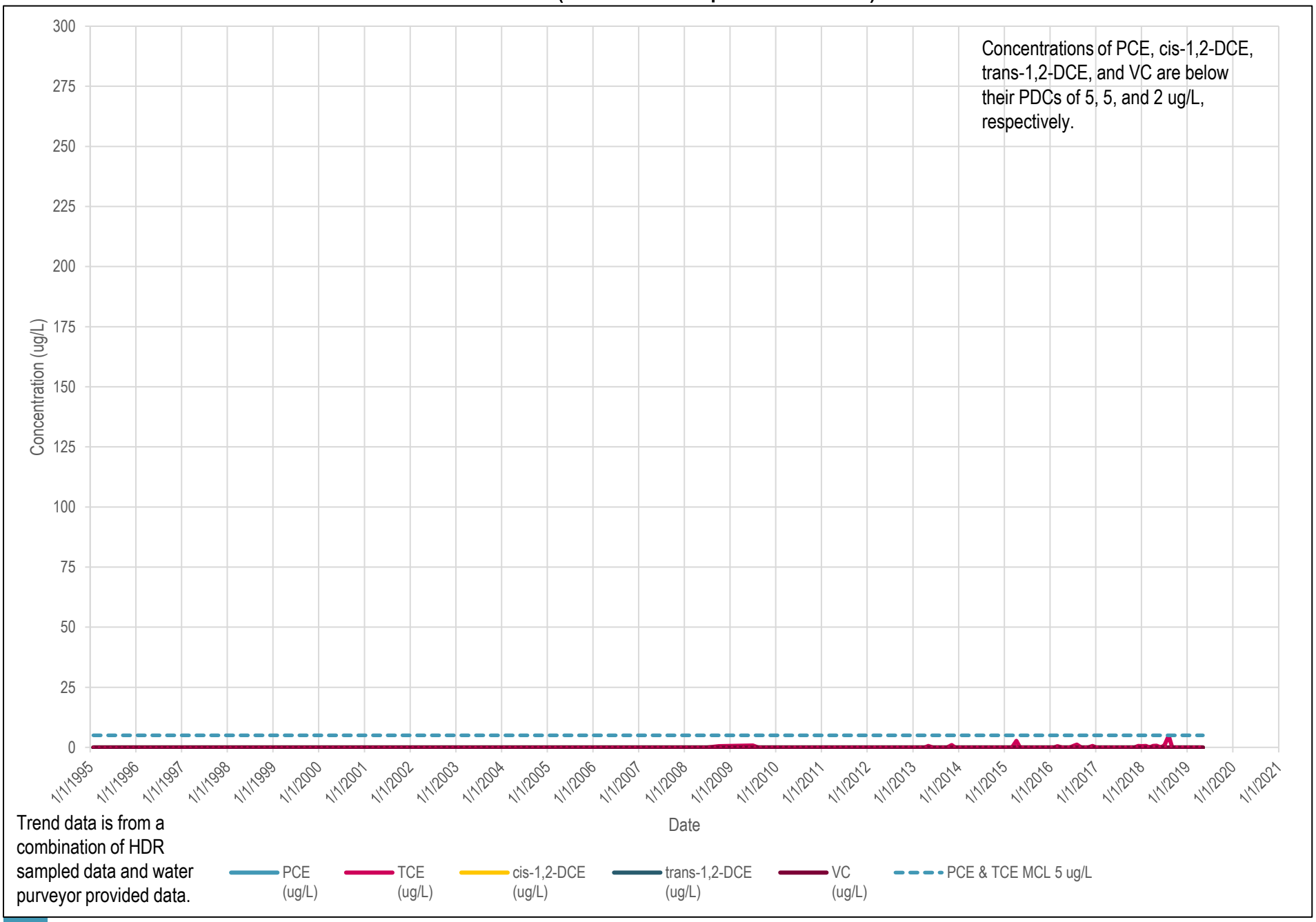
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-03603
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-8
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-03604 (Franklin Square Well 2)



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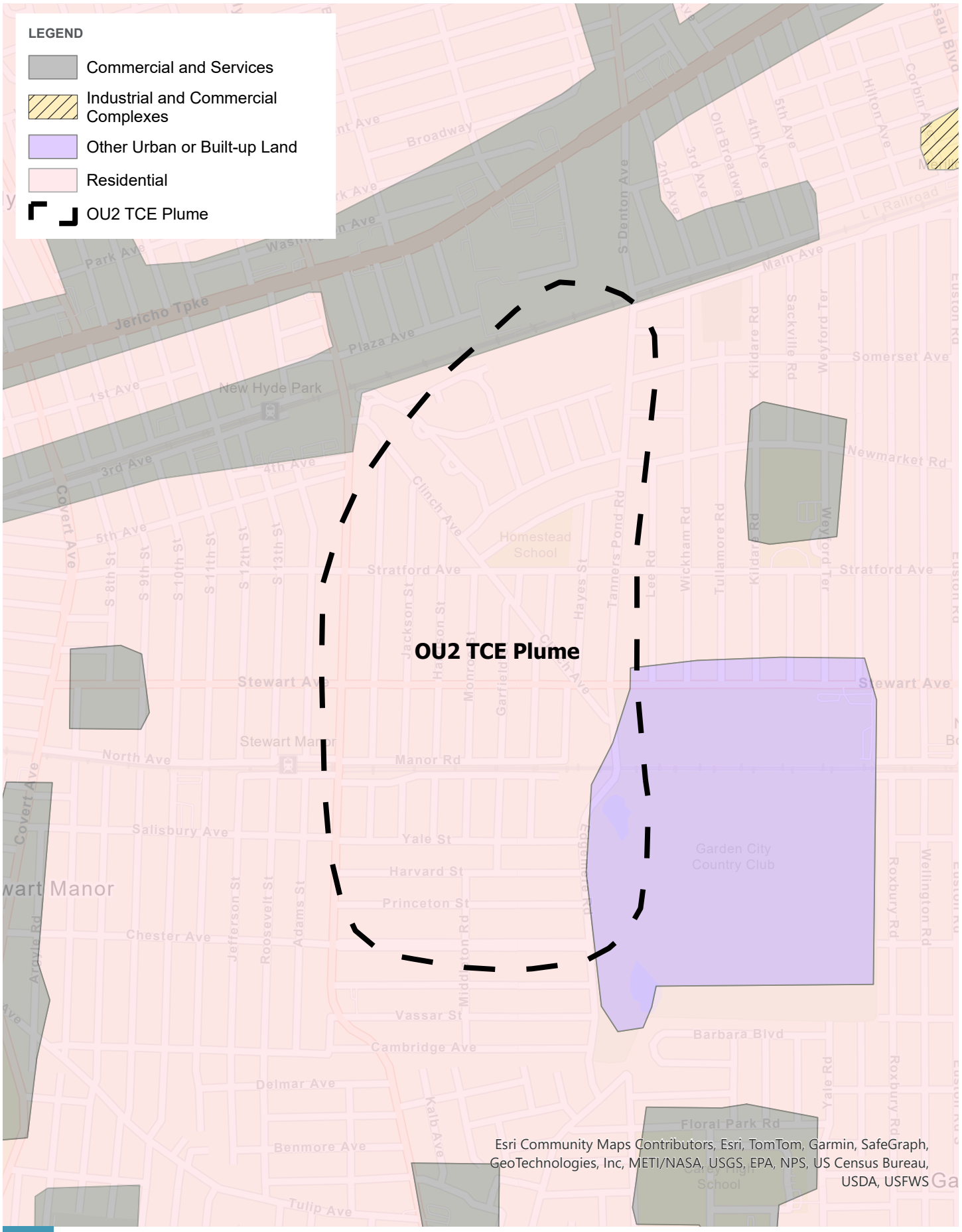
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-03604
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-9
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts



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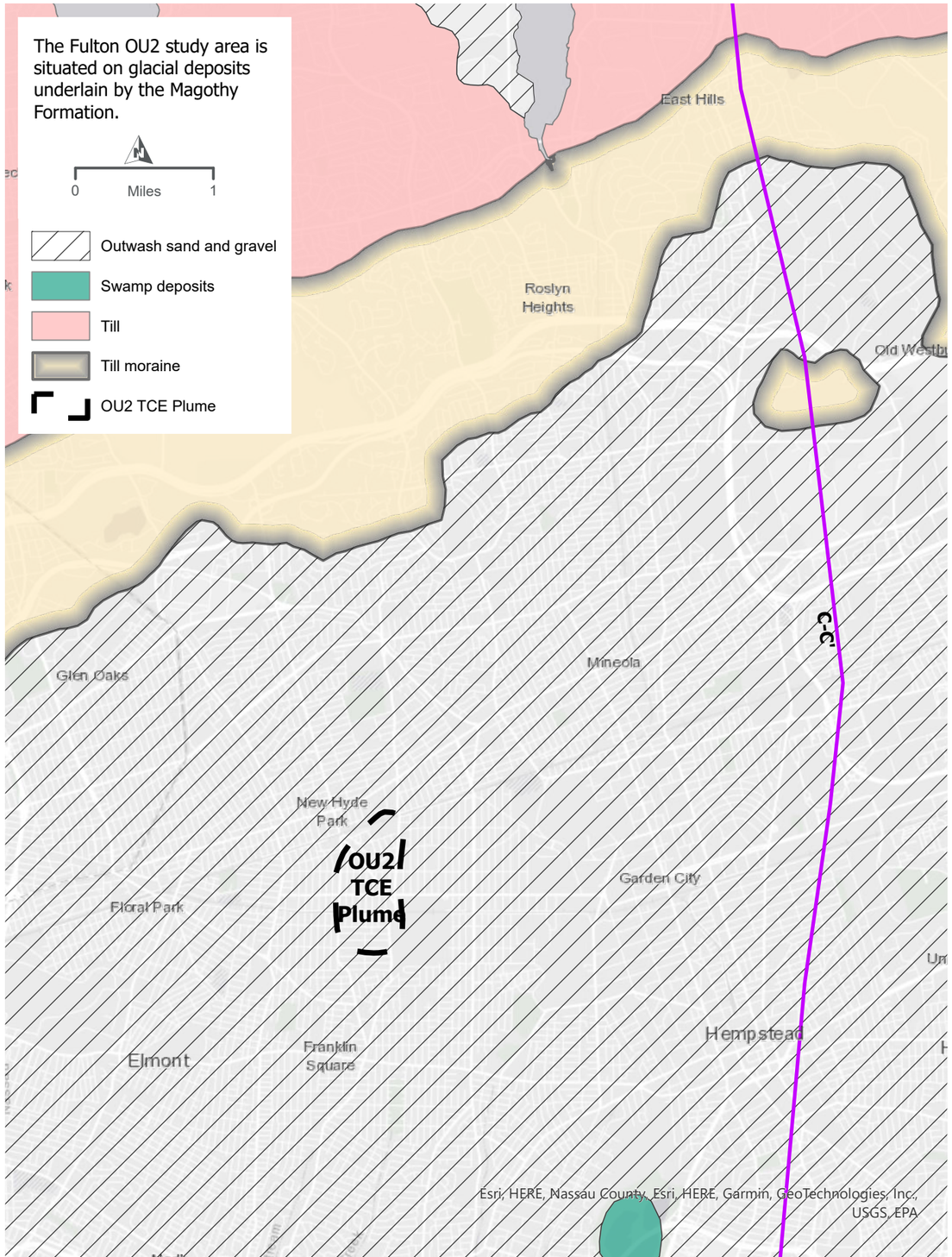
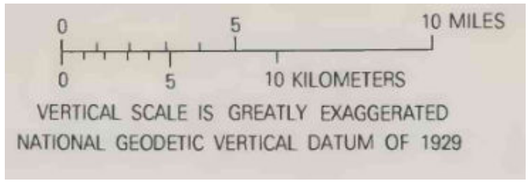
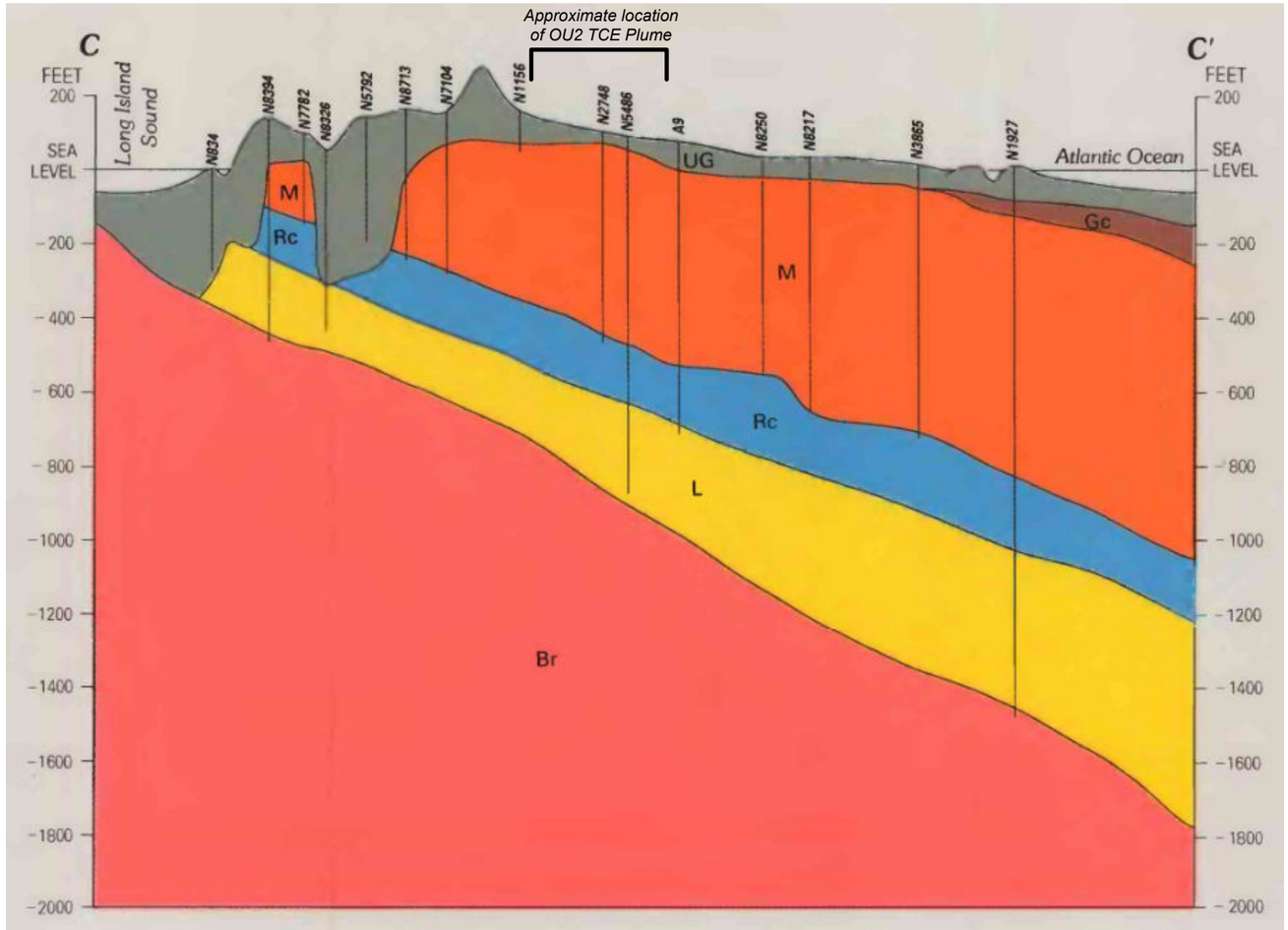
0 Feet 1,000

LAND USE AND LAND COVER
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-10





DATA SOURCE:
Hydrologic framework of Long Island, New York
Hydrologic Atlas 709
By: Douglas A. Smolensky, Herbert T. Buxton, and Peter K. Shernoff



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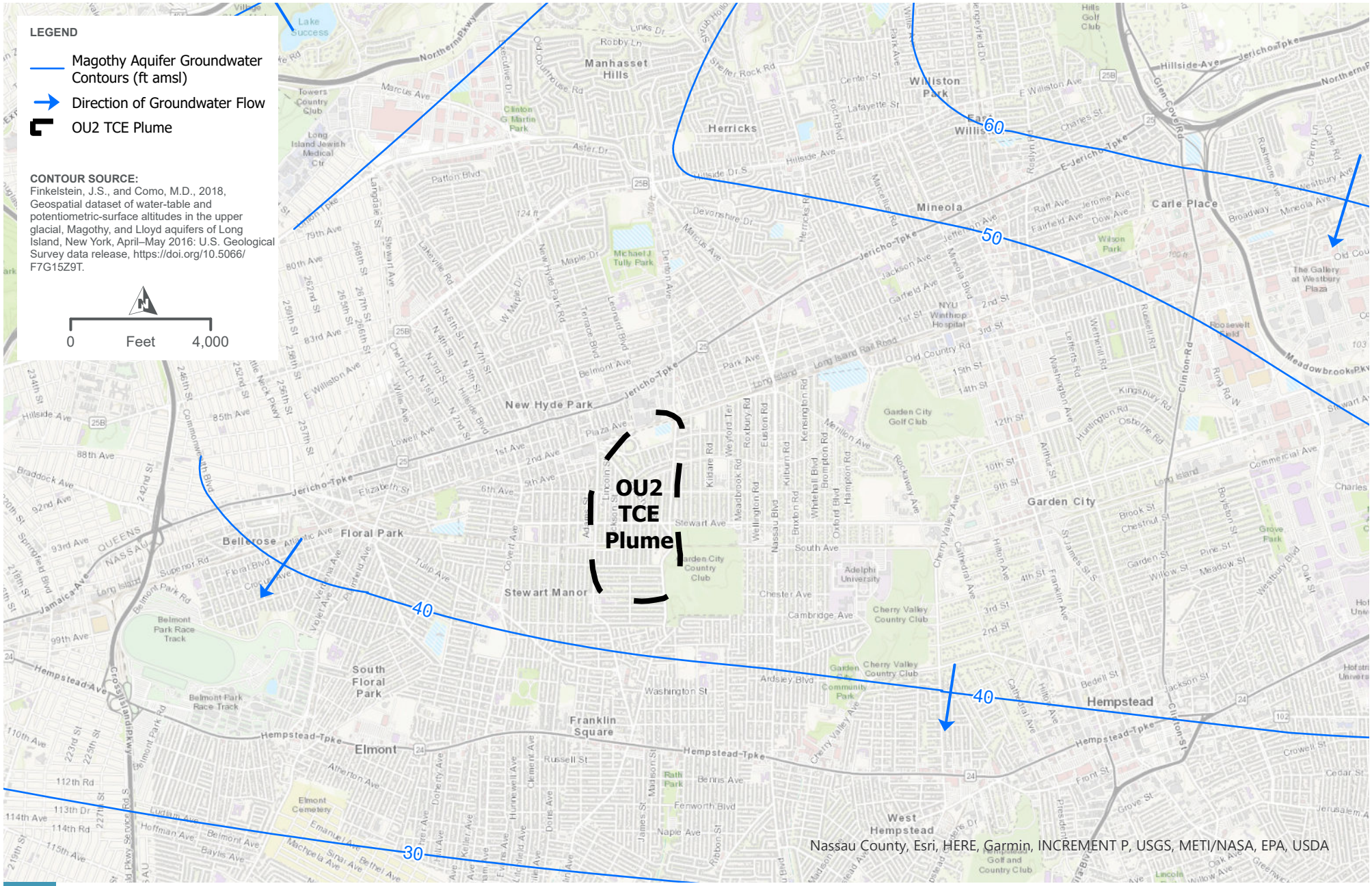
PLAN VIEW AND CROSS SECTION GEOLOGY
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-11



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REGIONAL POTENTIOMETRIC SURFACE OF MAGOTHY AQUIFER

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-12

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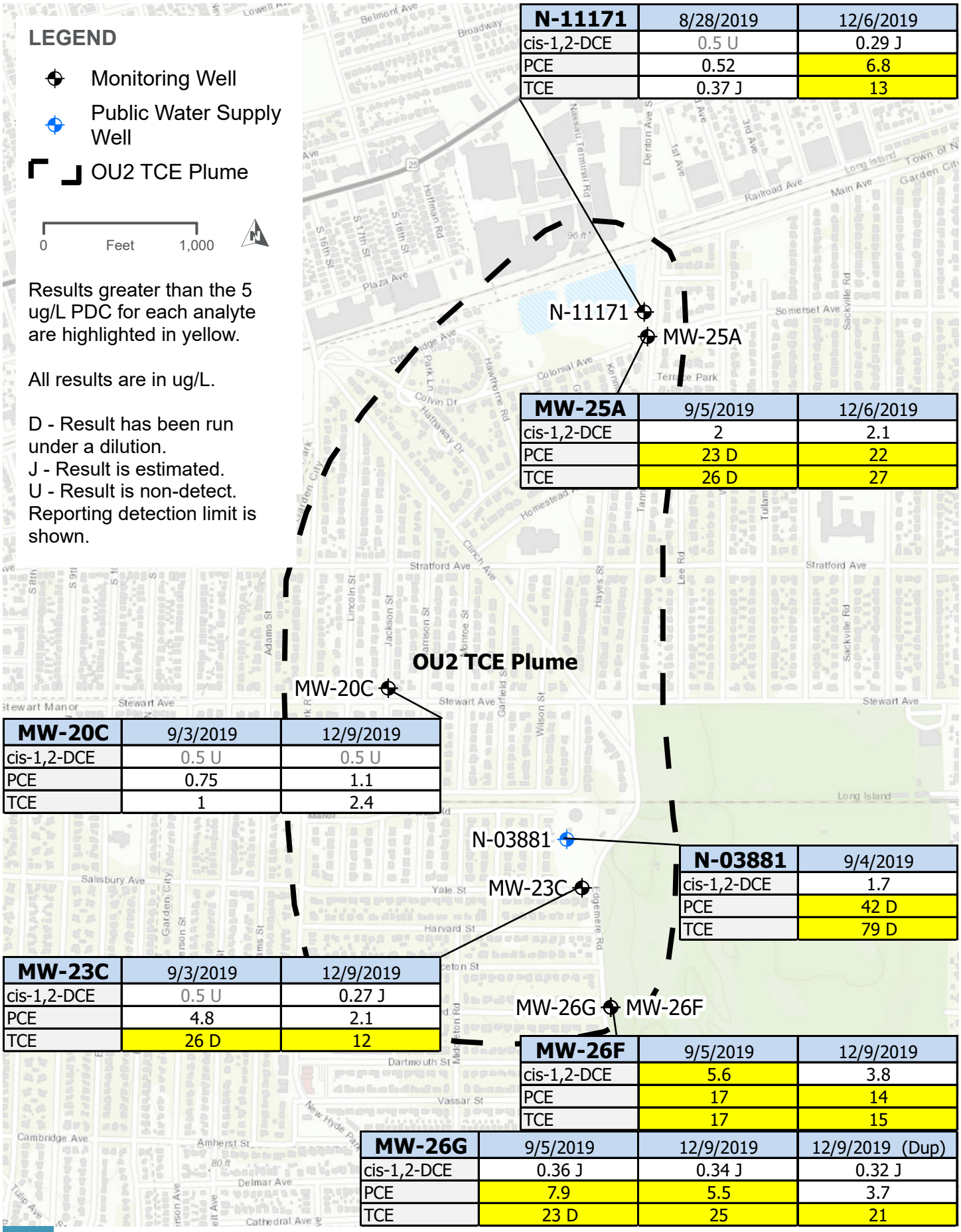
SURFACE WATER AND RECHARGE LOCATIONS

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-13



N-11171	8/28/2019	12/6/2019
cis-1,2-DCE	0.5 U	0.29 J
PCE	0.52	6.8
TCE	0.37 J	13

MW-25A	9/5/2019	12/6/2019
cis-1,2-DCE	2	2.1
PCE	23 D	22
TCE	26 D	27

MW-20C	9/3/2019	12/9/2019
cis-1,2-DCE	0.5 U	0.5 U
PCE	0.75	1.1
TCE	1	2.4

N-03881	9/4/2019
cis-1,2-DCE	1.7
PCE	42 D
TCE	79 D

MW-23C	9/3/2019	12/9/2019
cis-1,2-DCE	0.5 U	0.27 J
PCE	4.8	2.1
TCE	26 D	12

MW-26F	9/5/2019	12/9/2019
cis-1,2-DCE	5.6	3.8
PCE	17	14
TCE	17	15

MW-26G	9/5/2019	12/9/2019	12/9/2019 (Dup)
cis-1,2-DCE	0.36 J	0.34 J	0.32 J
PCE	7.9	5.5	3.7
TCE	23 D	25	21

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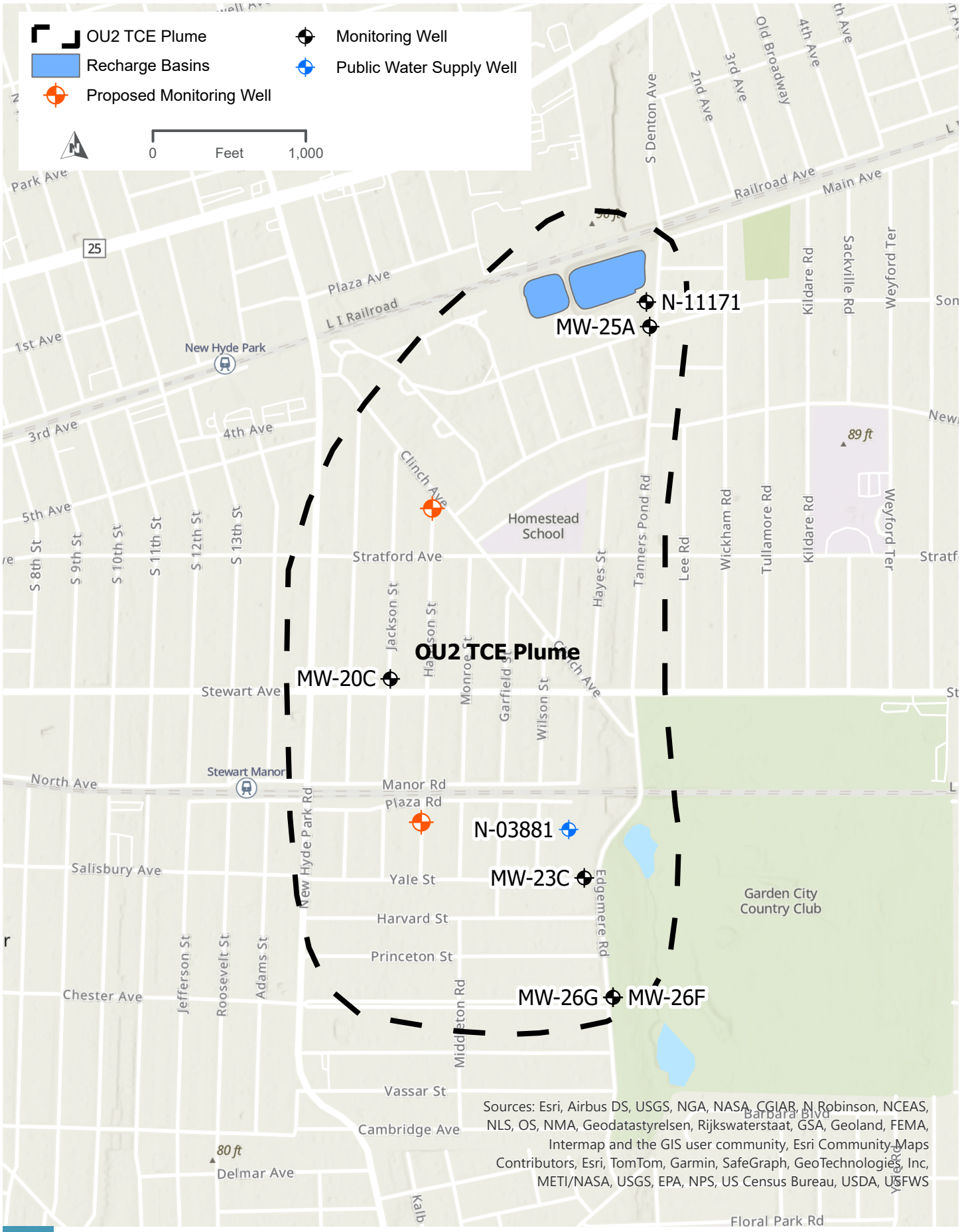
DISTRIBUTION OF VOCS EXCEEDING THE POTENTIAL DELINEATION CRITERIA IN GROUNDWATER SAMPLES

FULTON AVE SUPERFUND SITE OU2

FIGURE 3-1



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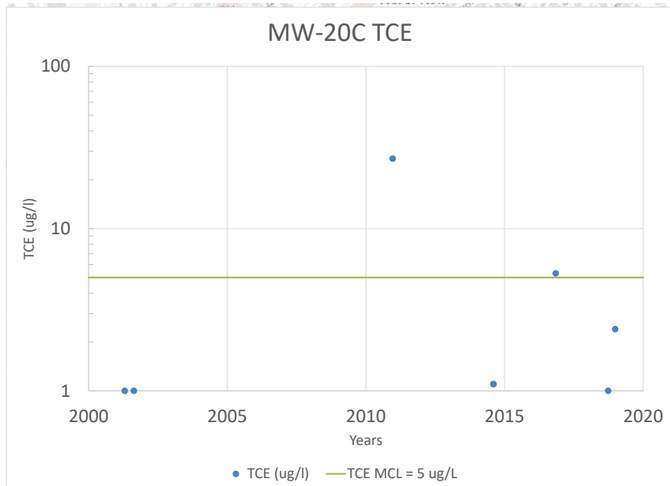
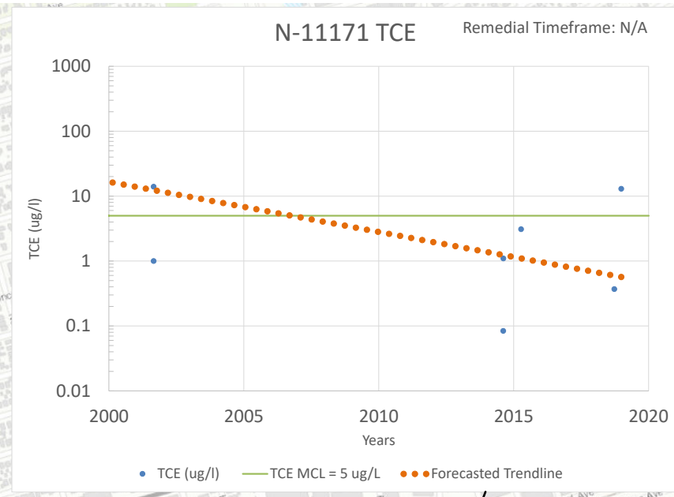
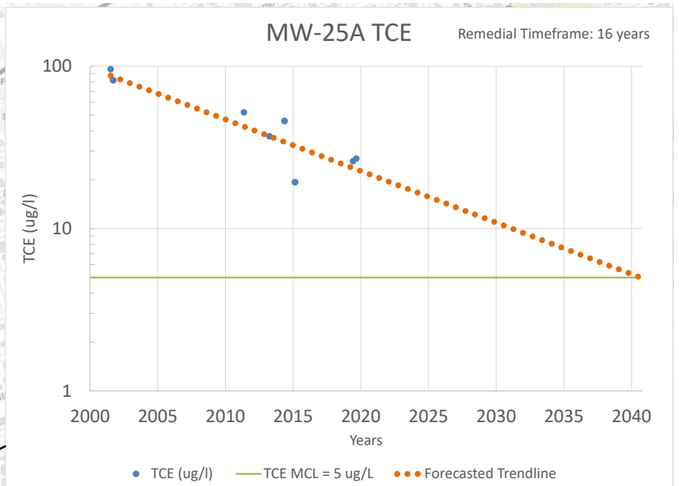
ALTERNATIVE 2 - ICS WITH LTM

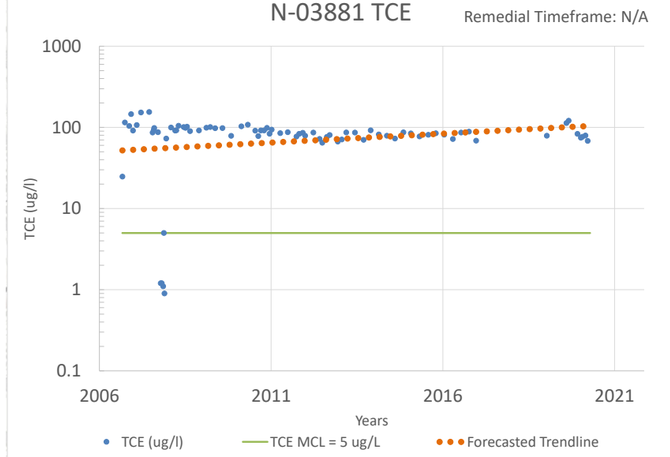
FULTON AVE SUPERFUND SITE OU2

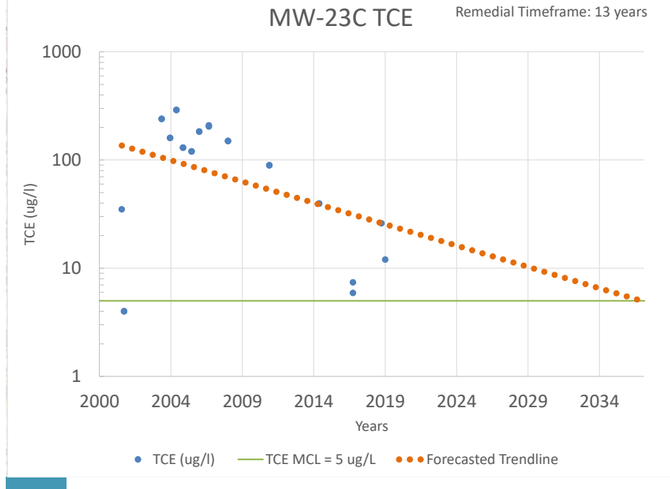
FIGURE 8-1

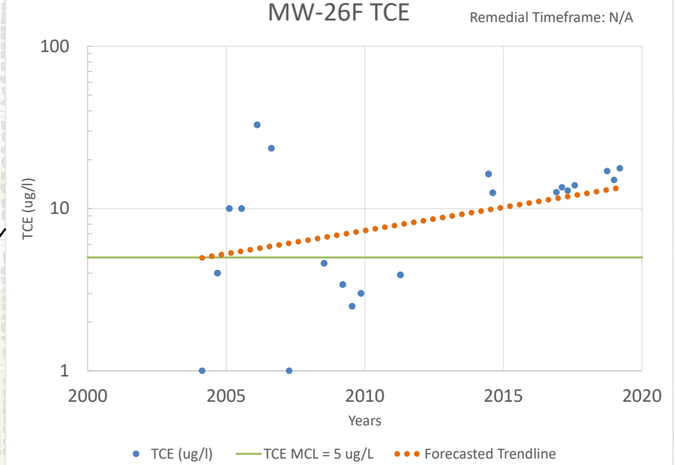


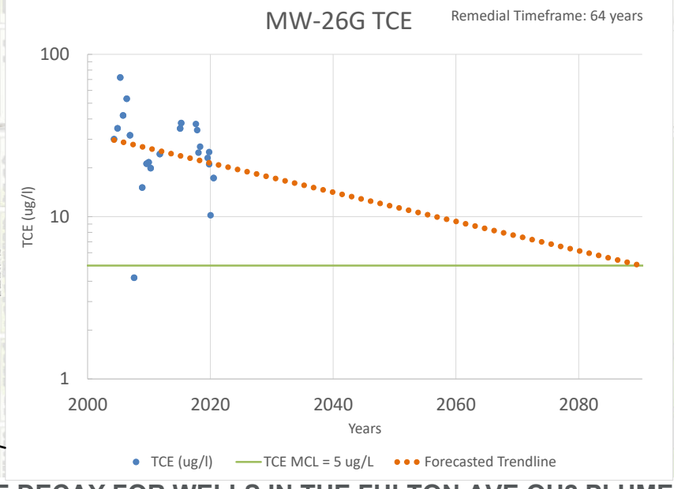








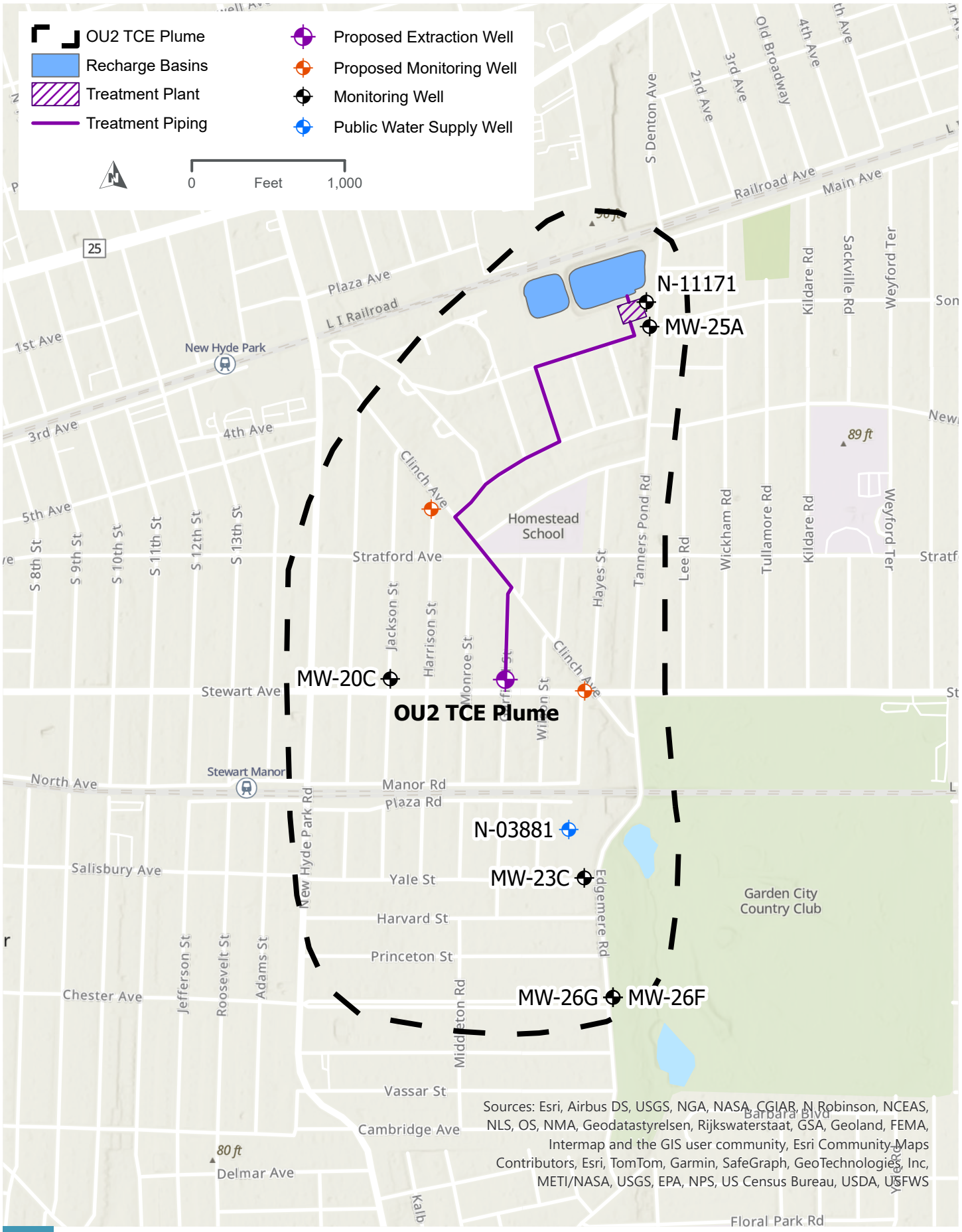




FIRST ORDER RATES OF TCE DECAY FOR WELLS IN THE FULTON AVE OU2 PLUME

FULTON AVE SUPERFUND SITE OU2

FIGURE 8-2



ALTERNATIVE 3 - CORE OF THE PLUME GROUNDWATER REMEDIATION: GROUNDWATER EXTRACTION, TREATMENT, GROUNDWATER DISCHARGE, ICS, AND LTM
FULTON AVE SUPERFUND SITE OU2

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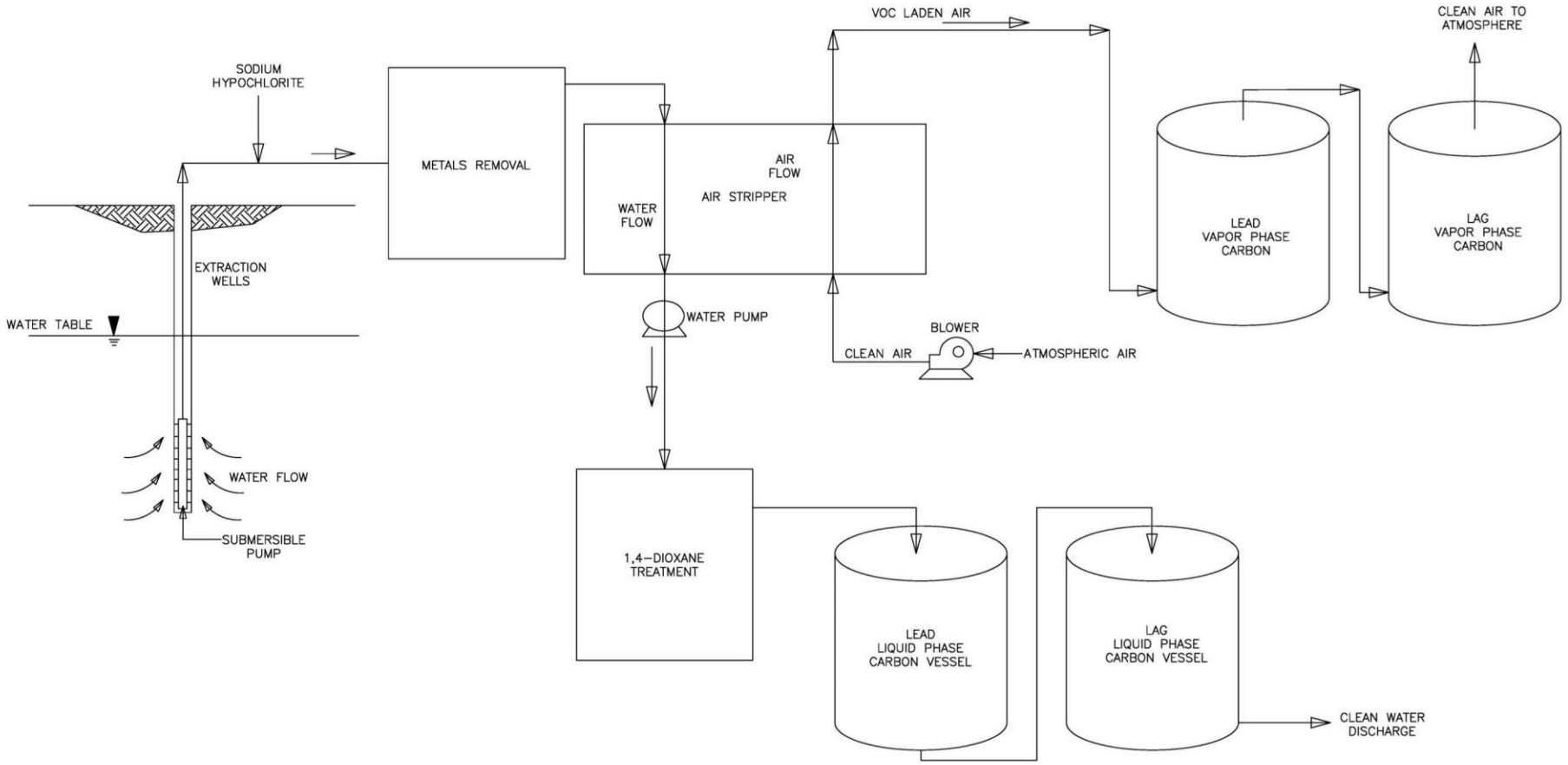
FIGURE 8-3



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TYPICAL GROUNDWATER TREATMENT SYSTEM PROCESS FLOW DIAGRAM
FULTON AVE SUPERFUND SITE OU2
FIGURE 8-4

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\10042584\4.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

Appendix A

Cost Estimate

Summary of Costs			2024
Site:	Fulton Avenue Superfund Site - Operable Unit 2	**Date:**	August 14, 2024
Location:	Nassau County, New York		
Phase:	Feasibility Study (-30% - +50%)		

Description	**Alternative 1**	**Alternative 2**	**Alternative 3**
	No Action	ICs with LTM	Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM
Estimated Project Duration with LTM for FS (Years)	-	30	30
Capital Cost	$ -	$ 816,000	$ 12,766,000
Total O&M Cost (NPV)	$ -	$ 1,952,000	$ 24,731,000
Total Periodic Cost (NPV)	$ -	$ 432,000	$ 1,127,000
Total Present Value of Options	**$ -**	**$ 3,200,000**	**$ 38,624,000**

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Table A-1 - Alternative 1 Cost Breakdown

No Action

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: No Action

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
1	**TOTAL CAPITAL COST**				**$ -**	

O&M COST:

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
2	**Long-Term Monitoring and Reporting**					
2.1	LTM	0	LS	$ -	$ -	
	Sub-Total				**$ -**	
	Project Management	5%			$ -	
	Contingency	10%			$ -	5% scope + 5% bid.
	Sub-Total				**$ -**	

PERIODIC COSTS:

Item No.	Description	Year	Quantity	Unit	Unit Cost	Total	Notes
3	**ICs**						
3.1	ICs	5	0	LS	$ -	$ -	
	Sub-Total					**$ -**	
	Project Management		5%			$ -	
	Contingency		10%			$ -	5% scope + 5% bid.
	Sub-Total					**$ -**	

PRESENT VALUE ANALYSIS: Discount Rate 3%

Item No.	Cost Type	Year	Total Cost	Present Value	Notes
1	**CAPITAL COSTS:**	0	$ -	**$ -**	
2	**OPERATIONAL AND MAINTENANCE COSTS:**				
2.1	Long-Term Monitoring and Reporting		$ -	$ -	Annual cost for the life of the system
	Sub-Total			**$ -**	**NPV Assuming 3% Discount Rate**
3	**PERIODIC COSTS:**				
3.1	ICs	5	$ -	$ -	Every 5 years
	Sub-Total			**$ -**	**NPV Assuming 3% Discount Rate**
	TOTAL PRESENT VALUE OF ALTERNATIVE			**$ -**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Table A-2 - Alternative 2 Cost Breakdown

ICs with LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 2 consists ICs and long-term monitoring. It includes a pre-design investigation to deterine the area for ICs and to install wells to include in the long-term monitoring program.

Item No.	Description	Quantity	Unit		Unit Cost		Total	Notes
	Number of ~500 ft deep monitoring wells (PDI/LTM)	2						
1. CAPITAL COSTS:								
1.1	**Pre-Design Investigation**							
1.1.1	Site Preparation	1	LS	$	142,500	$	142,500	Includes Work Plan and Site Clearing
1.1.2	Well Driller Mob/Demob	1	LS	$	75,000	$	75,000	
1.1.3	Monitoring Well Installation	2	EA	$	185,400	$	370,800	2.5-inch diameter; 500 ft deep.
1.1.4	Baseline Groundwater Sampling & Analyses (VOCs and Metals only)	1	EA	$	22,500	$	22,500	Includes 2 new and 7 existing wells
1.1.5	Pre-Construction Survey	1	LS	$	30,000	$	30,000	Aerial/Topographic Survey.
1.1.6	Data Reduction, Evaluation, and Reporting	1	LS	$	35,000	$	35,000	
	Sub-Total					**$**	**675,800**	
Sub-Total						**$**	**675,800**	Sub-Total All Construction Costs.
	Contingency	15%				$	101,000	10% scope + 5% bid.
Sub-Total						**$**	**776,800**	
Project Management		5%				$	39,000	
TOTAL CAPITAL COST						**$**	**816,000**	

2. OPERATIONAL AND MAINTENANCE COSTS:

Item No.	Description	Quantity	Unit		Unit Cost	Total	Notes
2.1	**Annual Site-Wide Long-Term Monitoring**						
2.1.1	Site Management Plan (Year 1)	1	EA		30,000	**$ 30,000**	SMP prepared prior to first sampling event.
2.1.2	Annual Site-Wide Long-Term Monitoring (Year 1-5)	4	EA	$	55,500	**$ 222,000**	Quarterly Sampling
2.1.3	Annual Site-Wide Long-Term Monitoring (Year 6-10)	2	EA	$	55,500	**$ 111,000**	Semi-Annual Sampling
2.1.4	Annual Site-Wide Long-Term Monitoring (Year 11-30)	1	EA	$	55,500	**$ 55,500**	Annual Sampling

3. PERIODIC COSTS:

3.1	**Once in Every 5 Years**						
3.1.1	Well Maintenance	9	EA	$	10,000	$90,000	
3.1.2	Institutional Controls	1	LS	$	25,000	$25,000	
	Sub-Total					**$ 115,000**	
Contingency		10%				$ 12,000	5% scope + 5% bid.
Sub-Total						**$ 127,000**	
Project Management		5%				$ 6,000	
TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30						**$ 133,000**	

PRESENT VALUE ANALYSIS: Rate of Return 7% Inflation Rate 3%

Item No.	Cost Type	Year	Total Cost	Present Value	Notes
1	**CAPITAL COSTS:**	0	$ 816,000	**$ 816,000**	
2	**OPERATIONAL &AND MAINTENANCE COSTS:**				
2.1	Site Management Plan		$ 30,000	$ 29,000	Initial SMP
2.2	Annual Site-Wide Long-Term Monitoring (Year 1-5)		$ 222,000	$ 992,000	Annual cost for year 1-5
2.3	Annual Site-Wide Long-Term Monitoring (Year 6-10)		$ 111,000	$ 410,000	Annual cost for year 6-10
2.4	Annual Site-Wide Long-Term Monitoring (Year 11-30)		$ 55,500	$ 521,000	Annual cost for year 11-30
	Sub-Total			**$ 1,952,000**	**Net Present Value**
3	**PERIODIC COSTS:**				
3.1	TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30		$ 133,000	$ 432,000	Once every 5 years
	Sub-Total			**$ 432,000**	**Net Present Value**
	TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 3,200,000**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Table A-3 - Alternative 3 Cost Breakdown

Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 3 consists of:
1. Installation of one groundwater extraction well in the highest concentration of the downgradient portions of the OU2 contaminated groundwater plume
2. Treatment plant with metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and AOP for 1,4-dioxane treatment
3. Discharge to groundwater via new recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.
4. ICs
5. LTM

Item No.	Description	Quantity	Unit		Unit Cost		Total	Notes
	Number of ~500 ft deep monitoring wells (PDI/LTM)	2						
	Number of ~450 ft deep extraction wells	1						
	Total Number of 500 GPM (0.72 MGD) Treatment Plants	**1**						
	Total Number of New Recharge Basins	**1**						
1. CAPITAL COSTS:								
1.1	**Pre-Design Investigation**							
1.1.1	Site Preparation	1	LS	$	142,500	$	142,500	Includes Work Plan and Site Clearing
1.1.2	Well Driller Mob/Demob	1	LS	$	75,000	$	75,000	
1.1.3	Monitoring Well Installation	2	EA	$	185,400	$	370,800	2.5-inch diameter; 500 ft deep.
1.1.4	Groundwater Sampling & Analyses (VOCs and Metals only)	1	EA	$	22,500	$	22,500	Includes 2 new and 7 existing wells
1.1.5	Pre-Construction Survey	1	LS	$	30,000	$	30,000	Aerial/Topographic Survey.
1.1.6	Pilot/Treatiability Test	1	LS	$	100,000	$	100,000	Air stripper, AOP and carbon evaluation.
1.1.7	Data Reduction, Evaluation, and Reporting	1	LS	$	75,000	$	75,000	Includes reducing data generating, isoconcentration maps, and producing report
	Sub-Total					**$**	**815,800**	
1.2	**Extraction Well - Site Preparation**							
1.2.1	Site Clearing	1	LS	$	10,000	$	10,000	
1.2.2	Property Acquisition	1	EA	$	1,300,000	$	1,300,000	For extraction well and booster pump station
1.2.3	Pre-Construction Submittals/Permits	1	LS	$	25,000	$	25,000	
1.2.4	Baseline Groundwater Sampling	1	EA	$	22,500	$	22,500	
	Sub-Total					**$**	**1,357,500**	
1.3	**Extraction Well - Installation**							
1.3.1	Mobilization (Well Installation)	1	LS	$	125,000		$125,000	
1.3.2	Extraction Well Installation (~ 450 feet bgs)	1	EA	$	591,400		$591,400	
1.3.3	Aquifer Pump Test	1	LS	$	350,000	$	350,000	72-hour pump test at extraction well. Nine locations set up with transducers. Water to frac tank for IDW handling (below). Includes reporting.
1.3.4	IDW	2,160,000	Gallons	$	0.20	$	432,000	Pumping tests. Assumes 500 gpm for 72 hours and discharge to sewer system through temporary treatment.
1.3.5	Extraction Well Electrical, Instrumentation and Permitting	1	EA	$	346,500		$346,500	
	Sub-Total					**$**	**1,844,900**	
1.4	**Treatment - ~500 GPM (0.72 MGD)**							
1.4.1	Land Acquisition for Treatment Plant	1	EA	$	-		$0	Property of Nassau County
1.4.2	~ 500 GPM (0.72 MGD) Plant Building Construction	1	EA	$	459,100		$459,100	
1.4.3	Site Work	1	EA	$	146,700		$146,700	
1.4.4	Electrical & Instrumentation	1	EA	$	1,025,000		$1,025,000	
1.4.5	Process Equipment	1	EA	$	2,126,900		$2,126,900	
1.4.6	Start-Up and Reporting	1	EA	$	321,000		$321,000	
	Sub-Total					**$**	**4,078,700**	
1.5	**Discharge - Existing Recharge Basin (up to 500 gpm)**							
1.5.1	Land Cost	0.8	Acre	$	-		$0	
1.5.2	Site Preparation	1	LS	$	50,000		$50,000	Mobilization, Soil E & D Control, Site Civil
1.5.3	Recharge Basin Rehabilitation	339,800	Cubic Ft	$	0.65		$220,870	
1.5.4	Miscellaneous Cost	1	LS	$	77,315		$77,315	
	Sub-Total					**$**	**348,185**	
1.6	**Conveyance System**							
1.6.1	Pipe Conveyance	1	LS	$	1,626,800		$1,626,800	
1.6.2	Pumps and Booster Stations	1	LS	$	500,000		$500,000	
	Sub-Total					**$**	**2,126,800**	
	Sub-Total					**$**	**10,571,885**	Sub-Total All Construction Costs.
	Contingency	15%				$	1,586,000	10% scope + 5% bid.
	Sub-Total					**$**	**12,157,885**	
	Project Management	5%				$	608,000	
	TOTAL CAPITAL COST					**$**	**12,766,000**	

Table A-3 - Alternative 3 Cost Breakdown

Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 3 consists of:
1. Installation of one groundwater extraction well in the highest concentration of the downgradient portions of the OU2 contaminated groundwater plume
2. Treatment plant with metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and AOP for 1,4-dioxane treatment
3. Discharge to groundwater via new recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.
4. ICs
5. LTM

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
2. OPERATIONAL AND MAINTENANCE COSTs:						
2.1	**Annual O & M (Extraction & Treatment)**					
2.1.1	Annual Power (Extraction)	1	EA	$ 70,000	$70,000	
2.1.2	Annual Power (Pump Stations)	1	EA	$ 70,000	$70,000	
2.1.3	Annual Operational Labor	1	EA	$ 136,700	$136,700	
2.1.4	Annual Power (Treatment)	1	EA	$ 343,800	$343,800	
2.1.5	Annual Material/Chemicals Usage	1	EA	$ 315,800	$315,800	
2.1.6	Annual System Maintenance	1	EA	$ 51,400	$51,400	
2.1.7	Treatment Plant Monitoring	1	EA	$ 116,600	$116,600	
	Sub-Total				**$ 1,104,300**	
2.2	**Recharge Basin Maintenance**					
2.2.1	Recharge Basin Maintenance (~500 GPM)	1	EA	$ 20,400	$20,400	
	Sub-Total				**$ 20,400**	
	Sub-Total				**$ 1,124,700**	Sub-Total Annual O & M Costs.
	Contingency	10%			$ 112,000	5% scope + 5% bid.
	Sub-Total				**$ 1,236,700**	
	Project Management	5%			$ 62,000	
	Total Annual O & M (Extraction and Treatment) (0-30)				**$ 1,298,700**	
2.3	**Annual Site-Wide Long-Term Monitoring**					
2.1.1	Site Management Plan (Year 1)	1	EA	30,000	**$ 30,000**	SMP prepared prior to first sampling event.
2.3.1	Annual Site-Wide Long-Term Monitoring (Year 1-5)	4	EA	$ 55,500	**$ 222,000**	
2.3.2	Annual Site-Wide Long-Term Monitoring (Year 6-10)	2	EA	$ 55,500	**$ 111,000**	
2.3.3	Annual Site-Wide Long-Term Monitoring (Year 11-30)	1	EA	$ 55,500	**$ 55,500**	
3. PERIODIC COSTS:						
3.1	**Once in Every 2 Years**					
3.1.1	Extraction Well Pump Rehabilitation	1	EA	$ 15,000	$15,000	stopped here
	Contingency	15%			$ 2,000	10% scope + 5% bid.
	Sub-Total				**$ 17,000**	
	Project Management	5%			$ 1,000	
	Technical Support	3%			$ 1,000	
	TOTAL PERIODIC COSTS @ EVERY 2 YEARS				**$ 19,000**	
3.2	**Once in Every 5 Years**					
3.2.1	Well Maintenance	1	EA	$ 80,000	$80,000	
3.2.2	Bag Filter Pump Replacement	1	EA	$ 25,000	$25,000	
3.2.3	Air Stripper Cleaning	1	EA	$ 24,400	$24,400	
3.2.4	Replace Interconnection Piping and Valves	1	LS	$ 15,000	$15,000	
3.2.5	Institutional Controls	1	LS	$ 25,000	$25,000	
	Sub-Total				**$ 169,400**	
	Contingency	10%			$ 17,000	5% scope + 5% bid.
	Sub-Total				**$ 186,400**	
	Project Management	5%			$ 9,000	
	TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30				**$ 195,400**	
3.3	**Once in Every 10 Years**					
3.3.1	Extraction Well Pump Replacement	10	1	EA	$ 85,000	$85,000
3.3.2	Pump Stations - Pump Replacement	10	1	LS	$ 100,000	$100,000
3.3.3	Recharge Basin Rehabilitation	10	1	LS	$ 8,000	$8,000
	Sub-Total					**$ 193,000**
	Contingency		10%			$ 19,000
	Sub-Total					**$ 212,000**
	Project Management		5%			$ 11,000
	TOTAL PERIODIC COSTS @ YEAR 10, 20 and 30					**$ 223,000**

Table A-3 - Alternative 3 Cost Breakdown

Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 3 consists of:
1. Installation of one groundwater extraction well in the highest concentration of the downgradient portions of the OU2 contaminated groundwater plume
2. Treatment plant with metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and AOP for 1,4-dioxane treatment
3. Discharge to groundwater via new recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.
4. ICs
5. LTM

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes

PRESENT VALUE ANALYSIS: Rate of Return 7% Inflation Rate 3%

Item No.	Cost Type	Year	Total Cost	Present Value	Notes
1	**CAPITAL COSTS:**	0	$ 12,766,000	**$ 12,766,000**	
2	**OPERATIONAL & MAINTENANCE COSTS:**				
2.1	Total Annual O & M (Extraction and Treatment) (0-30)		$ 1,298,700	$ 22,779,000	Annual cost for the life of the system
2.2	Site Management Plan (Year 1)		$ 30,000	$ 29,000	Initial SMP
2.3	Annual Site-Wide Long-Term Monitoring (Year 1-5)		$ 222,000	$ 992,000	Annual cost for year 1-5
2.4	Annual Site-Wide Long-Term Monitoring (Year 6-10)		$ 111,000	$ 410,000	Annual cost for year 6-10
2.5	Annual Site-Wide Long-Term Monitoring (Year 11-30)		$ 55,500	$ 521,000	Annual cost for year 11-30
	Sub-Total			**$ 24,731,000**	**Net Present Value**
3	**PERIODIC COSTS:**				
3.1	TOTAL PERIODIC COSTS @ EVERY 2 YEARS		$ 19,000	$ 164,000	Every 2 years
3.2	TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30		$ 195,400	$ 635,000	Every 5 years
3.3	TOTAL PERIODIC COSTS @ YEAR 10, 20 and 30		$ 223,000	$ 328,000	Every 10 years
	Sub-Total			**$ 1,127,000**	**Net Present Value**
	TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 38,624,000**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Appendix B

Natural Attenuation Evaluation

Memo

Date:	Friday, March 15, 2024
Project:	Fulton Avenue Superfund Site OU2 RI/FS
To:	USEPA
From:	HDR-APTIM JV
Subject:	Natural Attenuation Evaluation

This technical memorandum presents the results of a natural attenuation evaluation of trichloroethene (TCE) in the Operable Unit 2 (OU2) of the Fulton Avenue Superfund Site. Data from the Fulton Avenue OU2 Remedial Investigation (RI), previous New York State Department of Environmental Conservation (NYSDEC) investigations and Municipal/County water supply monitoring were used. The memorandum discusses the evaluation process, data analysis and conclusions on the occurrence and extent of TCE attenuation by natural processes at the site.

The evaluation employed several EPA guidance documents and tools related for evaluating natural attenuation at Superfund Sites, including: *Use of Monitored Natural Attenuation at Superfund, RCRA, Corrective Action, and Underground Storage Tank Sites* OSWER Directive Number 9200.4-17P (EPA, 1999), *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* EPA 600/R-98/128 (EPA, 1998) and other supporting literature. References are provided at the end of the memorandum.

Evaluation Process

As discussed in EPA 600/R-98/128, natural attenuation of TCE and other chlorinated solvents is affected by several destructive and nondestructive processes, including biodegradation, sorption, dispersion and volatilization. The document further indicates that biodegradation, volatilization and discharge to surface water are the key processes that impact natural attenuation of a plume under steady state conditions. Of these processes, biodegradation is the most important destructive mechanism and plays a key role in determining the degree of natural attenuation that occurs at a site and whether or not monitored natural attenuation (MNA) should be considered when evaluating remedial action for the site. EPA discusses a three-tiered approach to evaluate the potential efficacy of a MNA remedy in OSWER Directive 9200.4-17.P The three tiers, or "lines-of-evidence" are:

1. Historical groundwater chemistry data demonstrates a clear and meaningful trend of decreasing contaminant mass and/or concentration over time.
2. Hydrogeologic and geochemical data indirectly demonstrate the type of natural attenuation processes active and the rate at which processes will reduce contaminant concentrations to required levels.
3. Data from field or microcosm studies directly demonstrates the occurrence of a particular natural attenuation process and its ability to degrade the contaminants of concern. (EPA 1999, OSWER Directive 9200.4-17P)

The natural attenuation of TCE within the Fulton Avenue OU2 plume was evaluated based on available data, which included field measurement of physical/chemical parameters such as pH, dissolved oxygen and oxidation-reduction potential (ORP), and laboratory analysis for geochemical and groundwater chemistry parameters. Microcosm studies were not performed, either during the RI or in previous studies.

Trend analysis (see Line of Evidence #1 section below) was based on all available data, which included previous studies and monitoring of groundwater quality from 1953 through 2020, and RI monitoring from 2011 through 2020. Evaluation of data for evidence of known TCE breakdown products from both biotic and abiotic degradation mechanisms was based on data from the two most recent rounds of RI sampling (September 2019 and December 2019).

Screening to evaluate indirect evidence of anaerobic biodegradation, the dominant attenuation mechanism for chlorinated solvents, was based on the September and December 2019 RI results and methods presented in EPA 600/R-98/128. The screening process included review of available site data, numerical ranking of individual parameters that impact anerobic degradation and totaling the individual ranks to provide an overall value that indicates the likelihood of TCE degradation at core Fulton Avenue OU2 wells (see Line of Evidence #2 section below).

Line of Evidence #1: Decreasing Trend with Time

TCE Concentrations

TCE data were plotted against time to evaluate the first potential line of evidence; demonstration of a decreasing trend in contaminant concentrations. Tables, summarizing TCE results, and concentration versus time graphs are presented in **Attachment 1**. A summary of whether or not decreasing trends were observed is provided below.

Eight core wells, MW-20C, MW-23C, MW-24A, MW-25A, MW-26F, MW-26G, N-03881 and N-11171, were evaluated. The evaluation indicated the following:

- Decreasing trends were found at four wells; MW-23C, MW-25A, MW-26G and N-11171:
  - All of these wells are located on the eastern edge of OU2.
  - Concentrations at MW-23C ranged 290 ug/L to less than 10 ug/L. Concentrations were estimated to reach the remediation goal (RG) of 5 ug/L in 2027, based on current trends.
  - Concentrations at MW-25A showed a similar range and is estimated to meet the RG in 2031.
  - MW-26G concentrations also showed a similar range, but the estimated time to meet the RG in 2078 based on its current trend.
  - Well N-11171 concentrations ranged from 261 ug/L to less than 1 ug/L. The long term trend indicates that the RG has been met, however, data fluctuations resulted in the most recent result exceeding the RG.
- Increasing trends were found at four wells; MW-20C, MW-24A, MW-26F and N-03881:
  - Well MW-20C concentrations were generally below 10 ug/L and showed a slightly increasing trend.
  - Well MW-24A concentrations ranged from less than 1 ug/L to more than 100 ug/L and showed a more strongly increasing trend.

- Well MW-26F concentrations ranged from 1 ug/L to 32.8 ug/L and showed a similar increasing trend to MW-24A.
- Well N-03881 concentrations ranged from 155 ug/L to approximately 68 ug/L and shows a slow rate of increase.

Breakdown Products

Reductive dechlorination is the dominant process in the natural attenuation of CVOCs. During this process, the bioremediation of TCE and other chlorinated ethenes take place under anaerobic aquifer conditions. Microorganisms that produce hydrogen (H_2) as a natural byproduct of fermentation reactions, use the H_2 as an electron donor, and replace chlorine atoms in the oxidized CVOC. This process acts as a respiratory mechanism to derive metabolically useful energy (EPA, 2000; AFCEE, 2004). If groundwater contains enough organic electron donors and the appropriate strains of microorganisms (e.g. Dehalococcoides), this process can proceed until all the chlorine atoms are removed. TCE can be dechlorinated completely to 1,2-DCE, vinyl chloride and finally to ethene, a harmless end product. As discussed in the EPA CLU-IN website discussion of anerobic biodegradation, if appropriate strains of microorganisms are not present, degradation can stop and result in a buildup of DCE or vinyl chloride.

The process of reductive dechlorination has been shown to preferentially produce specific daughter compounds. For example, while all three DCE isomers (1,1-DCE and cis- and trans-1,2-DCE) can theoretically be produced, it has been found that the cis-1,2-DCE isomer is the most common. Cis-1,2-DCE, was detected in seven of the eight monitoring wells reviewed, at low to trace concentrations ranging from 0.27 µg/L to 5.6 µg/L. The highest concentration of 5.6 µg/L was detected at MW-26F.

The next intermediate along the dechlorination path is vinyl chloride. The anaerobic reductive dechlorination of the more highly chlorinated (more oxidized) chlorinated hydrocarbons, such as PCE and TCE, occurs more readily than the dechlorination of chlorinated hydrocarbons that already are somewhat reduced (less oxidized), such as DCE and VC. Reductive dichlorination of DCE and VC typically cannot occur without the presence of Dehalococcoides or other species. Vinyl chloride was not detected at any of the eight monitoring wells.

The presence of 1,2 DCE indicates that reductive dichlorination of TCE is taking place to some degree at the Fulton Avenue OU2 site. However, the absence of vinyl chloride indicates that the process is incomplete.

Abiotic degradation of TCE tends to favor dichloro-elimination reactions that form acetylene (EPA, 2009). Abiotic processes can also degrade chlorinated ethenes to glycolate, acetate, formate and carbon dioxide (Darlington et al., 2008). Acetylene and carbon dioxide, however, were not analyzed for in any sample collected during the OU2 RI.

Line of Evidence #2: Indirect Evidence of Attenuation Mechanisms

EPA developed a screening process to evaluate a site's potential for anaerobic biodegradation by ranking the field data using a point system (EPA, 1998; Table 2.3). For example, if a sample shows indication of a parameter that contributes to a reductive pathway (e.g., low dissolved oxygen concentrations), the parameter is assigned a point value (e.g., 3). If a sample shows indication of a parameter that may suppress the reductive pathway (e.g., outside pH range), the parameter is

assigned a lower or negative point value (e.g., -2). The point values are then summed for each sample and the total score is interpreted for potential anaerobic biodegradation based on ranges (EPA, 1998; Table 2.4):

- Score 0 to 5 = Inadequate evidence for anaerobic biodegradation of CVOCs;
- Score 6 to 14 = Limited evidence;
- Score 15 to 20 = Adequate evidence; and
- Score > 20 = Strong evidence.

This process was applied to the data collected during the Fulton Avenue RI to evaluate whether or not natural biodegradation is taking place. Results are presented on **Attachment 2.**

The evaluation process was conducted for the eight core wells within the Fulton Avenue OU2 study area. However, it was concluded that the low score of "inadequate evidence" at N-03881 was a result of data limitations (e.g. pH, DO, ORP) and may not accurately represent it's actual potential for anaerobic biodegradation. Evaluation of the remaining seven wells generally resulted in "inadequate evidence" to "limited evidence" of anaerobic biodegradation as shown in the following table. One sampling event for MW-26F scored in the adequate range indicating local conditions may be more favorable for biodegradation in that portion of the aquifer. However these conditions did not correlate with a long term decreasing trend in TCE concentrations.

Preliminary Screening Results for Anaerobic Degradation Processes at Fulton Avenue OU2

Well ID	Score		Interpretation		Long Term Trend
	September 2019	December 2019	September 2019	December 2019	
MW-20C	6	4	limited	inadequate	Decreasing
MW-23C	8	8	limited	limited	Increasing
MW-24A	8	8	limited	limited	Decreasing
MW-25A	6	5	limited	inadequate	Increasing
MW-26F	12	17	limited	adequate	Increasing
MW-26G	8	10	limited	limited	Decreasing
N-11171	9	9	limited	limited	Decreasing
N-03881	4	Not sampled	inadequate	-	Increasing

In addition to the data limitations for N-03881, data for a number of parameters were not available for all of the wells, including carbon dioxide, hydrogen and sulfide. The lack of these results may skew the point totals low by up to 4 points out of a total of 42 possible points, based on the point values for those scoring parameters. Those results would not have significantly changed the overall scoring. Point totals for the eight wells evaluated ranged from 4 to 17.

Comparison to the results of long term trend analysis indicate that there is no correlation between reducing trends and results of the anerobic degradation screening process.

Conclusions

An evaluation of the potential for the natural attenuation of TCE within the Fulton Avenue OU2 study area was performed in accordance with EPA guidance. The evaluation indicated the following:

- Trend analysis of concentration vs time data indicate that natural attenuation of TCE is variable throughout Fulton Avenue OU2, and that where it is occurring, it may take up to another 54 years to meet RG s based on the current trend.
- cis-1,2-DCE was the only TCE breakdown product detected in Fulton Avenue OU2. The presence of DCE indicates that some level of biological degradation is occurring.
- Vinyl chloride was not detected in Fulton Avenue OU2, indicating that any natural biodegradation of TCE may be occurring does not proceed beyond cis-1,2-DCE.
- Some abiotic degradation of TCE may be occurring, however, based on the ferrous iron concentrations it is most likely to a limited degree.
- Although reducing conditions do appear to be present in portions of the aquifer, the overall result of screening indicates that there is only limited evidence of the natural attenuation of TCE in Fulton Avenue OU2.

In general, while some natural attenuation is likely happening in Fulton Avenue OU2, there is not enough evidence to indicate that the processes are proceeding to completion and that it is happening consistently throughout the study area. A standalone MNA remedy would likely not fully achieve a remedial action objective of meeting MCLs or NYSDEC ambient water quality criteria in a reasonable amount of time.

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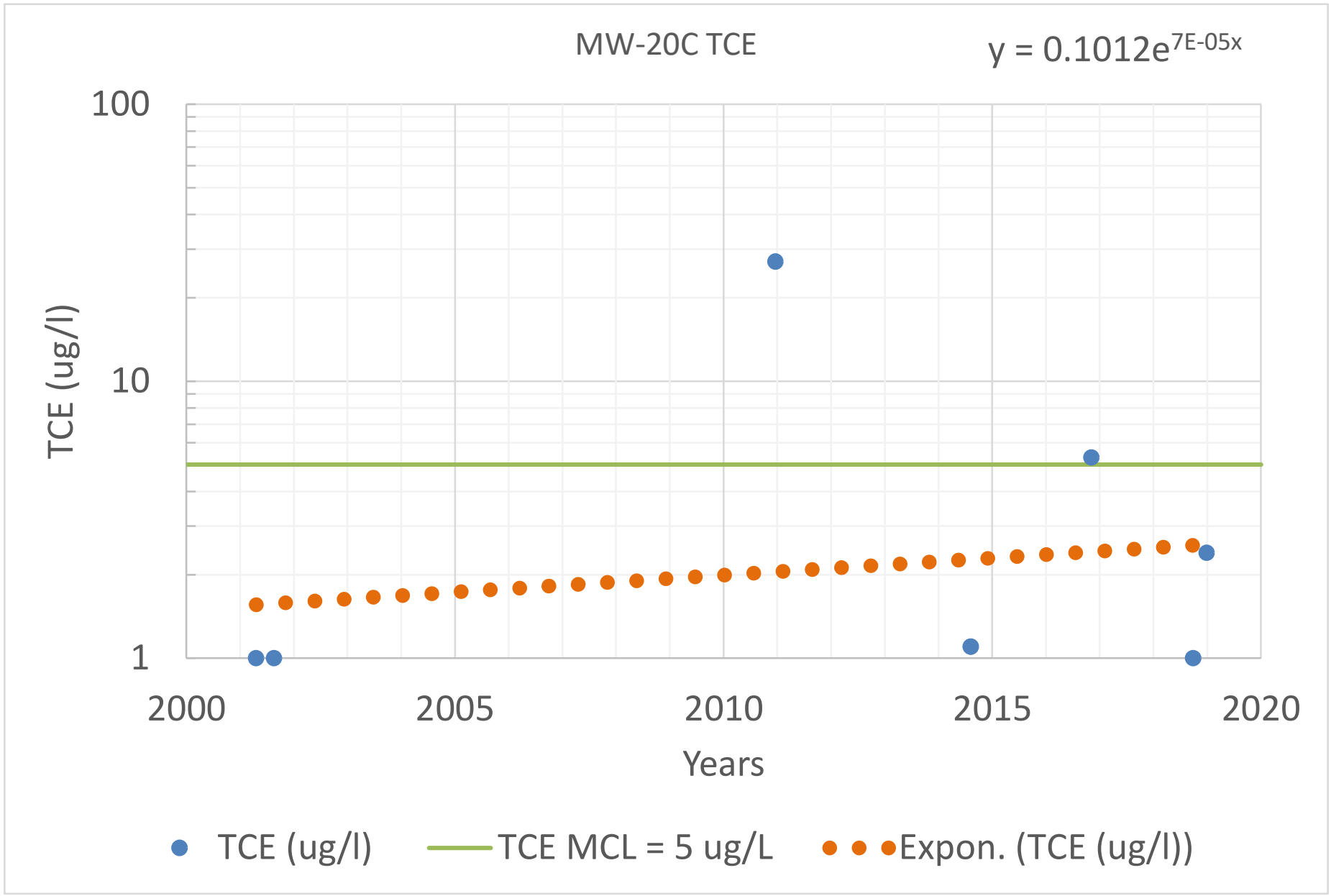
Attachment 1

TCE Historical Data and Trend Charts

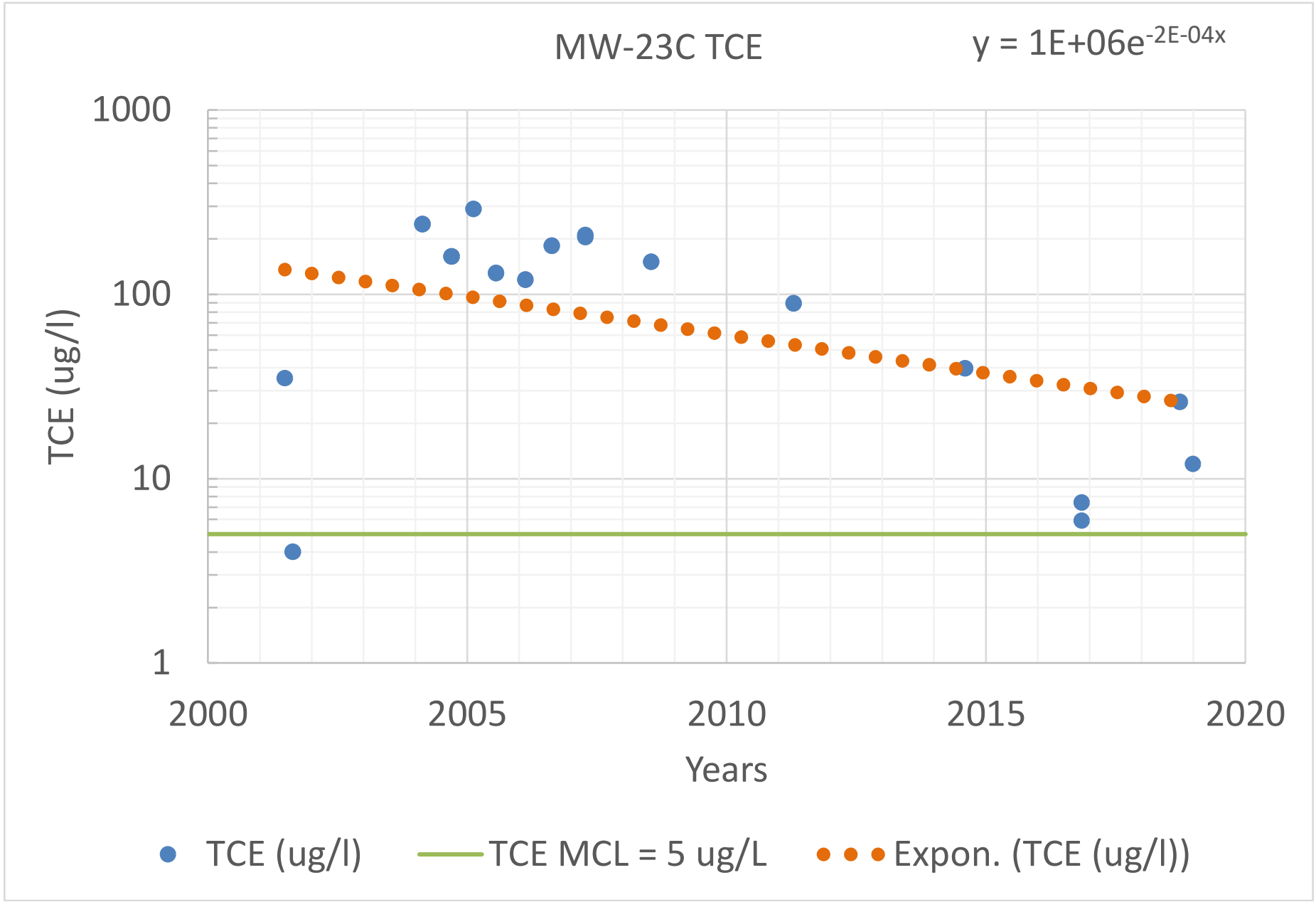
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1a
MW-20C TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-20C	MW20C_400-410_20010514	5/14/2001	1	
MW-20C	MW20C_400-410_20010918	9/18/2001	1	
MW-20C	MW20C_405_20010918	9/18/2001		U
MW-20C	FUL_WG_MW-20C_300-300_N_20110707	7/7/2011	27	
MW-20C	MW20C_405_20150430	4/30/2015	1.1	
MW-20C	ACTDJB93700201505151449004	4/30/2015	1.1	
MW-20C	ACTDJC50336201806072040005	9/7/2017	5.3	
MW-20C	MW-20C-GW-405-20190903-0	9/3/2019	1	
MW-20C	MW-20C-GW-405-20191209-0	12/9/2019	2.4	


MW-20C TCE
y = 0.1012e7E-05x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

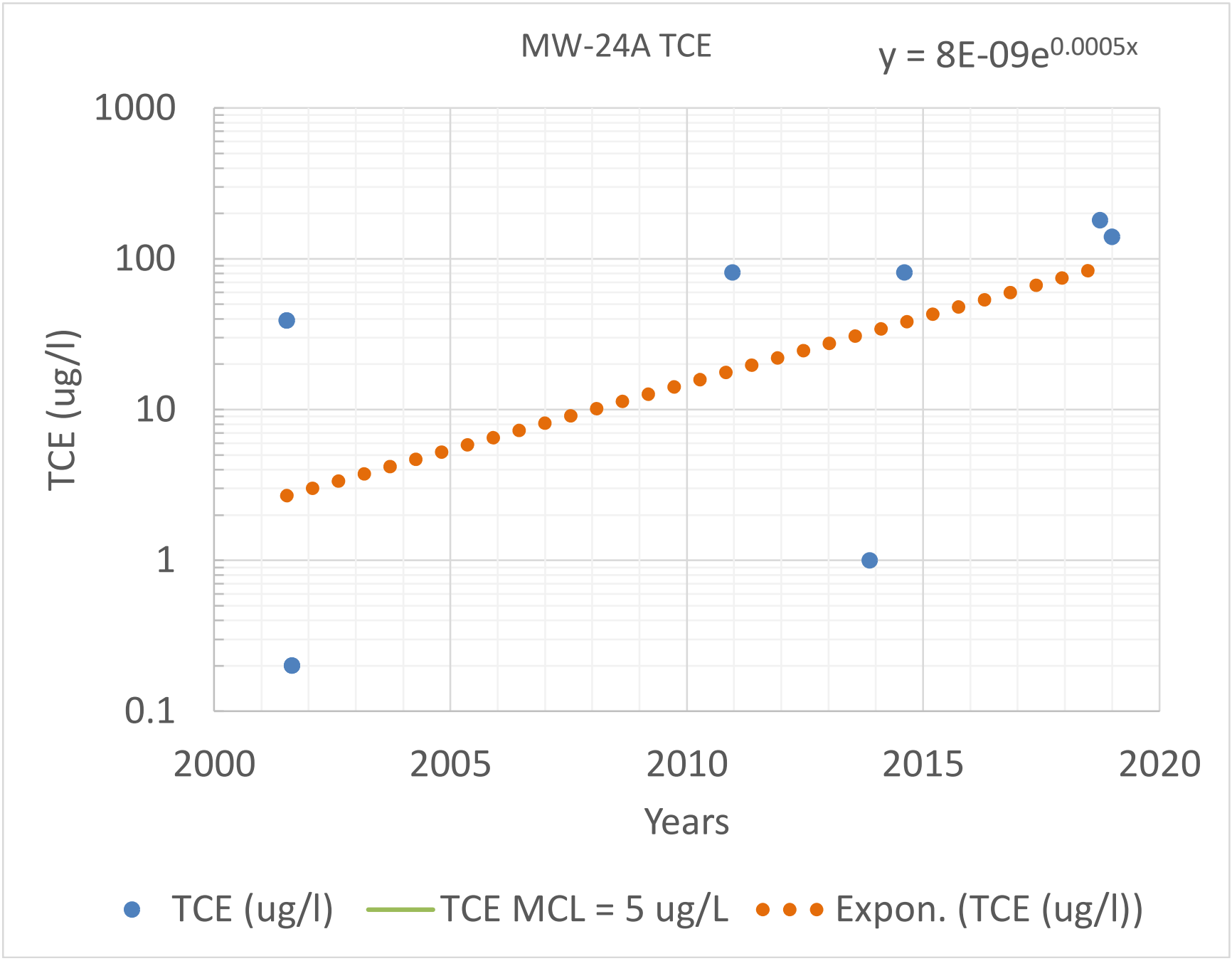
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1b
MW-23C TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-23C	MW23C_398-408_20010723	7/23/2001	35	
MW-23C	MW23C_398-408_20010920	9/20/2001	4	
MW-23C	MW23C_403_20010920	9/20/2001	4	
MW-23C	MW23C_398-408_20040505	5/5/2004	240	
MW-23C	MW23C_403_20040505	5/5/2004	240	
MW-23C	MW23C_20041206	12/6/2004	160	
MW-23C	MW23C_398-408_20041206	12/6/2004	160	
MW-23C	MW23C_20050518	5/18/2005	290	
MW-23C	MW23C_398-408_20050518	5/18/2005	290	
MW-23C	MW23C_20051031	10/31/2005	130	
MW-23C	MW23C_398-408_20051031	10/31/2005	130	
MW-23C	MW23C_20060606	6/6/2006	120	
MW-23C	MW23C_398-408_20060606	6/6/2006	120	
MW-23C	MW23C_20061219	12/19/2006	183	
MW-23C	MW23C_398-408_20061219	12/19/2006	183	
MW-23C	MW23C_20070822	8/22/2007	204	
MW-23C	MW23C_398-408_20070822	8/22/2007	209	
MW-23C	MW23C_20081222	12/22/2008	150	
MW-23C	MW23C_398-408_20081222	12/22/2008	150	
MW-23C	MW23C_20111110	11/10/2011	89.3	
MW-23C	MW23C_398-408_20111110	11/10/2011	89.3	
MW-23C	MW23C_403_20150430	4/30/2015	39.6	
MW-23C	ACTDJB93700201505151449006	4/30/2015	39.6	
MW-23C	ACTDJC50488201806072052001	9/8/2017	7.4	
MW-23C	ACTDJC50488201806072052007	9/8/2017	5.9	
MW-23C	MW-23C-GW-403-20190903-0	9/3/2019	26	D
MW-23C	MW-23C-GW-403-20191209-0	12/9/2019	12	


MW-23C TCE
y = 1E+06e-2E-04x
1000
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

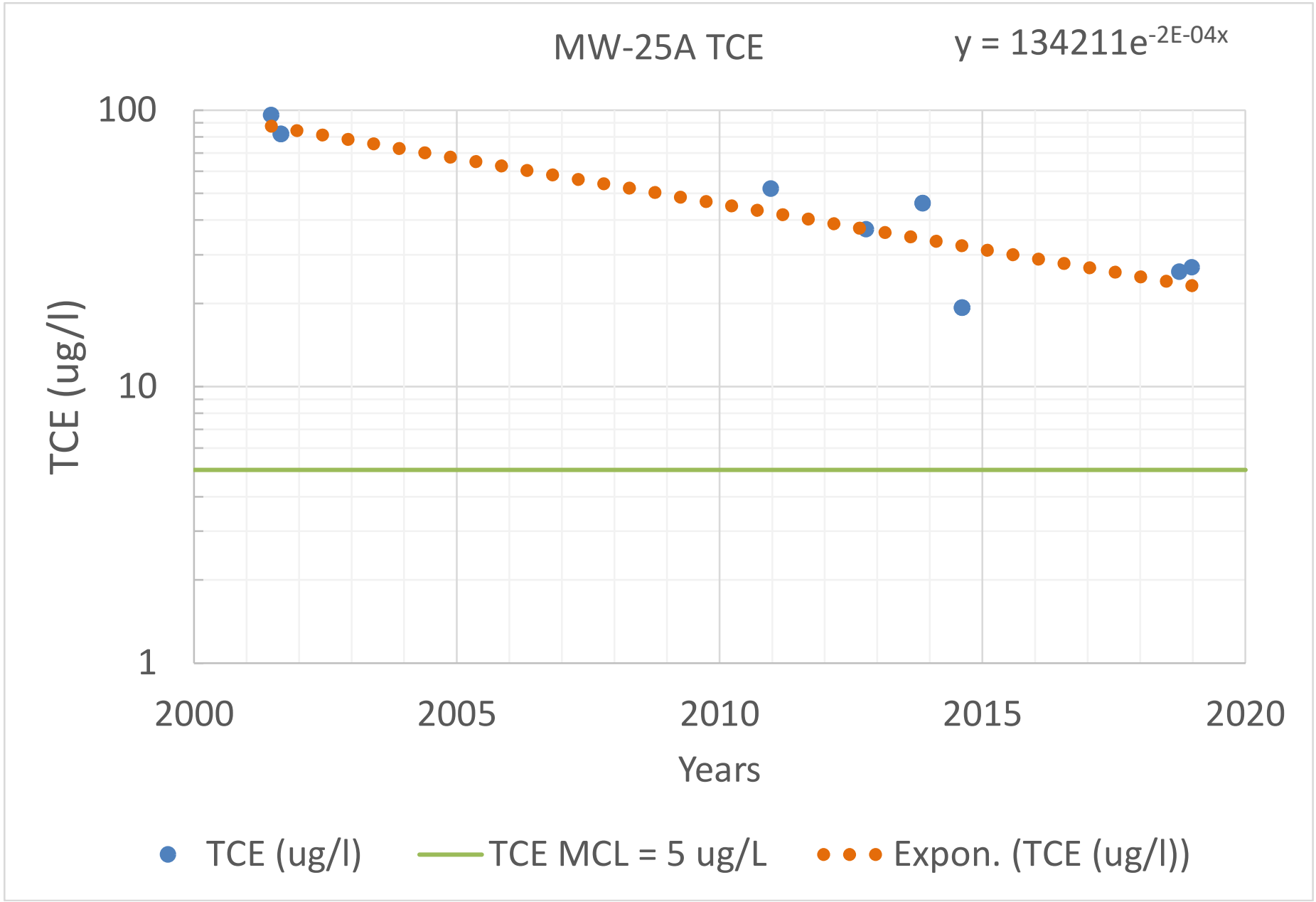
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1c
MW-24A TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-24A	MW24A_340-350_20010813	8/13/2001	39	
MW-24A	MW24A_345-355_20010813	8/13/2001	39	
MW-24A	MW24A_340-350_20010925	9/25/2001	0.2	
MW-24A	MW24A_345_20010925	9/25/2001	0.2	
MW-24A	FUL_WG_MW-24A_300-300_N_20110708	7/8/2011	81	
MW-24A	FUL_WG_MW-24A_297-297_N_20140724	7/24/2014	1	U
MW-24A	ACTDJB93787201505151447006	5/1/2015	81.2	
MW-24A	MW-24A-GW-350-20190905-0	9/5/2019	180	D
MW-24A	MW-24A-GW-350-20191211-0	12/11/2019	140	


MW-24A TCE
y = 8E-09e0.0005x
1000
100
10
1
0.1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

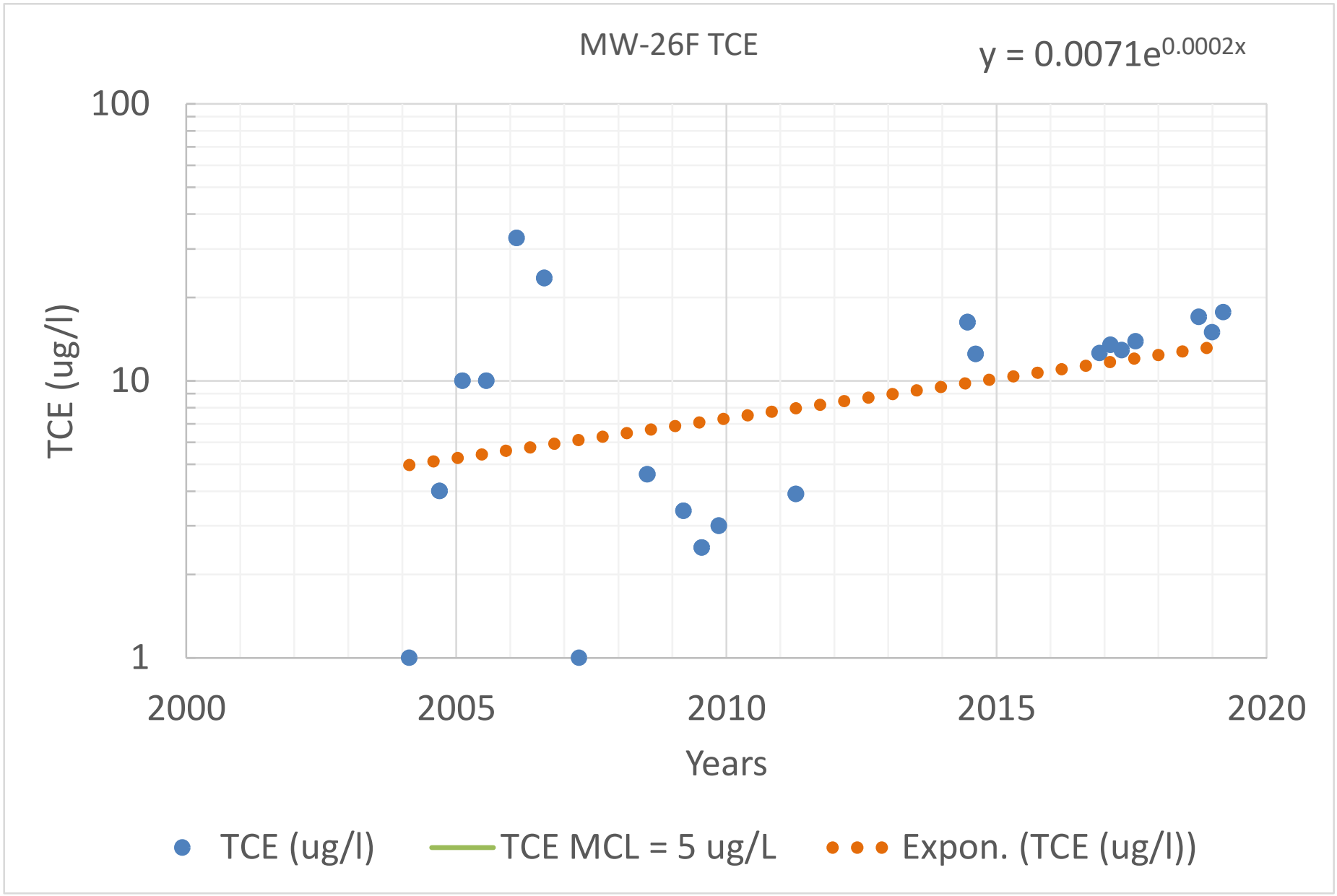
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1d
MW-25A TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-25A	MW25A_340-350_20010719	7/19/2001	96	
MW-25A	MW25A_340-350_20010927	9/27/2001	82	
MW-25A	MW25A_345_20010927	9/27/2001	82	
MW-25A	FUL_WG_MW-25A_300-300_N_20110711	7/11/2011	52	
MW-25A	FUL_WG_MW-25A_297-297_N_20130604	6/4/2013	37	
MW-25A	FUL_WG_MW-25A_297-297_FD_20140723	7/23/2014	46	
MW-25A	FUL_WG_MW-25A_297-297_N_20140723	7/23/2014	46	
MW-25A	MW25A_345_20150506	5/6/2015	19.3	
MW-25A	ACTDJB94107201505151508003	5/6/2015	19.3	
MW-25A	MW-25A-GW-345-20190905-0	9/5/2019	26	D
MW-25A	MW-25A-GW-345-20191206-0	12/6/2019	27	


MW-25A TCE
y = 134211e-2E-04x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

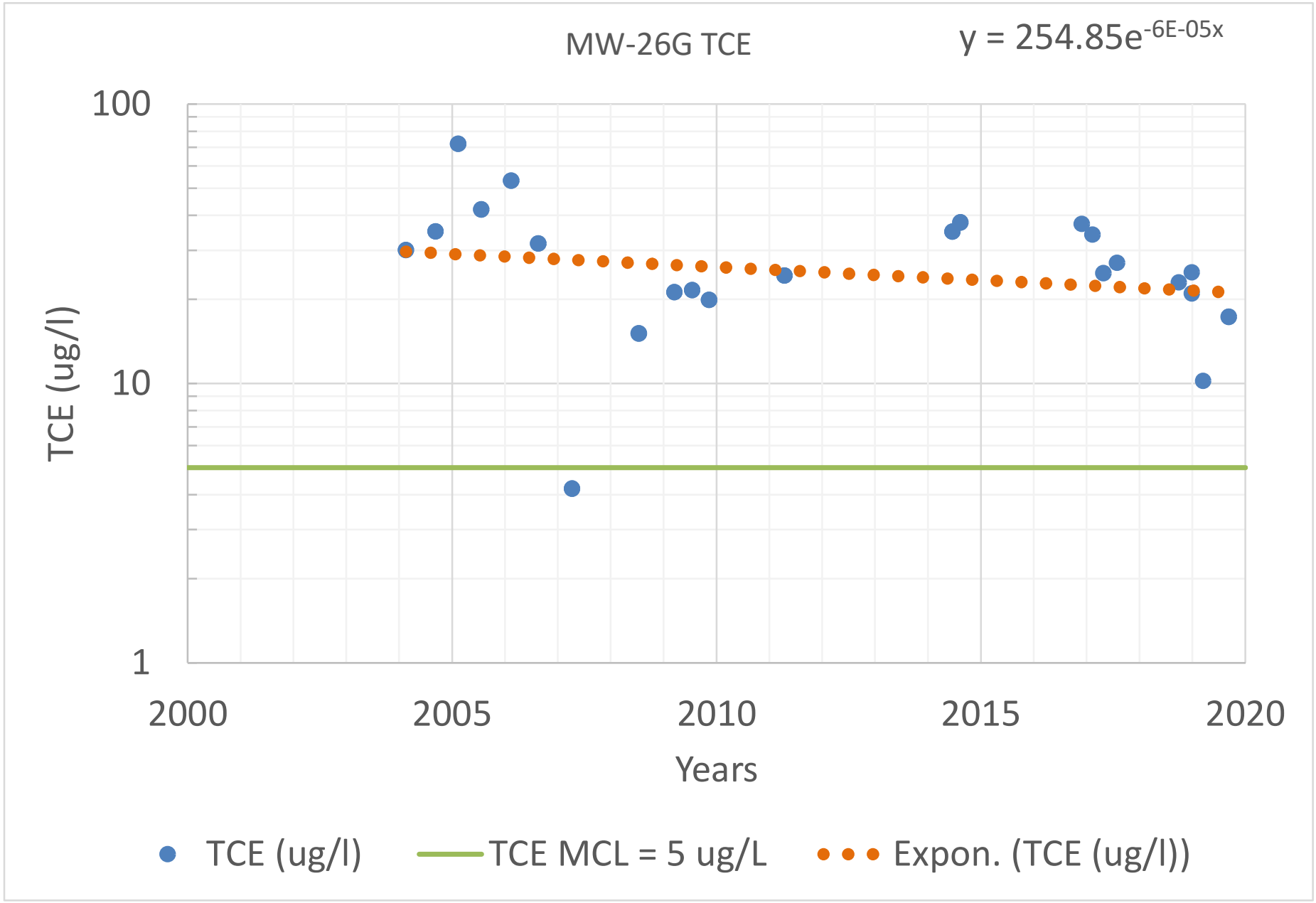
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1e
MW-26F TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-26F	MW26_410.5-410.5_20040503	5/3/2004	1	
MW-26F	MW26F_405-415_20040503	5/3/2004		U
MW-26F	MW26_410.5-410.5_20041203	12/3/2004	4	
MW-26F	MW26F_20041203	12/3/2004	4	
MW-26F	MW26_410.5-410.5_20050516	5/16/2005	10	
MW-26F	MW26F_20050516	5/16/2005	10	
MW-26F	MW26_410.5-410.5_20051031	10/31/2005	10	
MW-26F	MW26F_20051031	10/31/2005	10	
MW-26F	MW26_410.5-410.5_20060605	6/5/2006	32.8	
MW-26F	MW26F_20060605	6/5/2006	32.8	
MW-26F	MW26_410.5-410.5_20061218	12/18/2006	23.5	
MW-26F	MW26F_20061218	12/18/2006	23.5	
MW-26F	MW26_410.5-410.5_20070820	8/20/2007	1	
MW-26F	MW26F_20070820	8/20/2007		U
MW-26F	MW26_410.5-410.5_20081217	12/17/2008	4.6	
MW-26F	MW26F_20081217	12/17/2008	4.6	
MW-26F	MW26_410.5-410.5_20090831	8/31/2009	3.4	
MW-26F	MW26F_20090831	8/31/2009	3.4	
MW-26F	MW26_410.5-410.5_20100107	1/7/2010	2.5	
MW-26F	MW26F_20100107	1/7/2010	2.5	
MW-26F	MW26_410.5-410.5_20100510	5/10/2010	3	
MW-26F	MW26F_20100510	5/10/2010	3	
MW-26F	MW26_410.5-410.5_20111107	11/7/2011	3.9	
MW-26F	MW26F_20111107	11/7/2011	3.9	
MW-26F	MW26F_20150309	3/9/2015	16.3	
MW-26F	ACTDJB89617201508180243004	3/9/2015	16.3	
MW-26F	MW26F_410.5_20150506	5/6/2015	12.5	
MW-26F	ACTDJB94107201505151508008	5/6/2015	12.5	
MW-26F	ACTDJC52396201806072220007	10/2/2017	12.6	
MW-26F	ACTDJC57685201806072333012	12/18/2017	13.5	J
MW-26F	ACTDJC61943201805221738008	3/8/2018	12.9	
MW-26F	ACTDJC67971201904151527008	6/13/2018	13.9	
MW-26F	MW-26F-GW-410-20190905-0	9/5/2019	17	
MW-26F	MW-26F-GW-410-20191209-0	12/9/2019	15	
MW-26F	MW26F-410.5-022720	2/27/2020	17.7	


MW-26F TCE
y = 0.0071e^0.0002x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1f
MW-26G TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-26G	MW26_443-443_20040503	5/3/2004	30	
MW-26G	MW26G_438-448_20040503	5/3/2004	30	
MW-26G	MW26_443-443_20041203	12/3/2004	35	
MW-26G	MW26G_20041203	12/3/2004	35	
MW-26G	MW26_443-443_20050516	5/16/2005	72	
MW-26G	MW26G_20050516	5/16/2005	72	
MW-26G	MW26_443-443_20051031	10/31/2005	42	
MW-26G	MW26G_20051031	10/31/2005	42	
MW-26G	MW26_443-443_20060605	6/5/2006	53.2	
MW-26G	MW26G_20060605	6/5/2006	53.2	
MW-26G	MW26_443-443_20061218	12/18/2006	31.7	
MW-26G	MW26G_20061218	12/18/2006	31.7	
MW-26G	MW26_443-443_20070820	8/20/2007	4.2	
MW-26G	MW26G_20070820	8/20/2007	4.2	
MW-26G	MW26_443-443_20081217	12/17/2008	15.1	
MW-26G	MW26G_20081217	12/17/2008	15.1	
MW-26G	MW26_443-443_20090831	8/31/2009	21.2	
MW-26G	MW26G_20090831	8/31/2009	21.2	
MW-26G	MW26_443-443_20100107	1/7/2010	21.6	
MW-26G	MW26G_20100107	1/7/2010	21.6	
MW-26G	MW26_443-443_20100510	5/10/2010	19.9	
MW-26G	MW26G_20100510	5/10/2010	19.9	
MW-26G	MW26_443-443_20111107	11/7/2011	24.3	
MW-26G	MW26G_20111107	11/7/2011	24.3	
MW-26G	MW26G_20150309	3/9/2015	34.9	
MW-26G	ACTDJB89617201508180243005	3/9/2015	34.9	
MW-26G	MW26G_443_20150506	5/6/2015	37.7	
MW-26G	ACTDJB94107201505151508009	5/6/2015	37.7	
MW-26G	ACTDJC52396201806072220008	10/2/2017	37.2	
MW-26G	ACTDJC57685201806072333013	12/18/2017	34.1	J
MW-26G	ACTDJC61943201805221738009	3/8/2018	24.8	
MW-26G	ACTDJC67971201904151527009	6/13/2018	27	
MW-26G	MW-26G-GW-443-20190905-0	9/5/2019	23	D
MW-26G	MW-26G-GW-443-20191209-0	12/9/2019	25	
MW-26G	MW-26G-GW-443-20191209-1	12/9/2019	21	
MW-26G	MW26H-478.5-022720	2/27/2020	10.2	
MW-26G	DUP090120	9/1/2020	17.3	
MW-26G	MW-26G-443-090120	9/1/2020	17.3	


MW-26G TCE
y = 254.85e-6E-05x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1g
N-03881 TCE Data

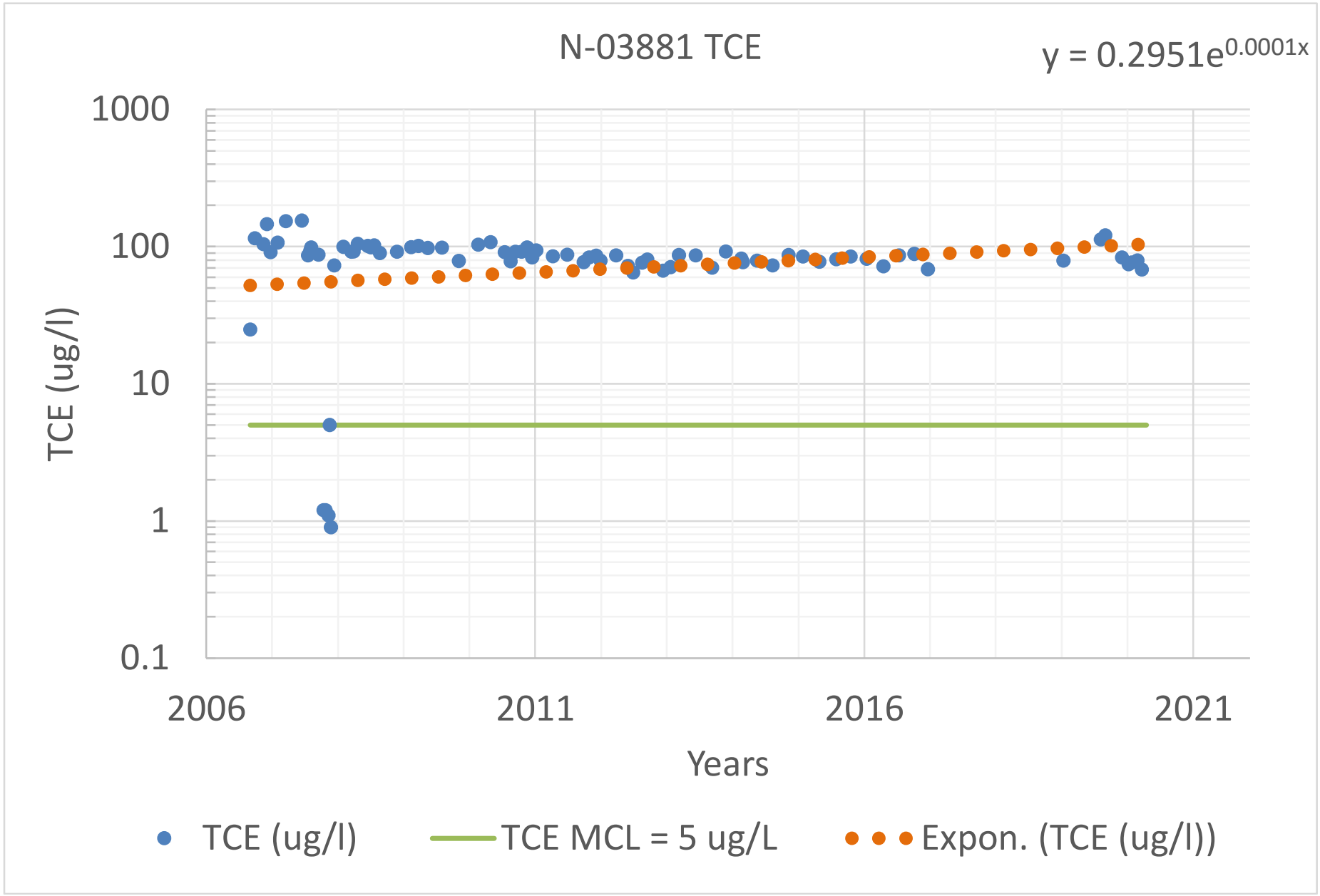
Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-03881	FUL_GCTY_N-03881_WG_19530301	3/1/1953		
N-03881	FUL_GCTY_N-03881_WG_19540701	7/1/1954		
N-03881	FUL_GCTY_N-03881_WG_19550301	3/1/1955		
N-03881	FUL_GCTY_N-03881_WG_19571101	11/1/1957		
N-03881	FUL_GCTY_N-03881_WG_19611001	10/1/1961		
N-03881	FUL_GCTY_N-03881_WG_19620401	4/1/1962		
N-03881	FUL_GCTY_N-03881_WG_19630501	5/1/1963		
N-03881	FUL_GCTY_N-03881_WG_19640101	1/1/1964		
N-03881	FUL_GCTY_N-03881_WG_19650101	1/1/1965		
N-03881	FUL_GCTY_N-03881_WG_19651101	11/1/1965		
N-03881	FUL_GCTY_N-03881_WG_19661001	10/1/1966		
N-03881	FUL_GCTY_N-03881_WG_19671010	10/10/1967		
N-03881	FUL_GCTY_N-03881_WG_19680503	5/3/1968		
N-03881	FUL_GCTY_N-03881_WG_19690320	3/20/1969		
N-03881	FUL_GCTY_N-03881_WG_19701005	10/5/1970		
N-03881	FUL_GCTY_N-03881_WG_19710319	3/19/1971		
N-03881	FUL_GCTY_N-03881_WG_19720112	1/12/1972		
N-03881	FUL_GCTY_N-03881_WG_19721228	12/28/1972		
N-03881	FUL_GCTY_N-03881_WG_19731207	12/7/1973		
N-03881	FUL_GCTY_N-03881_WG_19740226	2/26/1974		
N-03881	FUL_GCTY_N-03881_WG_19740315	3/15/1974		
N-03881	FUL_GCTY_N-03881_WG_19750121	1/21/1975		
N-03881	FUL_GCTY_N-03881_WG_19750228	2/28/1975		
N-03881	FUL_GCTY_N-03881_WG_19760106	1/6/1976		
N-03881	FUL_GCTY_N-03881_WG_19760810	8/10/1976		
N-03881	FUL_GCTY_N-03881_WG_19770412	4/12/1977		
N-03881	FUL_GCTY_N-03881_WG_19770425	4/25/1977		
N-03881	FUL_GCTY_N-03881_WG_19771116	11/16/1977	4	U
N-03881	FUL_GCTY_N-03881_WG_19771214	12/14/1977	4	U
N-03881	FUL_GCTY_N-03881_WG_19780404	4/4/1978		
N-03881	FUL_GCTY_N-03881_WG_19780511	5/11/1978	4	U
N-03881	FUL_GCTY_N-03881_WG_19780928	9/28/1978		
N-03881	FUL_GCTY_N-03881_WG_19781003	10/3/1978	1	U
N-03881	FUL_GCTY_N-03881_WG_19781202	12/2/1978	4	U
N-03881	FUL_GCTY_N-03881_WG_19790202	2/2/1979		
N-03881	FUL_GCTY_N-03881_WG_19790327	3/27/1979		
N-03881	FUL_GCTY_N-03881_WG_19791127	11/27/1979	1	U
N-03881	FUL_GCTY_N-03881_WG_19800115	1/15/1980		
N-03881	FUL_GCTY_N-03881_WG_19800820	8/20/1980		
N-03881	FUL_GCTY_N-03881_WG_19800829	8/29/1980	4	U
N-03881	FUL_GCTY_N-03881_WG_19801007	10/7/1980	3	
N-03881	FUL_GCTY_N-03881_WG_19810106	1/6/1981		
N-03881	FUL_GCTY_N-03881_WG_19810526	5/26/1981		
N-03881	FUL_GCTY_N-03881_WG_19810527	5/27/1981	4	
N-03881	FUL_GCTY_N-03881_WG_19811020	10/20/1981	4	
N-03881	FUL_GCTY_N-03881_WG_19820112	1/12/1982		
N-03881	FUL_GCTY_N-03881_WG_19820316	3/16/1982	4	
N-03881	FUL_GCTY_N-03881_WG_19820921	9/21/1982	6	
N-03881	FUL_GCTY_N-03881_WG_19830111	1/11/1983		
N-03881	FUL_GCTY_N-03881_WG_19830117	1/17/1983	10	
N-03881	FUL_GCTY_N-03881_WG_19831004	10/4/1983	11	
N-03881	FUL_GCTY_N-03881_WG_19840103	1/3/1984		
N-03881	FUL_GCTY_N-03881_WG_19840730	7/30/1984	16	
N-03881	FUL_GCTY_N-03881_WG_19841205	12/5/1984	15	
N-03881	FUL_GCTY_N-03881_WG_19850107	1/7/1985	18	
N-03881	FUL_GCTY_N-03881_WG_19850528	5/28/1985	18	
N-03881	FUL_GCTY_N-03881_WG_19860603	6/3/1986	20	
N-03881	FUL_GCTY_N-03881_WG_19860721	7/21/1986	20	
N-03881	FUL_GCTY_N-03881_WG_19980508	5/8/1998	3.7	
N-03881	FUL_GCTY_N-03881_WG_20000314	3/14/2000		
N-03881	FUL_GCTY_N-03881_WG_20000414	4/14/2000	1.7	
N-03881	FUL_GCTY_N-03881_WG_20000717	7/17/2000	1.8	
N-03881	FUL_GCTY_N-03881_WG_20000907	9/7/2000	0.5	
N-03881	FUL_GCTY_N-03881_WG_20010131	1/31/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20010420	4/20/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20010525	5/25/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20010612	6/12/2001	2.2	
N-03881	FUL_GCTY_N-03881_WG_20010725	7/25/2001	4.2	
N-03881	FUL_GCTY_N-03881_WG_20010816	8/16/2001	0.5	U

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1g
N-03881 TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-03881	FUL_GCTY_N-03881_WG_20010920	9/20/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20011023	10/23/2001	9.7	
N-03881	FUL_GCTY_N-03881_WG_20011121	11/21/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20011205	12/5/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20011213	12/13/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020123	1/23/2002	31	
N-03881	FUL_GCTY_N-03881_WG_20020307	3/7/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020328	3/28/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020411	4/11/2002	30	
N-03881	FUL_GCTY_N-03881_WG_20020531	5/31/2002	36	
N-03881	FUL_GCTY_N-03881_WG_20020613	6/13/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020619	6/19/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020625	6/25/2002	39	
N-03881	FUL_GCTY_N-03881_WG_20020718	7/18/2002	43	
N-03881	FUL_GCTY_N-03881_WG_20020820	8/20/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020912	9/12/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020919	9/19/2002		
N-03881	FUL_GCTY_N-03881_WG_20021022	10/22/2002	46	
N-03881	FUL_GCTY_N-03881_WG_20021107	11/7/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20021218	12/18/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20021230	12/30/2002	36	
N-03881	FUL_GCTY_N-03881_WG_20030117	1/17/2003	44	
N-03881	FUL_GCTY_N-03881_WG_20030422	4/22/2003	37	
N-03881	FUL_GCTY_N-03881_WG_20030714	7/14/2003	45	
N-03881	FUL_GCTY_N-03881_WG_20030925	9/25/2003		
N-03881	FUL_GCTY_N-03881_WG_20031023	10/23/2003	50	
N-03881	FUL_GCTY_N-03881_WG_20040122	1/22/2004	55	
N-03881	FUL_GCTY_N-03881_WG_20040415	4/15/2004	69	
N-03881	FUL_GCTY_N-03881_WG_20040722	7/22/2004	89	
N-03881	FUL_GCTY_N-03881_WG_20040909	9/9/2004		
N-03881	FUL_GCTY_N-03881_WG_20041020	10/20/2004	91	
N-03881	FUL_GCTY_N-03881_WG_20050107	1/7/2005	88	
N-03881	FUL_GCTY_N-03881_WG_20050412	4/12/2005	100	
N-03881	FUL_GCTY_N-03881_WG_20050720	7/20/2005	89	
N-03881	FUL_GCTY_N-03881_WG_20050818	8/18/2005	96	
N-03881	FUL_GCTY_N-03881_WG_20050916	9/16/2005	100	
N-03881	FUL_GCTY_N-03881_WG_20050923	9/23/2005		
N-03881	FUL_GCTY_N-03881_WG_20051013	10/13/2005	89	
N-03881	FUL_GCTY_N-03881_WG_20051117	11/17/2005	82	
N-03881	FUL_GCTY_N-03881_WG_20060124	1/24/2006	86	
N-03881	FUL_GCTY_N-03881_WG_20060208	2/8/2006	5	U
N-03881	FUL_GCTY_N-03881_WG_20060303	3/3/2006	82	
N-03881	FUL_GCTY_N-03881_WG_20060425	4/25/2006	98	
N-03881	FUL_GCTY_N-03881_WG_20060515	5/15/2006	93	
N-03881	FUL_GCTY_N-03881_WG_20060615	6/15/2006	110	
N-03881	FUL_GCTY_N-03881_WG_20060721	7/21/2006	110	
N-03881	FUL_GCTY_N-03881_WG_20060804	8/4/2006	110	
N-03881	FUL_GCTY_N-03881_WG_20060823	8/23/2006		
N-03881	FUL_GCTY_N-03881_WG_20060914	9/14/2006	24.8	
N-03881	FUL_GCTY_N-03881_WG_20061012	10/12/2006	115	
N-03881	FUL_GCTY_N-03881_WG_20061130	11/30/2006	104	
N-03881	FUL_GCTY_N-03881_WG_20061220	12/20/2006	146	
N-03881	FUL_GCTY_N-03881_WG_20070111	1/11/2007	91.3	
N-03881	FUL_GCTY_N-03881_WG_20070221	2/21/2007	107	
N-03881	FUL_GCTY_N-03881_WG_20070409	4/9/2007	153	
N-03881	FUL_GCTY_N-03881_WG_20070711	7/11/2007	155	
N-03881	FUL_GCTY_N-03881_WG_20070817	8/17/2007	86.5	
N-03881	FUL_GCTY_N-03881_WG_20070831	8/31/2007	93.3	
N-03881	FUL_GCTY_N-03881_WG_20070905	9/5/2007	98.5	
N-03881	FUL_GCTY_N-03881_WG_20070917	9/17/2007		
N-03881	FUL_GCTY_N-03881_WG_20071017	10/17/2007	87.4	
N-03881	FUL_GCTY_N-03881_WG_20071116	11/16/2007	1.2	
N-03881	FUL_GCTY_N-03881_WG_20071128	11/28/2007	1.2	
N-03881	FUL_GCTY_N-03881_WG_20071214	12/14/2007	1.1	
N-03881	FUL_GCTY_N-03881_WG_20071221	12/21/2007	5	U
N-03881	FUL_GCTY_N-03881_WG_20071228	12/28/2007	0.9	
N-03881	FUL_GCTY_N-03881_WG_20080116	1/16/2008	73	
N-03881	FUL_GCTY_N-03881_WG_20080310	3/10/2008	99.7	
N-03881	FUL_GCTY_N-03881_WG_20080425	4/25/2008	91.5	

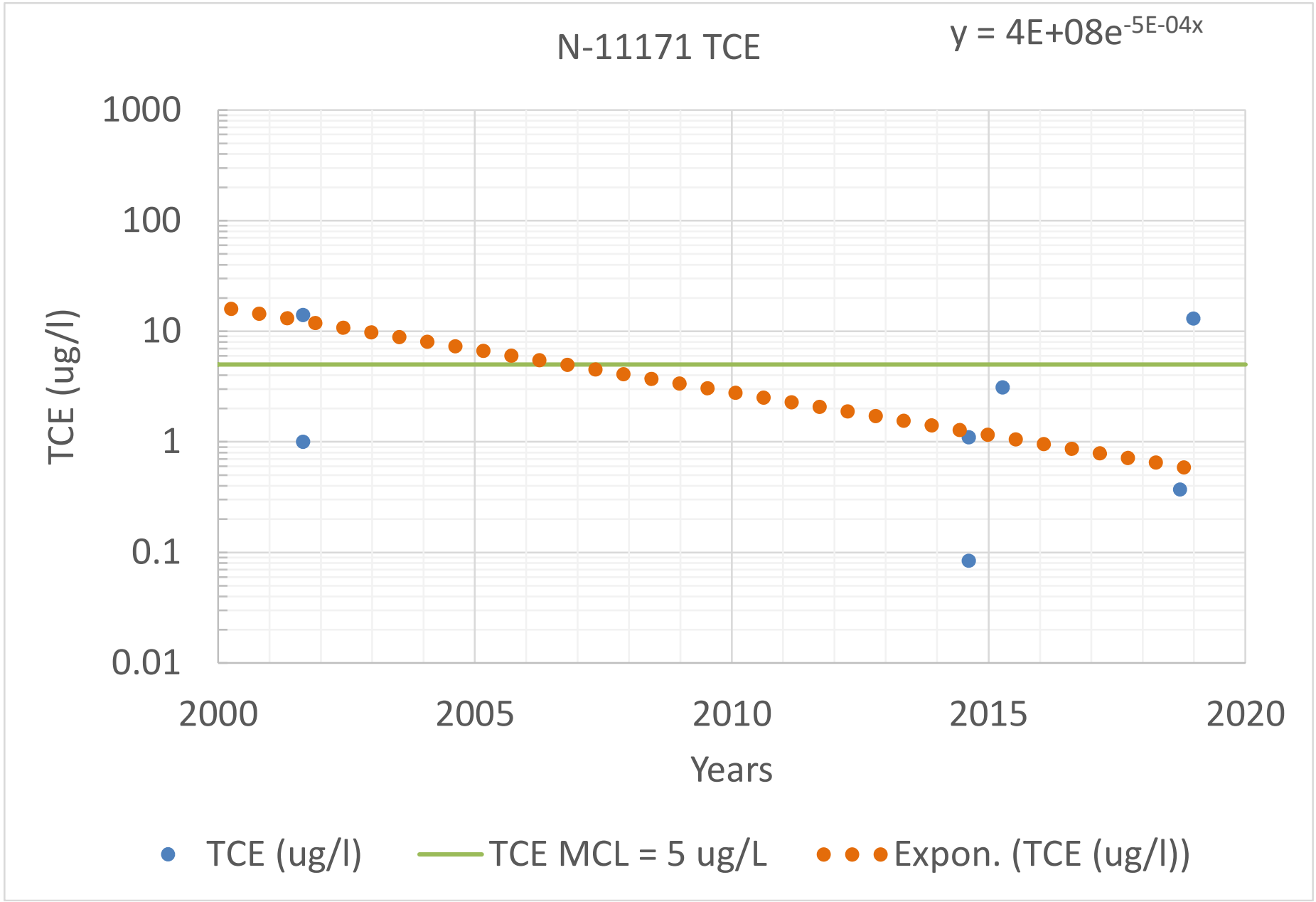
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1g
N-03881 TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-03881	FUL_GCTY_N-03881_WG_20080508	5/8/2008	92	
N-03881	FUL_GCTY_N-03881_WG_20080602	6/2/2008	105	
N-03881	FUL_GCTY_N-03881_WG_20080730	7/30/2008	101	
N-03881	FUL_GCTY_N-03881_WG_20080818	8/18/2008	98.6	
N-03881	FUL_GCTY_N-03881_WG_20080905	9/5/2008	102	
N-03881	FUL_GCTY_N-03881_WG_20081009	10/9/2008	90	
N-03881	FUL_GCTY_N-03881_WG_20090116	1/16/2009	91.8	
N-03881	FUL_GCTY_N-03881_WG_20090409	4/9/2009	99	
N-03881	FUL_GCTY_N-03881_WG_20090522	5/22/2009	101	
N-03881	FUL_GCTY_N-03881_WG_20090716	7/16/2009	97.7	
N-03881	FUL_GCTY_N-03881_WG_20090831	8/31/2009		
N-03881	FUL_GCTY_N-03881_WG_20091005	10/5/2009	98	
N-03881	FUL_GCTY_N-03881_WG_20100111	1/11/2010	78.6	
N-03881	FUL_GCTY_N-03881_WG_20100505	5/5/2010	103	
N-03881	FUL_GCTY_N-03881_WG_20100716	7/16/2010	108	
N-03881	FUL_GCTY_N-03881_WG_20100812	8/12/2010		
N-03881	FUL_GCTY_N-03881_WG_20101006	10/6/2010	91	
N-03881	FUL_GCTY_N-03881_WG_20101110	11/10/2010	78.1	
N-03881	FUL_GCTY_N-03881_WG_20101208	12/8/2010	91.6	
N-03881	FUL_GCTY_N-03881_WG_20110113	1/13/2011	91.7	
N-03881	FUL_GCTY_N-03881_WG_20110214	2/14/2011	98.6	
N-03881	FUL_GCTY_N-03881_WG_20110315	3/15/2011	83.5	
N-03881	FUL_GCTY_N-03881_WG_20110408	4/8/2011	93.9	
N-03881	FUL_GCTY_N-03881_WG_20110713	7/13/2011	85	
N-03881	FUL_GCTY_N-03881_WG_20110810	8/10/2011		
N-03881	FUL_GCTY_N-03881_WG_20111005	10/5/2011	87.2	
N-03881	FUL_GCTY_N-03881_WG_20120109	1/9/2012	77.1	
N-03881	FUL_GCTY_N-03881_WG_20120209	2/9/2012	83.3	
N-03881	FUL_GCTY_N-03881_WG_20120321	3/21/2012	85.8	
N-03881	FUL_GCTY_N-03881_WG_20120416	4/16/2012	79.1	
N-03881	FUL_GCTY_N-03881_WG_20120716	7/16/2012	86.5	
N-03881	FUL_GCTY_N-03881_WG_20120814	8/14/2012		
N-03881	FUL_GCTY_N-03881_WG_20120924	9/24/2012	72.2	
N-03881	FUL_GCTY_N-03881_WG_20121024	10/24/2012	64.7	
N-03881	FUL_GCTY_N-03881_WG_20121214	12/14/2012	76.4	
N-03881	FUL_GCTY_N-03881_WG_20130114	1/14/2013	80.6	
N-03881	FUL_GCTY_N-03881_WG_20130415	4/15/2013	66.8	
N-03881	FUL_WG_N-03881_446-446_N_20130530	5/30/2013	71	
N-03881	FUL_GCTY_N-03881_WG_20130718	7/18/2013	86.8	
N-03881	FUL_GCTY_N-03881_WG_20130819	8/19/2013		
N-03881	FUL_GCTY_N-03881_WG_20131023	10/23/2013	86.4	
N-03881	FUL_GCTY_N-03881_WG_20140128	1/28/2014	70.3	
N-03881	FUL_GCTY_N-03881_WG_20140417	4/17/2014	92	
N-03881	FUL_WG_N-03881_446-446_N_20140716	7/16/2014	82	
N-03881	FUL_GCTY_N-03881_WG_20140724	7/24/2014	77	
N-03881	FUL_GCTY_N-03881_WG_20140815	8/15/2014		
N-03881	FUL_GCTY_N-03881_WG_20141015	10/15/2014	79	
N-03881	FUL_GCTY_N-03881_WG_20150114	1/14/2015	73	*
N-03881	FUL_GCTY_N-03881_WG_20150417	4/17/2015	86.9	*
N-03881	FUL_GCTY_N-03881_WG_20150709	7/9/2015	84.5	*
N-03881	FUL_GCTY_N-03881_WG_20150805	8/5/2015		
N-03881	FUL_GCTY_N-03881_WG_20151014	10/14/2015	77.3	*
N-03881	FUL_GCTY_N-03881_WG_20160120	1/20/2016	81	*
N-03881	FUL_GCTY_N-03881_WG_20160413	4/13/2016	84.6	*
N-03881	FUL_GCTY_N-03881_WG_20160715	7/15/2016	81.5	*
N-03881	FUL_GCTY_N-03881_WG_20160912	9/12/2016		
N-03881	FUL_GCTY_N-03881_WG_20161020	10/20/2016	72	
N-03881	FUL_GCTY_N-03881_WG_20170120	1/20/2017	86.3	
N-03881	FUL_GCTY_N-03881_WG_20170418	4/18/2017	88.7	
N-03881	FUL_GCTY_N-03881_WG_20170707	7/7/2017	68.6	
N-03881	N-03881-GW-426-466-20190904-0	9/4/2019	79	D
N-03881	FUL_GCTY_N-03881_WG_20200410	4/10/2020	113	
N-03881	FUL_GCTY_N-03881_WG_20200505	5/5/2020	121	
N-03881	FUL_GCTY_N-03881_WG_20200812	8/12/2020	83.4	
N-03881	FUL_GCTY_N-03881_WG_20200918	9/18/2020	74.6	
N-03881	FUL_GCTY_N-03881_WG_20201005	10/5/2020	76.6	
N-03881	FUL_GCTY_N-03881_WG_20201109	11/9/2020	79.4	
N-03881	FUL_GCTY_N-03881_WG_20201204	12/4/2020	68.1	


N-03881 TCE
y = 0.2951e^0.0001x
1000
100
10
1
0.1
TCE (ug/l)
2006
2011
2016
2021
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1h
N-11171 TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-11171	M6_19890522	5/22/1989	89.4	
N-11171	M6_19890616	6/16/1989	88.3	
N-11171	M6_19900711	7/11/1990	99	
N-11171	M6_19900820	8/20/1990	119	
N-11171	M6_19910418	4/18/1991	93.7	
N-11171	M6_19920115	1/15/1992	67.6	
N-11171	M6_19920520	5/20/1992	261	
N-11171	M6_19930706	7/6/1993	103	
N-11171	M6_19941102	11/2/1994	92.7	
N-11171	M6_19970206	2/6/1997		U
N-11171	M6_19980603	6/3/1998	2.5	
N-11171	M5_447-457_20010927	9/27/2001	1	
N-11171	M6_220_20010927	9/27/2001	14	
N-11171	M5_445_20150505	5/5/2015	0.084	
N-11171	ACTDJB93989201505151459004	5/5/2015	1.1	
N-11171	FUL_N11171_215-235_WG_N_20160113	1/13/2016	3.1	
N-11171	N-11171-GW-220-20190829-0	8/29/2019	0.37	J
N-11171	N-11171-GW-220-20191206-0	12/6/2019	13	


N-11171 TCE
y = 4E+08e-5E-04x
1000
100
10
1
0.1
0.01
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Attachment 2

MNA Screening Scoresheets

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 2, Table 1
MNA Screening September 2019

Parameter	Scoring Concentration	Units	Interpretation	Point Value	MW-20C 9/3/2019		MW-23C 9/3/2019		MW-24A 9/3/2019		MW-25A 9/5/2019	MW-25A 9/3/2019	MW-26F 9/5/2019	MW-26F 9/3/2019	MW-26G 9/5/2019	MW-26G 9/3/2019	N-03881 9/4/2019	N-03881 9/3/2019	N-11171 8/28/2019	N-11171 8/28/2019
					Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded
Dissolved Oxygen	< 0.5	mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	0	3	0	3	0	3	0	3	0	3	0.46	3	NM	0	0	3
Dissolved Oxygen	> 5	mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0	0	0	0	0	0	0	0.46	0	NM	0	0	0
Nitrate	< 1	mg/L	At higher concentrations may compete with reductive pathway	2	0.05 U	2	0.69	2	6.1	0	4.2	0	0.05 U	2	0.36	2	6.8	0	0.46	2
Iron II*	> 1	mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)- reducing conditions	3	0.25 J	0	2.5 J	3	0.09 J	0	0.2 J	0	0.1 UJ	0	0.3 J	0	0.1 UJ	0	4.4 J	3
Sulfate	< 20	mg/L	At higher concentrations may compete with reductive pathway	2	23	0	20	0	32	0	32	0	5.1	2	27	0	12	2	27	0
Sulfide	> 1	mg/L	Reductive pathway possible	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Methane	< 0.5	mg/L	VC oxidizes	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Methane	> 0.5	mg/L	Ultimate reductive daughter product, VC accumulates	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
ORP	< 50	mV	Reductive pathway possible	1	-121	1	-40	0	-124	1	14	1	-256	1	23	1	NM	0	-53	1
ORP	< -100	mV	Reductive pathway likely	2	-121	2	-40	0	-124	2	14	0	-256	2	23	0	NM	0	-53	0
pH	5 > pH < 9	SU	Optimal range for reductive pathway	0	11.37	0	6.61	0	7.24	0	6.55	0	9.33	0	6.52	0	NM	0	6.57	0
pH	5 < pH > 9	SU	Outside optimal range for reductive pathway	-2	11.37	-2	6.61	0	7.24	0	6.55	0	9.33	-2	6.52	0	NM	0	6.57	0
TOC	> 20	mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	4.2	0	1.5	0	1.7	0	1.5	0	2.9	0	1 U	0	1	0	1.4	0
Temperature	> 20	°C	At T >20°C biochemical process is accelerated	1	16.99	0	15.37	0	17.17	0	16.24	0	16.41	0	15.94	0	NM	0	16.27	0
Carbon Dioxide	> 2x background	mg/L	Ultimate oxidative daughter product	1	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Alkalinity[a]	> 2x background	mg/L	Results from interaction between CO_2 and aquifer minerals	1	73	0	61	0	61	0	38	0	110	0	36	0	14	0	47	0
Chloride[a]	> 2x background	mg/L	Daughter product of organic chlorine	2	64	0	49	0	20	0	35	0	28	0	34	0	18	0	52	0
Hydrogen	> 1	nM	Reductive pathway possible, VC may accumulate	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Hydrogen	< 1	nM	VC oxidized	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Volatile Fatty Acids	> 0.1	mg/L	Intermediates resulting from biodegradation of more complex compounds; carbon and energy source	2	2 U	0	2 U	0	2 U	0	2 U	0	2.1	2	2 U	0	2 U	0	2 U	0
BTEX	> 0.1	mg/L	Carbon and energy source; drives dechlorination	2	0.0005 U	0	0.0005 U	0	0.00015 J	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.0005 U	0
Tetrachloroethene	--	ug/L	Material released	0	0.75	0	4.8	0	19	0	23 D	0	17	0	7.9	0	42 D	0	0.52	0
Trichloroethene	--	ug/L	Material released	0	1	0	26 D	0	180 D	0	26 D	0	17	0	23 D	0	79 D	0	0.37 J	0
DCE[b]	--	ug/L	Daughter product of TCE	2	0.5 U	0	0.5 U	0	1.3	2	2	2	5.6	2	0.36 J	2	1.7	2	0.5 U	0
Vinyl Chloride[b]	--	ug/L	Daughter product of DCE	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0
Chloroethane[b]	--	ug/L	Daughter product of DCA or VC under reducing conditions	2	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0
Ethene/Ethane[b]	> 0.01	mg/L	Daughter product of VC/ethene	2	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Ethene/Ethane[b]	> 0.1	mg/L	Daughter product of VC/ethene	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Total Points Awarded						6		8		8		6		12		8		4		9

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 2, Table 2
MNA Screening December 2019

Parameter	Scoring Concentration	Units	Interpretation	Point Value	MW-20C 12/9/2019		MW-23C 12/9/2019		MW-24A 12/9/2019		MW-25A 12/6/2019		MW-26F 12/9/2019		MW-26G 12/9/2019		MW-26G dup 12/9/2019		N-11171 12/6/2019	
					Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded
Dissolved Oxygen	< 0.5	mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	4.39	0	1.95	0	3.26	0	2.17	0	0.98	0	0.55	0	0.55	0	2.59	0
Dissolved Oxygen	> 5	mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	4.39	0	1.95	0	3.26	0	2.17	0	0.98	0	0.55	0	0.55	0	2.59	0
Nitrate	< 1	mg/L	At higher concentrations may compete with reductive pathway	2	0.054	2	0.05	2	7	0	4.9	0	0.05	2	0.05	2	0.05	2	3.1	0
Iron II*	> 1	mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)- reducing conditions	3	0.1	0	0.09	0	0.54 J	0	0.19 J	0	1.27	3	0.1	0	1.3 J	3	6.61 J	3
Sulfate	< 20	mg/L	At higher concentrations may compete with reductive pathway	2	22	0	7.9	2	31	0	30	0	6.4	2	19	2	22	0	32	0
Sulfide	> 1	mg/L	Reductive pathway possible	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Methane	< 0.5	mg/L	VC oxidizes	0	4.43	0	2640	0	137	0	527	0	3920	0	84.2	0	77.9	0	621	0
Methane	> 0.5	mg/L	Ultimate reductive daughter product, VC accumulates	3	4.43	3	2640	3	137	3	527	3	3920	3	84.2	3	77.9	3	621	3
ORP	< 50	mV	Reductive pathway possible	1	1	1	-57	1	-125	1	76	0	-208	1	-49	1	-49	1	-46	1
ORP	< -100	mV	Reductive pathway likely	2	1	0	-57	0	-125	2	76	0	-208	2	-49	0	-49	0	-46	0
pH	5 > pH < 9	SU	Optimal range for reductive pathway	0	10.86	0	9.97	0	6.49	0	5.93	0	8.63	0	6.95	0	6.95	0	5.91	0
pH	5 < pH > 9	SU	Outside optimal range for reductive pathway	-2	10.86	-2	9.97	-2	6.49	0	5.93	0	8.63	0	6.95	0	6.95	0	5.91	0
TOC	> 20	mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	6.1	0	1 U	0	1.1	0	1 U	0	2	0	1 U	0	1 U	0	1	0
Temperature	> 20	°C	At T >20°C biochemical process is accelerated	1	13.55	0	13.99	0	12.42	0	13.87	0	13.78	0	13.86	0	13.86	0	11.4	0
Carbon Dioxide	> 2x background	mg/L	Ultimate oxidative daughter product	1	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Alkalinity[a]	> 2x background: 53.2 x 2 = 106.4	mg/L	Results from interaction between CO_2 and aquifer minerals	1	130	0	55	0	57	0	40	0	96	0	48	0	44	0	47	0
Chloride[a]	> 2x background: 17 x 2 = 34	mg/L	Daughter product of organic chlorine	2	24	0	75	0	19	0	29	0	28	0	27	0	30	0	44	0
Hydrogen	> 1	nM	Reductive pathway possible, VC may accumulate	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Hydrogen	< 1	nM	VC oxidized	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Volatile Fatty Acids	> 0.1	mg/L	Intermediates resulting from biodegradation of more complex compounds; carbon and energy source	2	2 U	0	2 U	0	2 U	0	2 U	0	7	2	2 U	0	2 U	0	2 U	0
BTEX	> 0.1	mg/L	Carbon and energy source; drives dechlorination	2	0.00105	0	0.00037 J	0	0.0001 J	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.00008 J	0
Tetrachloroethene	--	ug/L	Material released	0	1.1	0	2.1	0	20	0	22	0	14	0	5.5	0	3.7	0	6.8	0
Trichloroethene	--	ug/L	Material released	0	2.4	0	12	0	140	0	27	0	15	0	25	0	21	0	13	0
DCE[b]	--	ug/L	Daughter product of TCE	2	0.5 U	0	0.27 J	2	1.1	2	2.1	2	3.871	2	0.34 J	2	0.32 J	2	0.29 J	2
Vinyl Chloride[b]	--	ug/L	Daughter product of DCE	2	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5	0	0.5	0
Chloroethane[b]	--	ug/L	Daughter product of DCA or VC under reducing conditions	2	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5	0	0.5	0
Ethene/Ethane[b]	> 0.01	mg/L	Daughter product of VC/ethene	2	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0
Ethene/Ethane[b]	> 0.1	mg/L	Daughter product of VC/ethene	3	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0
Total Points Awarded						4		8		8		5		17		10		11		9

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Table 3-1 Exceedances of PDC in OU2 - Phase 5 Groundwater Sampling
Fulton Avenue Superfund Site OU2
Garden City, New York

					Metals			VOCs		
				Analyte	Iron	Manganese	Sodium	cis-1,2-DCE	PCE	TCE
				CAS	7439-89-6	7439-96-5	7440-23-5	156-59-2	127-18-4	79-01-6
				PDC	300	300	20000	5	5	5
				Units	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
Sampling Event:	Location:	Sample:	Sample Type:	Sample Date:	Result	Result	Result	Result	Result	Result
2019 08-09 Phase 5 GW Sampling	MW-20C	MW-20C-GW-405-20190903-0		9/3/2019	17800		57200			
2019 08-09 Phase 5 GW Sampling	MW-23C	MW-23C-GW-403-20190903-0		9/3/2019	379000 D	2170 D	33900			26 D
2019 08-09 Phase 5 GW Sampling	MW-25A	MW-25A-GW-345-20190905-0		9/5/2019	3820		21700		23 D	26 D
2019 08-09 Phase 5 GW Sampling	MW-26F	MW-26F-GW-410-20190905-0		9/5/2019	831		23800	5.6	17	17
2019 08-09 Phase 5 GW Sampling	MW-26G	MW-26G-GW-443-20190905-0		9/5/2019	402				7.9	23 D
2019 08-09 Phase 5 GW Sampling	N-03881	N-03881-GW-426-466-20190904-0		9/4/2019					42 D	79 D
2019 08-09 Phase 5 GW Sampling	N-11171	N-11171-GW-220-20190829-0		8/28/2019	28000		31800			
2019 12 Phase 5 GW Sampling	MW-20C	MW-20C-GW-405-20191209-0		12/9/2019	18000		37300			
2019 12 Phase 5 GW Sampling	MW-23C	MW-23C-GW-403-20191209-0		12/9/2019	13000		55600			12
2019 12 Phase 5 GW Sampling	MW-25A	MW-25A-GW-345-20191206-0		12/6/2019	2700				22	27
2019 12 Phase 5 GW Sampling	MW-26F	MW-26F-GW-410-20191209-0		12/9/2019	1200				14	15
2019 12 Phase 5 GW Sampling	MW-26G	MW-26G-GW-443-20191209-0		12/9/2019	1500		21700		5.5	25
2019 12 Phase 5 GW Sampling	MW-26G	MW-26G-GW-443-20191209-1	Duplicate	12/9/2019	1600					21
2019 12 Phase 5 GW Sampling	N-11171	N-11171-GW-220-20191206-0		12/6/2019	11000		23500		6.8	13

Abbreviations
VOCs: volatile organic compounds
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
TCE: trichloroethene
CAS: Chemical Abstracts Service identifier
PDC: potential delineation criteria
ug/l: micrograms per liter

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Table 4-1A Chemical-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Media	Requirement	Citation	Description
Federal			
Groundwater/ Water	Safe Drinking Water Act	42 U.S.C. §§300f-300j-26	Drinking water standards, expressed as maximum contaminant levels (MCLs), which apply to specific contaminants that have been determined to have an adverse impact on human health.
Groundwater/ Water	USEPA National Primary Drinking Water Regulations	40 CFR §§ 141.1-141-861	Health-based standards for public drinking water systems. Also includes drinking water quality goals that are set at levels at which no adverse health effects are anticipated, with a safety margin.
State of New York			
Groundwater/ Water	NYSDEC - Derivation and Use of Standards and Guidance Values	6 NYCRR Part 702	Basis for derivation of water quality standards and guidance values to control toxic and other deleterious substances.
Groundwater/ Water	NYSDEC - Water Quality Standards and Classifications	6 NYCRR Part 703	Surface Water and Groundwater Quality Standards and Groundwater Effluent Limitations
Groundwater/ Water	NYSDEC - Division of Water - Technical and Operational Guidance Series - Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations (1998)	NYSDEC TOGS 1.1.1	Compilation of ambient water quality standards and guidance values and groundwater effluent limitations for use where there are no standards or regulatory effluent limitations.
Water	NYSDEC - Sources of Water Supply – Standards of Raw Water Quality	10 NYCRR Part 170.4	Raw water quality standards to protect sources of water supply dedicated for present or future public beneficial use for domestic and municipal purposes.
Water	NYSDOH - Ambient Water Quality Standards and Guidance Values	2021 Addendum to June 1998 Division of Water TOGS 1.1.1	New water quality guidance values for emerging contaminants PFOA, PFOS, and 1,4-dioxane.
Water	NYSDOH - Sources of Water Supply - Standards of Raw Water Quality	NYSDOH Part 5, Subpart 5-1.51/52	Maximum contaminant levels, maximum residual disinfectant levels and treatment technique requirements.

Notes:
CFR - Code of Federal Regulations
MCLs - Maximum Contaminant Levels
NYCRR - New York Codes, Rules, and Regulations
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
PFOA - perfluorooctanoic acid
PFOS - perfluorooctane sulfonic acid

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Table 4-1B Location-Specific ARARs and TBCs
Fulton Avenue Superfund Site
Garden City, New York

Location	Title	Citation	Description
Federal			
Groundwater	Federal Protection of Sole Source Aquifer	40 CFR §§ 149, et seq.	Describes the criteria to define a sole source aquifer and states that programs to reduce or prevent the contamination of sole source aquifers must be implemented when it is reasonably likely that contamination of such aquifers will occur
Floodplains	Federal Emergency Management Agency Executive Order 11988 - Floodplain Management	FEMA EO 11988	Activities taking place within floodplains must be performed to avoid adverse impacts and preserve beneficial values
Floodplains and Wetlands	Floodplain Management and Protection of Wetlands	24 CFR §§ 55.1 et seq.	Regulation that implments FEMA EO 11988
Floodplains and Wetlands	USEPA Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR Part 6, Appendix A, Section 6	Requirements associated with actions that have impacts on floodplains or wetlands
Wetlands	National Environmental Policy Act Executive Order 11990 - Protection of Wetlands	NEPA EO 11990	Activities performed within wetlands areas must be done to avoid adverse impacts
Wetlands	National Environmental Policy Act of 1969, as amended	42 U.S.C. §§ 4321, et seq.	Act that implements NEPA EO 11990
Floodplains and Wetlands	Office of Solid Waste and Emergency Response - Policy on Floodplains and Wetlands Assessments for CERCLA Actions (2005)	OSWER 9280.0-02	Guidance for implementing executive orders 11988 and 11990
Wetlands	Office of Solid Waste and Emergency Response - Wetlands Protection at CERCLA sites (1994)	OSWER 9280.0-03	Guidance document to be used to evaluate impacts to wetlands at Superfund sites
Historic or Cultural Lands	National Historic Preservation Act	16 U.S.C. §§ 470, et seq and 36 CFR Part 800	Established Requirements for the identification and preservation of historic and cultural resources
Critical Habitat Areas	Endangered Species Act and Fish and Wildlife Coordination Act	16 U.S.C. §§ 661, et seq. and 16 USC. §§ 1531, et seq.	Actions must be taken to conserve critical habitat in areas where they are endangered or threatened species
Floodplains	Resource Conservation and Recovery Act (RCRA) Regulations - Location Standards	40 CFR Part 264.18	Regulates the design, construction, operation, and maintenance of hazardous waste management facilities within the 100-year floodplain.

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Table 4-1B Location-Specific ARARs and TBCs
Fulton Avenue Superfund Site
Garden City, New York

Location	Title	Citation	Description
State of New York			
Critical Habitat Areas	New York State Department of Environmental Conservation - Endangered and Threatened Species of Fish and Wildlife	6 NYCRR Part 182	Provides standards for the protection of threatened and endangered species.
Wetlands	New York State Department of Environmental Conservation - Freshwater Wetlands Permit Requirements	6 NYCRR Part 663.1-663.11	Defines the procedural requirements for any activities taking place within or adjacent to wetlands.
Floodplains	New York State Department of Environmental Conservation - Floodplain Management Criteria for State Projects	6 NYCRR Part 502	Provides floodplain management criteria.

Notes:
CFR - Code of Federal Regulations
EO - Executive Order
FEMA - Federal Emergency Management Agency
NEPA - National Environmental Policy Act
NYCRR - New York Codes, Rules, and Regulations
NYS - New York State
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
OSWER - Office of Solid Waste and Emergency Response
TOGS - Technical and Operational Guidance Series
U.S.C. - United States Code

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description
Federal			
Disposal of Hazardous Materials	Resource Conservation and Recovery Act - Identification and Listing of Hazardous Wastes	40 CFR Part 261	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 40 CFR Parts 260 to 266.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Hazardous Waste Determination	40 CFR Part 262.11	Describes methods for identifying hazardous wastes and lists known hazardous wastes.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Manifesting	40 CFR Part 262, Subpart B	Describes manifest requirements applicable to small and large quantity generators.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Recordkeeping	40 CFR Part 262.40	Describes record keeping requirements for generators.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act – Labeling and Marking	40 CFR Part 262 Subpart C	Specifies EPA naming, labeling and container requirements for off-site disposal of hazardous waste.
Disposal of Hazardous Materials	Resource Conservation and Recovery Act - Land Disposal Restrictions	40 CFR Part 268	Restricts land disposal of hazardous wastes that exceed specific criteria. Establishes Universal Treatment Standards to which hazardous waste must be treated prior to disposal.
Generating Hazardous Materials	Resource Conservation and Recovery Act – Accumulation limitations	40 CFR Part 262.14	Allows generators of hazardous waste to store and treat hazardous waste at the generation site for up to 90 days in tanks, containers, and containment buildings without having to obtain a RCRA hazardous waste permit.

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description
Storage and Disposal of Hazardous Materials	Resource Conservation and Recovery Act - Treatment, Storage and Disposal of Hazardous Waste	40 CFR Parts 264/265/270	Specifies requirements for the operation of hazardous waste treatment, storage, and disposal facilities.
Transporting Hazardous Materials	US Department of Transportation - Hazardous Materials Transportation Regulations	49 CFR Parts 171-180	Establishes classification, packaging, and labeling requirements for shipments of hazardous materials.
Transporting Hazardous Materials	RCRA- Standards Applicable to Transporters of Applicable Hazardous Waste	40 CFR Part 263	Establishes the responsibility of off-site transporters of hazardous waste in the handling, transportation and management of the waste. Requires manifesting, recordkeeping and immediate action in the event of a discharge
Generating Air Emissions	Clean Air Act - National Primary and Secondary Ambient Air Quality Standards	40 CFR Parts 50.6 and 50.7	Establishes air quality standard for particles with an aerodynamic diameter less than or equal to a normal 10 micrometers (PM10) and 2.5 micrometers (PM2.5)
Generating Air Emissions	Clean Air Act - New Source Review and Prevention of Significant Deterioration Requirements	40 CFR Part 52 Subpart HH	New sources or modifications which emit greater than defined thresholds for listed pollutants must perform ambient impact analyses and install controls which meet best available control technology (BACT).
Generating Air Emissions	Clean Air Act - National Emissions Standards for Hazardous Air Pollutants (NESHAP)	40 CFR Part 61; 40 CFR Part 63	Source-specific regulations which establish emissions standards for hazardous air pollutants
Discharging Water	Clean Water Act - Effluent Guidelines and Standards; National Pollutant Discharge Elimination System (NPDES) Program	40 CFR Part 401; 40 CFR Parts 122, 124, and 125	Both on-site and off-site discharges from CERCLA sites to surface waters are required to meet the substantive Clean Water Act limitations, monitoring requirements, and best management practices. NPDES permits are required to discharge treated water to a surface water.
Re-injecting Water	Safe Drinking Water Act – Underground Injection Control Program	40 CFR 144, 146	Establish performance standards, well requirements, and permitting requirements for groundwater re-injection wells.
Remediation	Superfund Green Remediation Strategy	www.epa.gov/superfund/greenremediation/sf-gr-strategy.pdf	Provides the EPA's strategy to clean up hazardous waste sites in ways that use natural resources and energy efficiently and reduces negative impacts on human health and the environment.

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description
State of New York			
Treatment and Disposal of Hazardous Materials	New York State Department of Environmental Conservation - Standards for Universal Waste and Land Disposal Restrictions	6 NYCRR Part 374-3 6 NYCRR Part 376	These regulations establish standards for treatment and disposal of hazardous wastes.
Transporting Hazardous Materials	New York State Department of Environmental Conservation - Waste Transportation	6 NYCRR Part 364	Regulates the collection, transport, and delivery of regulated waste, originating or terminating at a location within this State.
Management of Hazardous Materials	New York State Department of Environmental Conservation - Hazardous Waste Management System – General	6 NYCRR Part 370	Provides definition of terms and general standards applicable to hazardous waste management systems.
Identification and Listing Hazardous Materials	New York State Department of Environmental Conservation - Identification and Listing of Hazardous Wastes	6 NYCRR Part 371	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 6 NYCRR Part 370 to 373, and 376.
Transporting Hazardous Materials	New York State Department of Environmental Conservation - Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities	6 NYCRR Part 372	Standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its recordkeeping requirements.
Generating Air Emissions	New York State Department of Environmental Conservation - Air Quality Standards	6 NYCRR Part 257	Standards promulgated to provide protection from the adverse health effects of air contamination; and are intended to protect and conserve the natural resources and environment and to promote maximum comfort and enjoyment and use of property consistent with the economic and social well-being of the community.
Discharging Groundwater	New York State Department of Environmental Conservation - State Pollutant Discharge Elimination System (SPDES)	6 NYCRR Part 750	Governs the discharge of any wastes into or adjacent to State waters that may alter the physical, chemical, or biological properties of State waters, except as authorized pursuant to a NPDES or State permit.
Discharging Groundwater	New York State Department of Environmental Conservation - Classifications - Surface Waters and Groundwaters	6 NYCRR Part 701	Defines discharge water quality requirements into water sources.
Discharging Groundwater	New York State Department of Environmental Conservation - Nassau County Waters	6 NYCRR Part 885	Defines the classifications and standards of quality and purity to all surface waters within the designated drainage basin on the Nassau County waters.
Discharging Groundwater	New York State Department of Environmental Conservation - Protection of Waters Program	6 NYCRR Part 608	Implements regulations that preserve and protect bodies of water including wetlands, lakes, rivers, streams, and ponds.
Decommissioning Groundwater Wells	New York State Department of Environmental Conservation - Groundwater Monitoring Well Decommissioning Policy	NYSDEC CP-43	Provides guidance on the decommissioning of groundwater monitoring wells.
Generating Air Emissions	New York State Department of Environmental Conservation - Prevention and Control of Air Contaminants and Air Pollution: Air Pollution Prohibited and Visible Emissions Limited	6 NYCRR Parts 200 and 211	Provides guidance on air pollution and visible emissions.

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Table 4-1C Action-Specific ARARs and TBCs
Fulton Avenue Superfund Site OU2
Garden City, New York

Action	Title	Citation	Description

Notes:

BACT - Best Available Control Technology
CFR - Code of Federal Regulations
NESHAP - National Emissions Standards for Hazardous Air Pollutants
NPDES - National Pollutant Discharge Elimination System
NSPS - New Source Performance Standards
NYCRR - New York Codes, Rules, and Regulations
NYS - New York State
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
RCRA - Resource Conservation and Recovery Act
TOGS - Technical and Operational Guidance Series

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Table 4-2
Preliminary Remediation Goals for Groundwater
Fulton Avenue Superfund Site OU2
Garden City, New York

Compounds of Concern	CAS Number	NYSDEC Part 703.5 Class GA (µg/L)	NYSDEC TOGS 1.1.1 Class GA (µg/L)	NYSDOH Part 5 Subpart 5-1 (µg/L)	Federal MCL (µg/L)	Primary Remediation Goal (µg/L)
VOLATILE ORGANIC COMPOUNDS (VOCs)						
Tetrachloroethylene (PCE)	127-18-4	5	5	5	5	5
Trichloroethylene (TCE)	79-01-6	5	5	5	5	5

Notes:
The Primary Remediation Goal is the minimum of the individual listed criteria.
(1) Criterion value is for total.
Abbreviations:
CAS = Chemical Abstracts Service
MCL = Maximum Contaminant Level (EPA 2009)
µg/L = micrograms per liter

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Table 6-1
Initial Screening of Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
No Action	No Action	No Action	No remedial action.	**Retained** - No Action is required for consideration by NCP.
Institutional Controls (ICs)	Not Applicable	ICs - Non-Engineering (Administrative/ Legal) Controls	ICs are non-engineering measures that help minimize the potential for human exposure to contamination and/ or protect the integrity of a remedy by limiting site or resource use.	**Retained** - ICs will be considered and developed in conjunction with all active remedial alternatives.
Monitored Natural Attenuation	Not Applicable	Not Applicable	Natural subsurface processes include destructive (e.g., biodegradation and chemical reactions with other subsurface constituents) and non-destructive (e.g., dilution, volatilization, biodegradation, adsorption, and chemical reactions) mechanisms that reduce contaminant concentrations to acceptable levels.	**Retained -** MNA is an implementable GRA and will be considered and developed in conjunction with other remedial technologies.
Long Term Monitoring	Not Applicable	LTM	Monitoring to assess movement of contaminants, remediation performance, and risk mitigation. Does not reduce contamination.	**Retained -** LTM will be considered and developed in conjunction with all active remedial alternatives.
Containment	Physical Barriers	Slurry Wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry.	**Not Retained** - The depth of groundwater contamination exceeds the practical limit for installing a slurry wall. Additionally, construction in densely populated area further limits implementability of this technology.
		Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes.	**Not Retained** - Construction in densely populated area limits the practicability of this technology.
		Funnel & Gate	Impermeable sheet pile wall (funnel) to direct water to a permeable reactive barrier (gate) for treatment.	**Not Retained** - The depth of groundwater contamination exceeds the practical limits for driving sheeting into the aquifer.
	Hydraulic Barrier	Groundwater Extraction and Treatment	Consists of pumping groundwater from an aquifer to remove dissolved phase contaminants and/or achieve hydraulic containment of contaminated groundwater to prevent migration, with subsequent treatment and disposal/discharge.	**Retained -** Groundwater extraction and treatment will be developed as a remedial alternative for OU2.
	Deep Well Injection	Geologic Sequestration	Waste disposal technology using injection wells to place untreated liquid waste into geologic formations that have little potential to allow migration of contaminants.	**Not Retained** - Geologic conditions, regulatory hurdles under the Underground Injection Control (UIC) and other environmental programs, community acceptance issues, hinder technical implementability at OU2.

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Table 6-1
Initial Screening of Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment	In Situ Biological Treatment	Enhanced Bioremediation	Process to accelerate the natural biodegradation process by introducing nutrients, electron acceptors, and/or competent contaminant-degrading microorganisms to the subsurface.	**Retained -** Enhanced bioremediation will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		Phytoremediation	Set of processes that use plants to remove, transfer, stabilize and / or destroy contamination in groundwater.	**Not Retained** - Based on the depth of groundwater contamination at OU2 and amount of land area needed for phytoremediation make technology not implementable.
	In-Situ Physical/ Chemical/ Thermal Treatment	Air Sparging / Soil Vapor Extraction (SVE)	Injected air traverses horizontally and vertically in channels through the soil column, creating a subsurface “air stripper” that removes contaminants by volatilization. SVE is used to extract and treat the contaminated air.	**Not Retained** - The groundwater contamination is below the practical limit for air sparging.
		Bioslurping	Combines the two remedial approaches of bioventing and vacuum-enhanced free-product recovery.	**Not Retained** - Bioslurping is traditionally used to remediate contamination by petroleum products with a LNAPL layer, which is not present at OU2.
		ISCO/ISCR	Chemically converts contaminants to less toxic compounds that are more stable, less mobile, and/or inert via either chemical oxidation or reduction reactions.	**Retained** - Both ISCO and ISCR are effective at treating COCs and will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		In Situ Adsorption	In-situ adsorption involves the injection of very fine particles of activated carbon into a subsurface contaminated zone. Contaminants are adsorbed onto treatment media and degraded by reactive amendments, reducing their concentration.	**Retained -** In-situ adsorption will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		Thermal Treatment	Thermal treatment technologies such as steam enhanced extraction (SEE), thermal conductive heating (TCH), electrical resistivity heating (ERH), and thermal conduction heating (TCH) work by introducing heat into the aquifer/ formation to destroy the organic contaminants present.	**Not Retained** - The plume size and depth is too large and deep to effectively implement these technologies. Additionally, construction in densely populated area limits the practicability of this technology.
		In Well Air Stripping	Air is injected into a vertical well that has been screened at two depths.	**Not Retained** - In Well Air Stripping is not implementable based on the depth limitation of the technology compared to the depth of contaminated groundwater at OU2.
		Passive/Reactive Treatment Barriers	Use of PRBs consisting of iron with a bulking agent to treat groundwater contaminated with chlorinated solvents. A PRB is installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. Use of horizontal wells could also deliver reagents to contaminated areas.	**Retained -** Passive/Reactive Treatment Barriers will be further evaluated for treatment of the dissolved-phase VOC groundwater plume.
		In Situ Flushing	In situ flushing involves the injection of chemicals like surfactants into a subsurface contaminated zone. The solution then flows through the contaminated zone and the resulting effluent is extracted downgradient where it is treated and discharged.	**Not Retained** - This technology would not be implementable given the size and depth of the plume and the densely populated area.

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Table 6-1
Initial Screening of Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Action	Remedial Technology	Process Option	Description	Screening Comments
Treatment (Continued)	Ex-Situ Biological Treatment	Bioreactors	Contaminants in extracted groundwater are put into contact with microorganisms in attached or suspended growth biological reactors.	**Not Retained** - Bioreactors are not applicable because of the diluted nature of contamination in the groundwater at OU2.
		Constructed Wetlands	The constructed wetlands-based treatment technology uses natural geochemical and biological processes inherent in an artificial wetland ecosystem to accumulate and fixate / remove metals and other contaminants from influent waters.	**Not Retained** - Constructed wetlands requires a large area of land for remediation which is not available near OU2.
	Ex-Situ Physical/ Chemical Treatment	Adsorption	Organic contaminants are adsorbed onto treatment media, reducing their concentration.	**Retained** - Ex-situ adsorption using GAC will be further evaluated as part of a groundwater extraction and treatment system.
		Advanced Oxidation Processes	Strong oxidizing chemicals or processes are used to destroy organic contaminants.	**Retained** - Advanced Oxidation Processes will be further evaluated as part of a groundwater extraction and treatment system.
		Ex Situ Air Stripping	Mass transfer of volatile contaminants from water to air.	**Retained** - Ex situ air stripping will be further evaluated as part of a groundwater extraction and treatment system.
Discharge/ Disposal	On-Site Discharge	Surface Water	Extracted water discharged to surface water	**Not Retained** - This technology requires nearby surface water for discharge which is not available at OU2.
		Groundwater	Extracted water treated and/or discharged into injection well or infiltration basin.	**Retained** - Groundwater discharge has been retained for use at OU2.
	Off-Site Discharge	POTW	Extracted water pre-treated and/or discharged to POTW.	**Retained** - POTW has been retained for use at OU2.

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Table 7-1
Detailed Screening of Remedial Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

General Response Actions	Remedial Technology	Process Options	Description	Effectiveness (RAOs, COCs, Impacts to HHE, Reliability)	Implementability (Technical & Administrative)	Relative Cost	Screening Comment
No Action	No Action	No Action	COCs in groundwater are left untreated.	**Poor.** Not effective, because no active measures are taken to address the COCs.	**High.** Technically implementable; however, No Action can't be selected under CERCLA.	**None.**	**Retained** per NCP.
Institutional Control (ICs)	Not Applicable	ICs - Non-Engineering (Administrative/ Legal) Controls	Exposure pathways are controlled by administrative controls.	**Moderate.** Requires administrative measures to limit exposure to contaminated groundwater. Institutional Controls are an effective supplement to remedial alternatives.	**High**. Readily implementable under EPA guidance (EPA 540-F-00-005)..	**Low.**	**Retained** in conjunction with other GRAs.
Monitored Natural Attenuation (MNA)	Not Applicable	MNA	Destructive and non-destructive natural mechanisms that reduce contaminant concentrations.	**Moderate.** MNA relies on natural attenuation processes to achieve the applicable standards	**Moderate.** Implementing an MNA program is technically and administratively achievable. However, must demonstrate effectiveness prior to implementation.	**Low.**	**Not Retained** as evaluation of site contaminants and conditions has shown little evidence of biologically driven natural attenuation.
Long Term Monitoring (LTM)	Not Applicable	LTM	Evaluates groundwater conditions over time.	**Moderate.** Requires administrative measures to limit exposure to contaminated groundwater. Institutional Controls are an effective supplement to remedial alternatives.	**High**. Readily implementable under EPA guidance (EPA 540-F-00-005).	**Low.**	**Retained** in conjunction with other remedies that treat the groundwater.
Containment	Hydraulic Containment	Groundwater extraction and treatment	Hydraulic containment is the process of prohibiting further migration of contaminants by capturing groundwater.	**High.** Hydraulic containment is a widely accepted and implementable remedy especially at sites where hydrogeology is well understood and pumping rates are achievable.	**High.** This technology is technically and administratively implementable.	**High.** Capital costs include installation of extraction wells and treatment plant equipment.	**Retained** for containment of OU2 plume. Will be combined with ex-situ treatment and discharge technologies as a groundwater extraction and treatment system.
Treatment	In Situ Biological Treatment	Enhanced Bioremediation	Enhanced bioremediation modifies environmental conditions to encourage microorganisms to destroy or detoxify organic contaminants in the environment.	**Moderate.** While bacteria will readily degrade COCs, the groundwater conditions are not conducive to biological degradation. Amendments would be required to create more favorable conditions. Those amendments could negatively affect nearby municipal water supply.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due to moderate effectiveness and significant implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood.
	In-Situ Physical/ Chemical/ Thermal Treatment	ISCO/ISCR	These processes convert the COCs to less toxic compounds via either chemical oxidation or reduction reactions.	**Low**. Can treat site COCs but not as effective at treating low concentration plumes. May negatively affect nearby municipal water supply.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due poor effectiveness at treating low concentration plumes, implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood. Safety concerns regarding chemical handling in residential neighborhoods also excludes this process option.
		In Situ Adsorption	Chemicals injected into subsurface to adsorb contaminants as groundwater flows through the injection transect.	**Moderate.** Effective at binding site COCs to prevent further migration. Does not chemically alter the contaminants.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due to implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood and potential for incomplete adsorption of COCs.
		Passive/Reactive Treatment Barriers	This process allows groundwater to passively migrate through treatment media to recover COCs.	**Moderate**. Passive/Reactive Treatment Barriers rely on passive treatment to achieve applicable standards. Effective at reducing low COC concentrations. May negatively affect nearby municipal water supply.	**Poor.** This technology is technically and administratively implementable, but site conditions (density of development and depth/area of plume) limit implementability.	**High.** High capital and O&M costs are associated with this technology at OU2 because of the depth and broad area of contamination. A high density of permanent injection points would be required.	**Not Retained** due to implementability challenges including injecting at close horizontal spacing across over 2,500 feet, injecting at depths up to 500 ft bgs in high density residential neighborhood.

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Table 7-1
Detailed Screening of Remedial Technologies and Process Options
Fulton Avenue Superfund Site OU2
Garden City, New York

Treatment (continued)	Ex Situ Physical/ Chemical/ Thermal Treatment	Adsorption	Organic contaminants are adsorbed onto treatment media, reducing their concentration.	**High**. Adsorption using GAC to treat the vapor-phase contaminants is highly effective at destroying the organic contaminants resultant from the ex situ air stripping operations at the Site.	**High.** This technology is technically and administratively implementable.	**Moderate.** High capital and O&M costs are associated with this technology.	**Retained** for liquid-phase treatment and vapor-phase treatment of the air stripper off gas.
		Advanced Oxidation Processes	Advance oxidation processes use hydroxyl radicals, which are powerful oxidizers, to sequentially oxidize organic contaminants to carbon dioxide, water, and residual chloride	**High.** AOP is one of only a few technologies with commercial viability to treat 1,4-dioxane	**High.** This technology is technically and administratively implementable.	**High.** High capital and O&M costs are associated with this technology.	**Retained** for potentially treating emerging contaminants, if needed.
		Air Stripping	Mass transfer of volatile contaminants from water to air.	**High.** Ex situ air stripping is a highly effective, safe and reliable means for treating the dissolved phase organics present in the Site groundwater. Additional treatment technologies will be required to treat the vapor-phase contaminants resulting from the air stripper.	**High.** This technology is technically and administratively implementable.	**Low.** Low capital and O&M costs are associated with this technology.	**Retained** as the primary ex situ groundwater treatment alternative.
Discharge/Disposal	Discharge	Groundwater	Extracted water treated and discharged to groundwater via recharge basin.	**High.** Discharge to groundwater via injection or infiltration will be an effective method for disposal of treated groundwater.	**High.** This technology is technically and administratively implementable.	**Moderate.** Capital costs could be high if land acquisition is necessary, but an existing recharge basin could be evaluated for use	**Retained** for groundwater discharge.
			Extracted water treated and discharged to groundwater via injection wells.	**Moderate.** Dependent on the formation's ability to receive water. Wells can foul over time.	**High.** This technology is technically and administratively implementable.	**Moderate.** Capital costs include installation of injection wells	**Not retained** as more effective option available
		POTW	Extracted water pre-treated and/or discharged to POTW.	**High.** Discharging to a sewer main would be effective for disposal of treated groundwater.	**Moderate.** This technology is technically implementable, but would require the sewer district to approve the discharge.	**High.** High capital costs are associated with upgrade to the sewer lines.	**Not retained** as more effective option available

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Table 8-1
Summary of Remedial Technologies and Process Options
Fulton Avenue Groundwater Contamination Superfund Site OU2
Garden City, New York

General Response Actions	Technology	Process Options
No Action	No Action	No Action
Institutional Control	ICs	Non-engineering, administrative/legal controls
Long Term Monitoring	LTM	LTM
Containment	Hydraulic Containment	Groundwater extraction and treatment
Treatment	Ex-Situ Treatment	Adsorption
		Advanced Oxidiation Processes
		Air Stripping
Discharge/Disposal	Discharge	Recharge Basin

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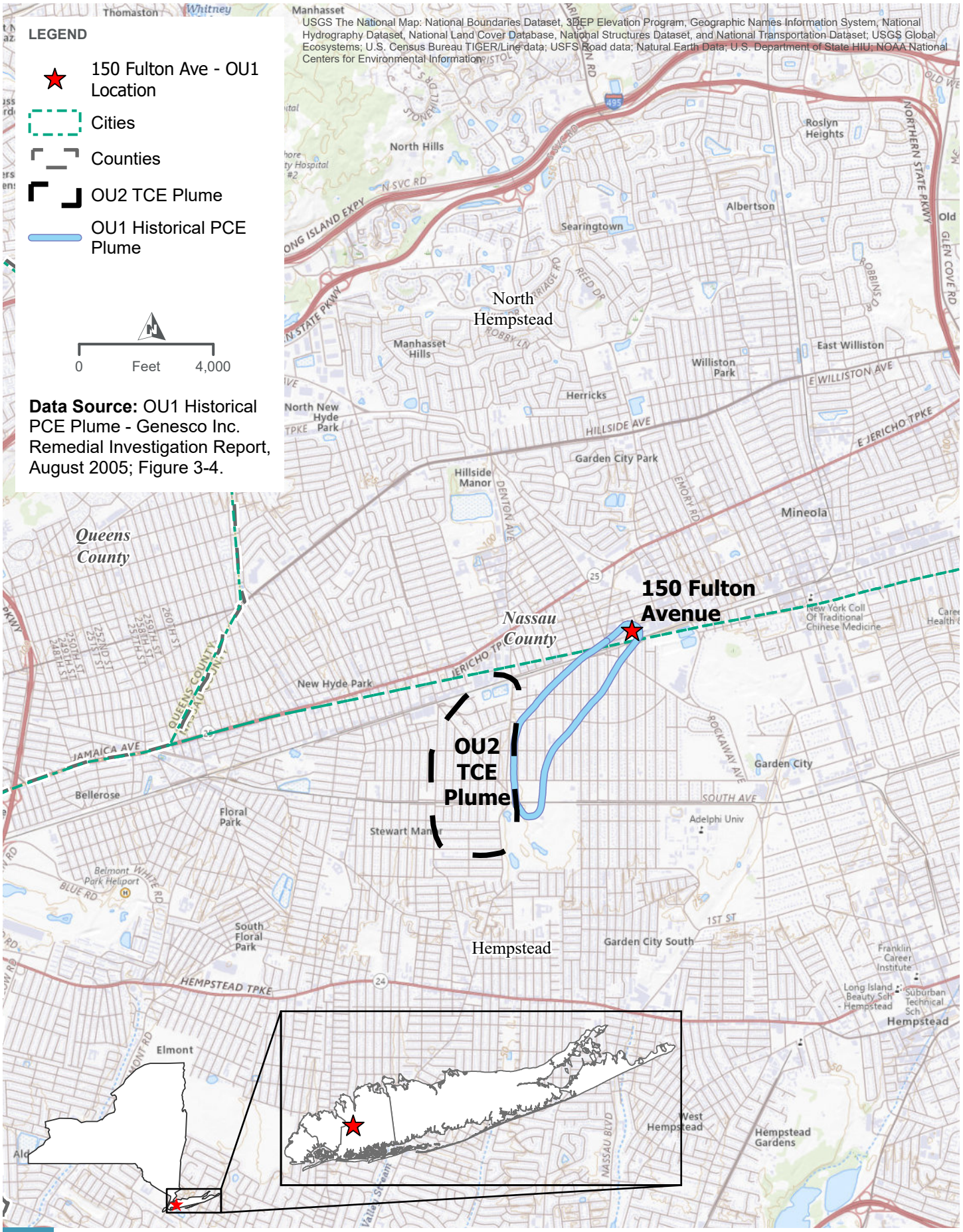
Table 9-1
Comparative Analysis of Remedial Alternatives
Fulton Avenue Superfund Site OU2
Garden City, New York

Alt. No.	Alternative Name	Overall Protection of Public Health and the Environment	Compliance with ARARs	Long Term Effectiveness and Permanence	Reduction of Toxicity, mobility or Volume of Contamination thru Treatment	Short Term Impacts and Effectiveness	Implementability	Cost Effectiveness	
1	**No Action**	- Will not meet any of the RAOs.	- Will not comply.	- Contaminants remain in the environment and may transform into other compounds. - Magnitude of potential risks will be unchanged.	- Does not reduce toxicity, mobility or volume of contamination present in the contaminated groundwater.	- Does not result in disruption of operations or pose a short term threat to public health or the environment. - No remedial timeframe is associated with this alternative.	- No technical or administrative difficulties or constraints.	Capital Cost: Total O&M Present Value: Total Present Value Cost:	$ - $ - $ -
2	**ICs with LTM**	-This alternative is protective of the public health by eliminating exposure pathways to contaminated groundwater. -Will meet RAOs by preventing human exposure pathways to contaminants.	-Will comply with ARARs and PRGs will be achieved over a time period of about 30 years. - Natural processes are assumed to achieve RAOs over time.	-COCs would be reduced over time by natural attenuation processes.	-This alternative would reduce the toxicity, mobility, and volume over time as natural processes attenuate the plume.	-Minimal short term impacts, associated with monitoring well installation and sampling.	-This alternative is readily implmentable.	Capital Cost: Total O&M Present Value: Periodic Costs Present Value: Total Present Value Cost:	$ 816,000 $ 1,952,000 $ 432,000 $ 3,200,000
3	**Core of Plume Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM**	-This alternative is protective of the public health and the environment. -Will meet RAOs by preventing human exposure pathways to contaminants, minimizing the migration of contaminated groundwater, and eventually restoring the impacted aquifer to its most beneficial use as a source of drinking water by active remediation in the most contaminated portion of OU2 through a combination of active remediation and ICs.	-Will comply with ARARs and PRGs will be achieved over time, about 30 years. - Active treatment and natural processes are assumed to achieve RAOs.	-Permanent reduction in groundwater contamination from active groundwater remediation area.	-This alternative will provide a reduction in toxicity and volume of the contaminants in groundwater by extracting and treating groundwater from the most contaminated portion of the plume.	-Short term impacts during construction including installation of the extraction well and conveyance piping. Construction of the GWTP and rehabilitation of the recharge basin would also have short term impacts. This would include increased traffic, noise, clearing, grubbing, and site work.	-This alternative is technically implementable using conventional construction methods and equipment. -Potential land acquisition and property access required for construction of extraction well and easements for the conveyance piping, GWTP, and recharge basin could pose challenge. -Services and materials for implementation of this alternative are readily available.	Capital Cost: Total O&M Present Value: Periodic Costs Present Value: Total Present Value Cost:	$ 12,766,000 $ 24,731,000 $ 1,127,000 $ 38,624,000



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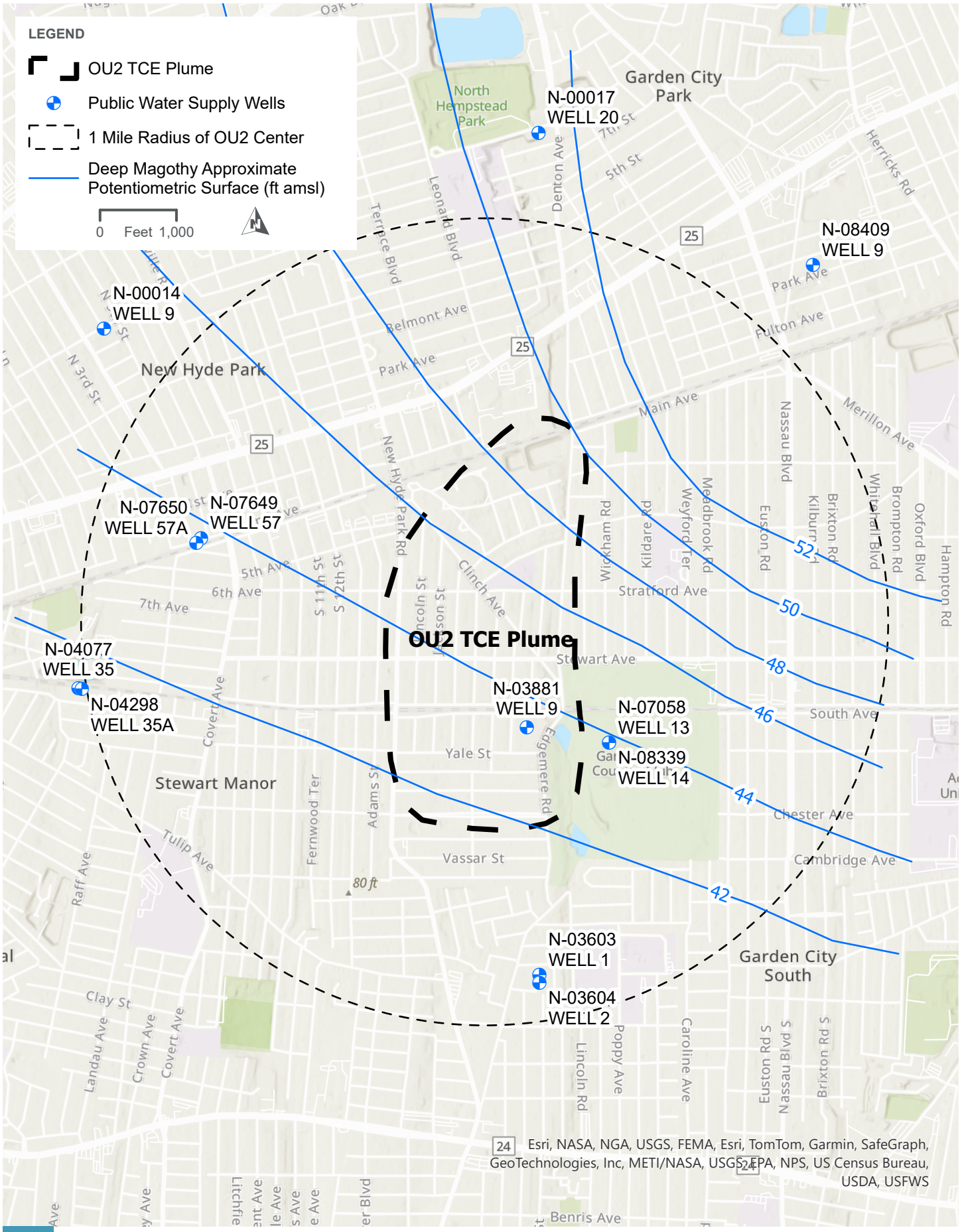
SITE LOCATION MAP

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-1



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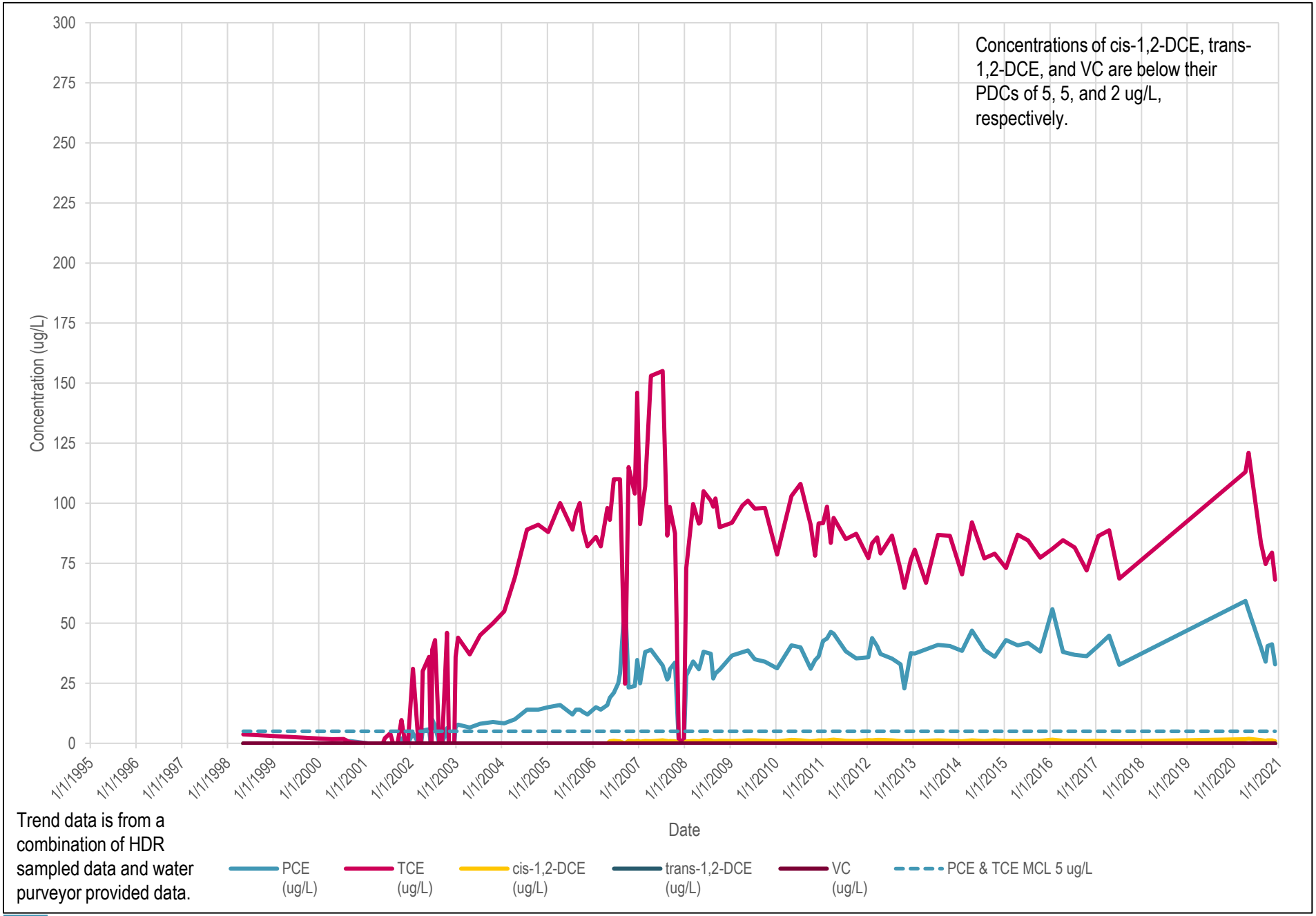
NEARBY PUBLIC WATER SUPPLY WELLS

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-2

N-03881 (Garden City Well 9)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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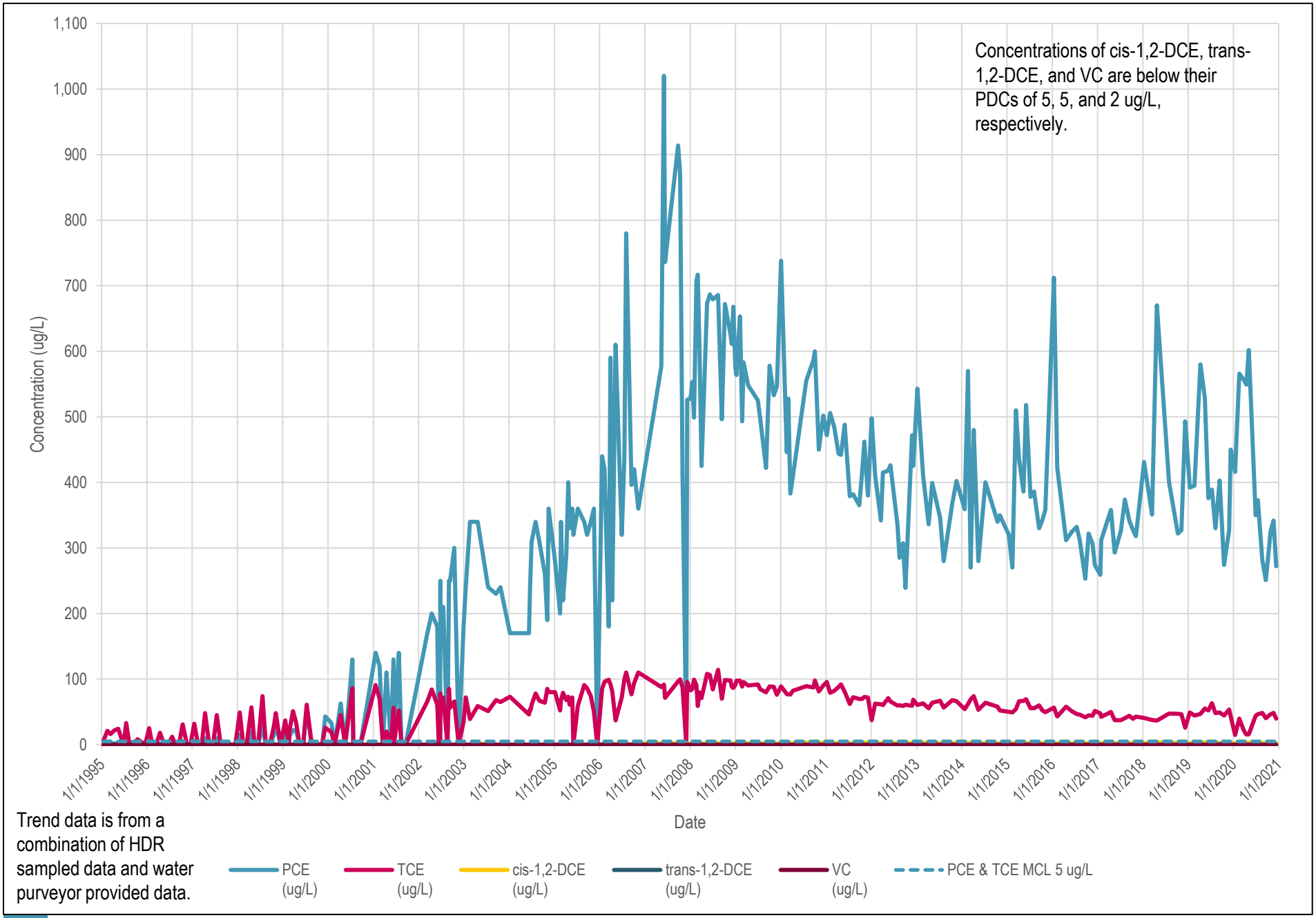
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-03881
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-3
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-07058 (Garden City Well 13)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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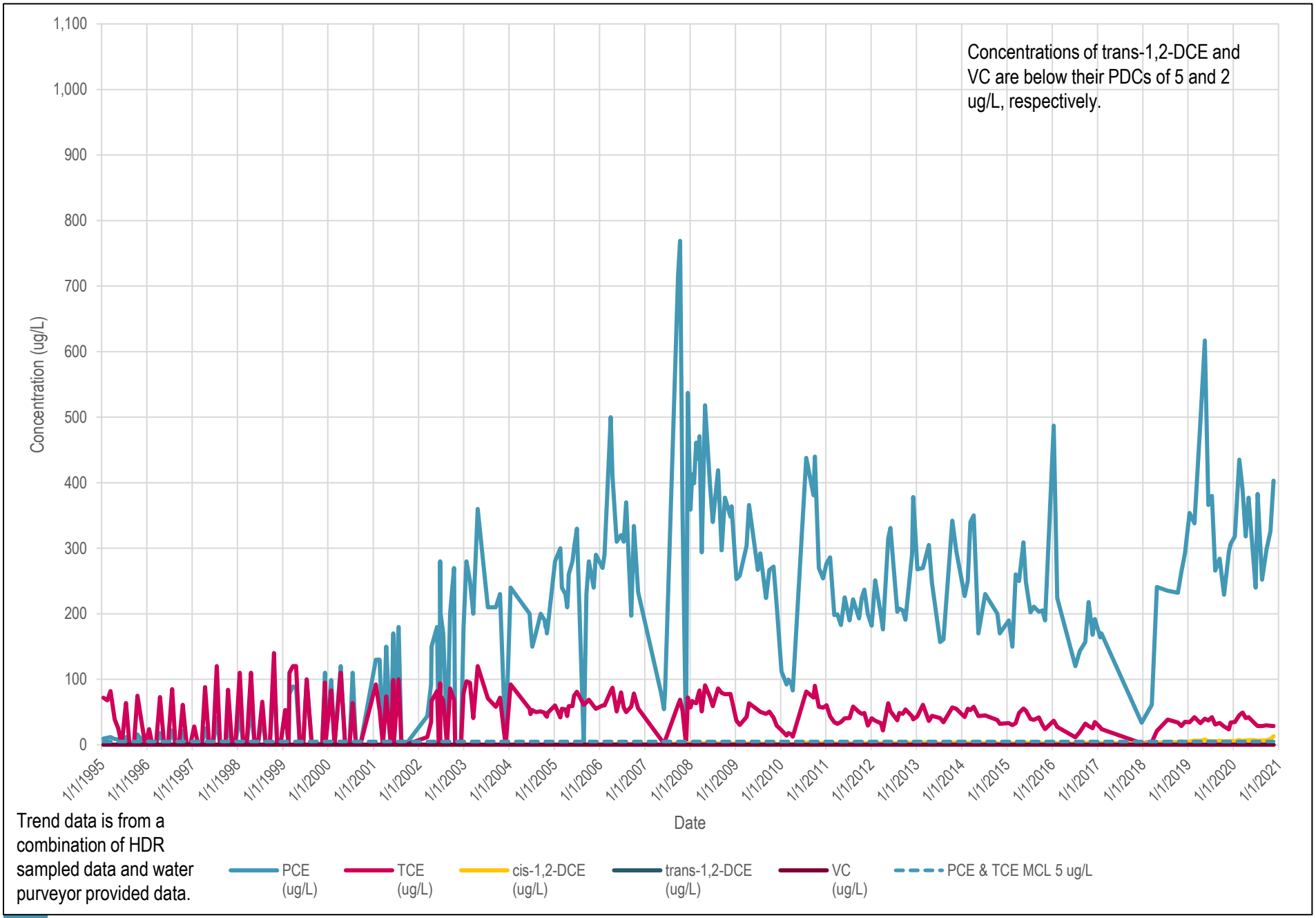
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-07058
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-4
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-08339 (Garden City Well 14)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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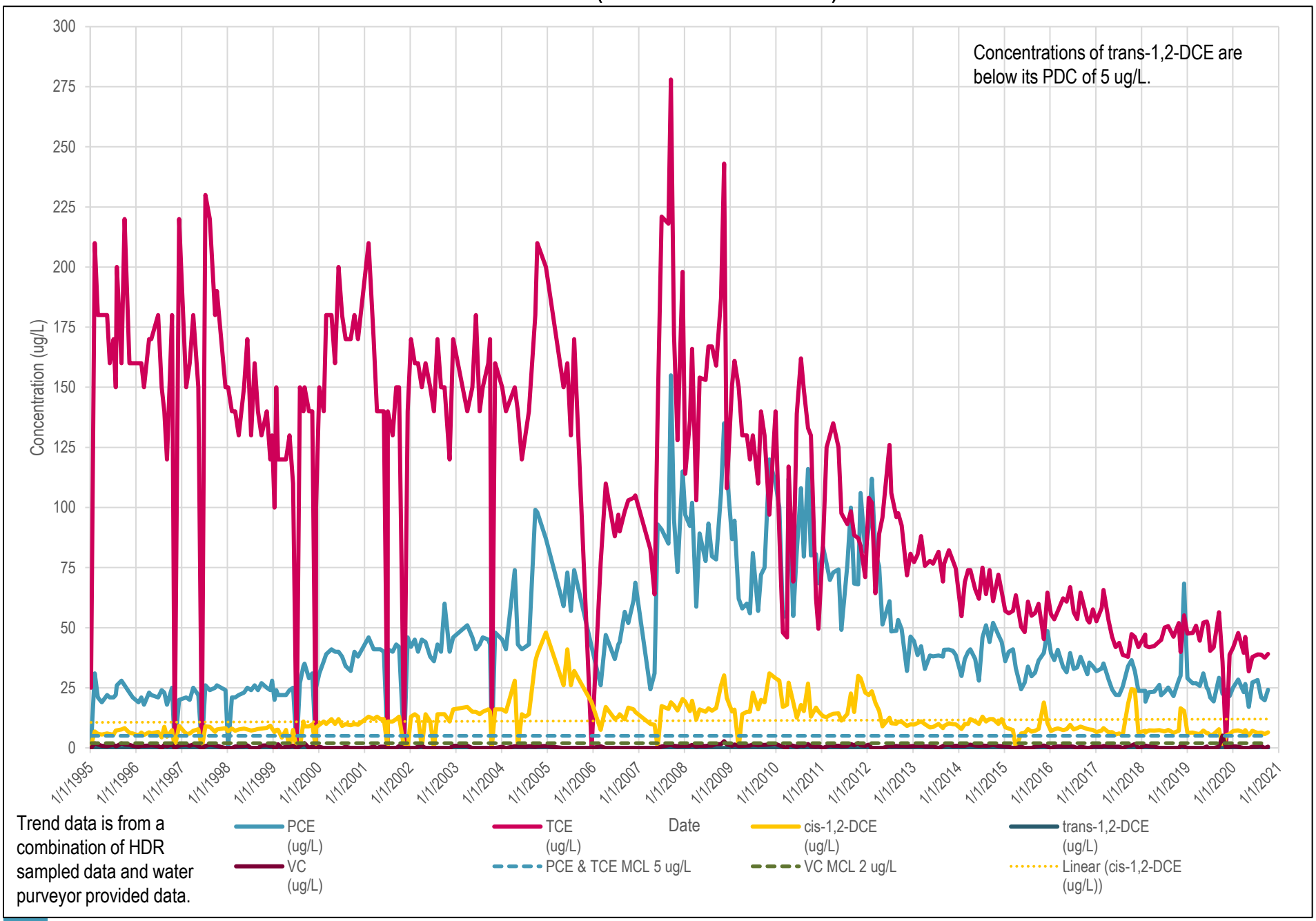
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-08339
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-5
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-07649 (WAWNC Well 57)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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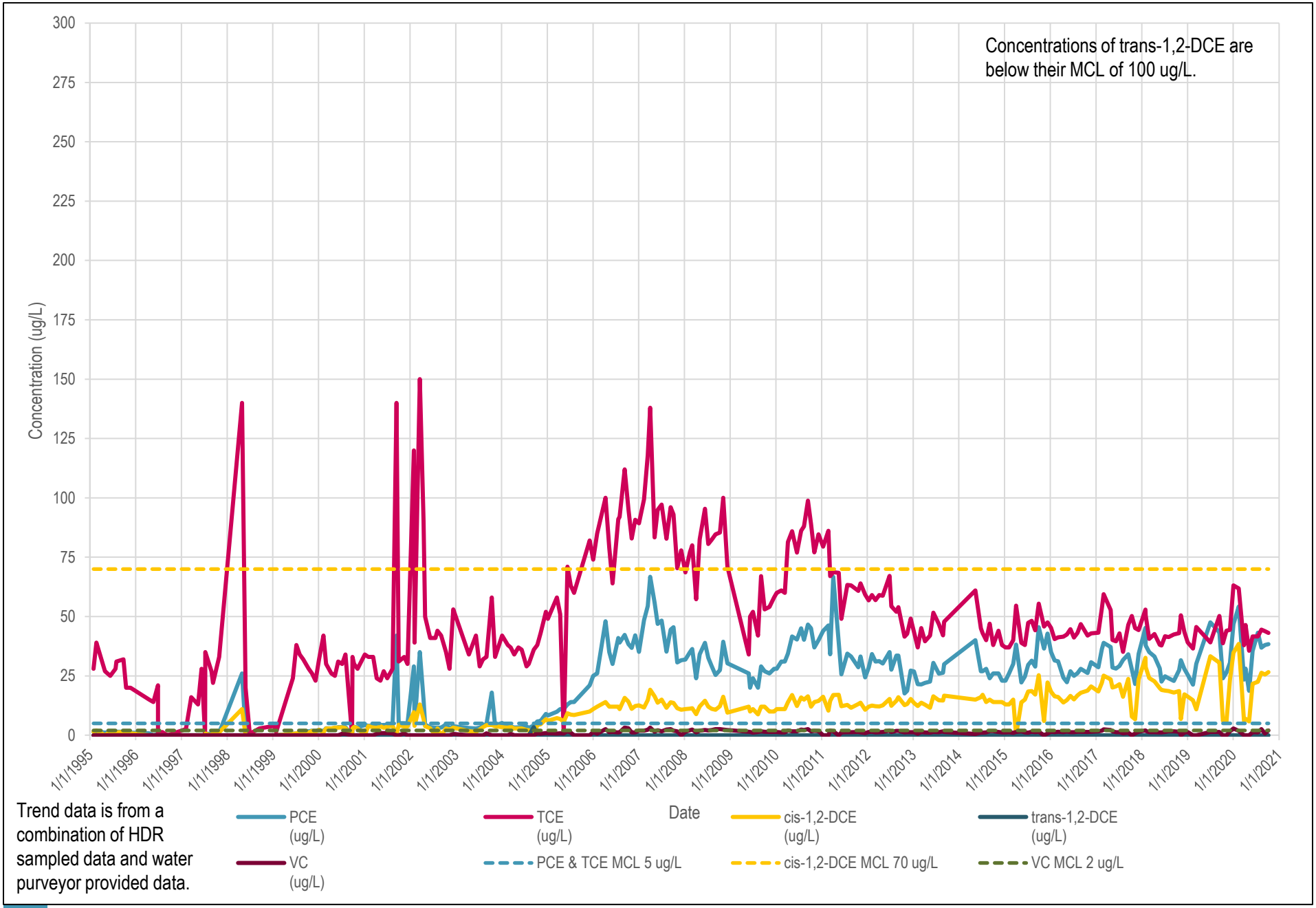
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-07649
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-6
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-07650 (WAWNC Well 57A)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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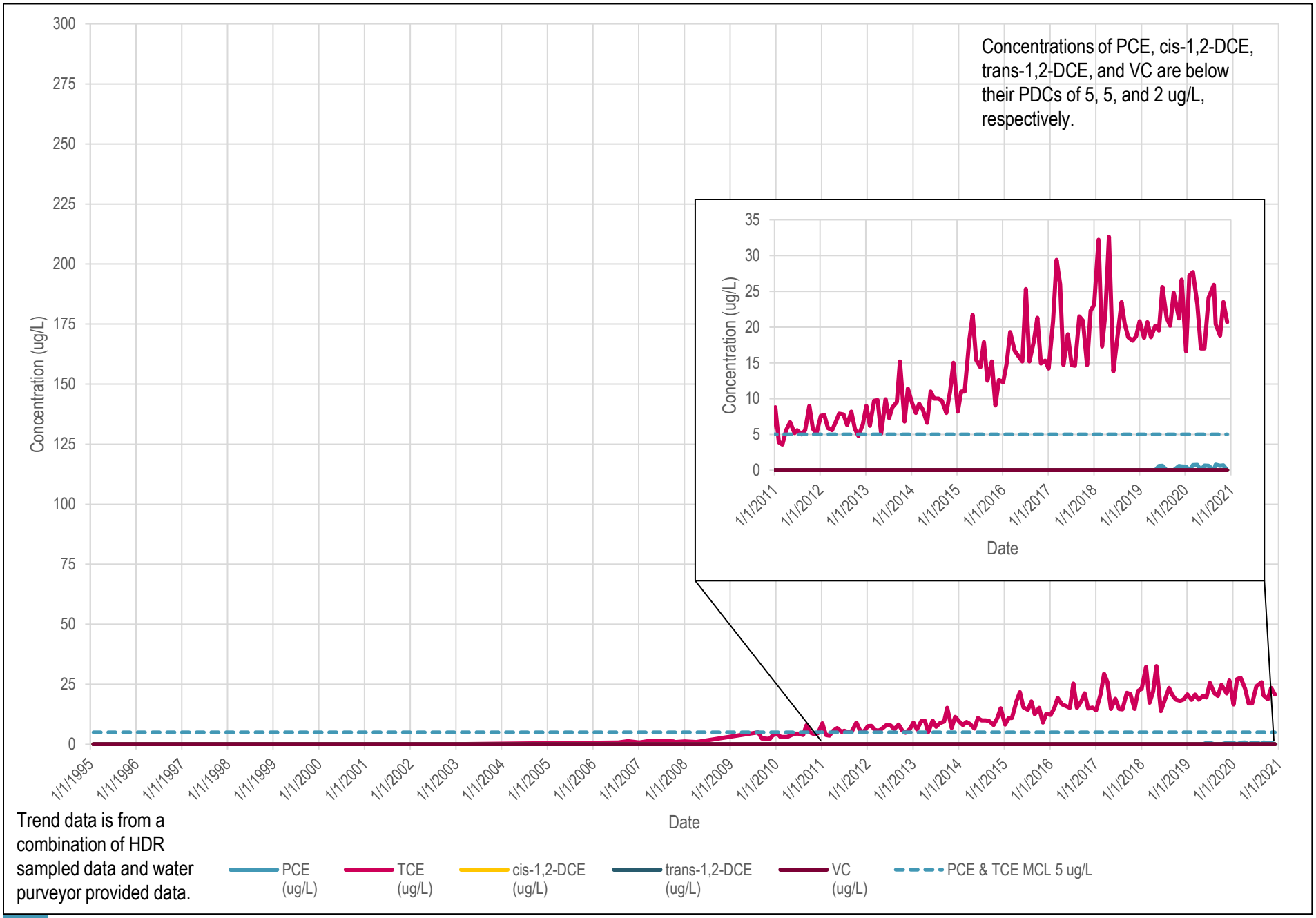
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-07650
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-7
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-03603 (Franklin Square Well 1)



Trend data is from a combination of HDR sampled data and water purveyor provided data.

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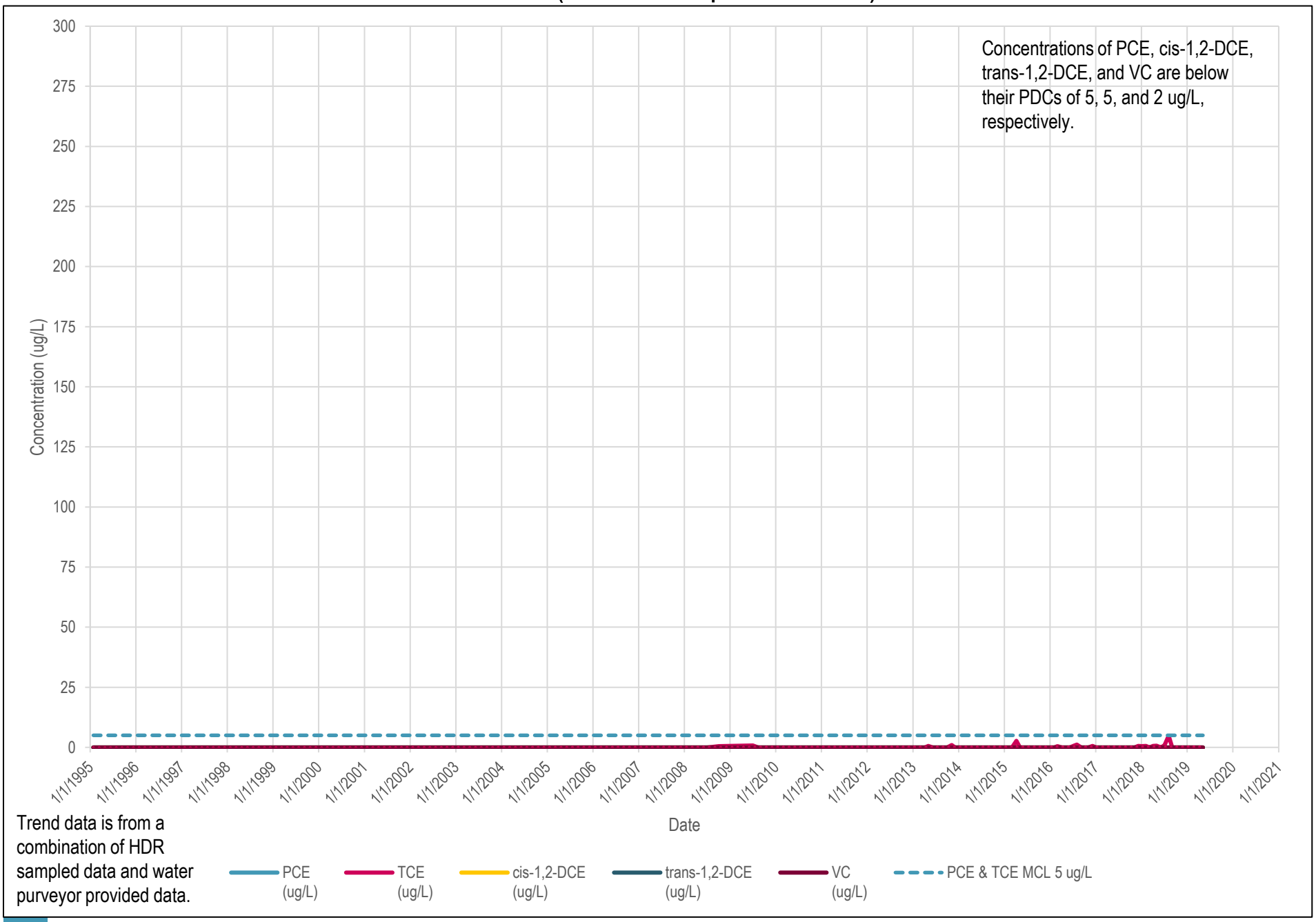
PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-03603
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-8
FULTON AVE OU2 FS

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\100425844.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

N-03604 (Franklin Square Well 2)



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PUBLIC WATER SUPPLY WELL CONCENTRATION VOC N-03604
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-9
FULTON AVE OU2 FS

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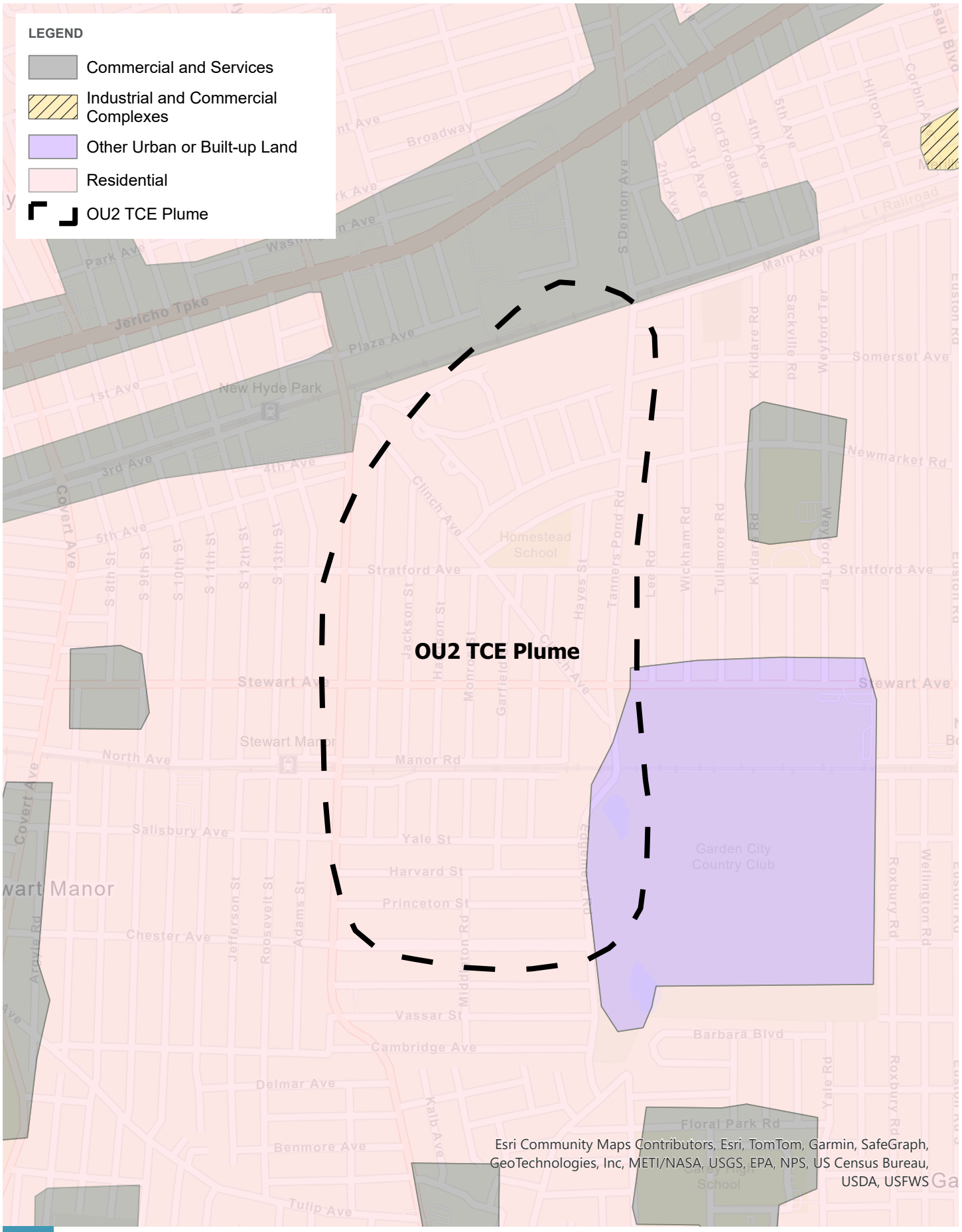

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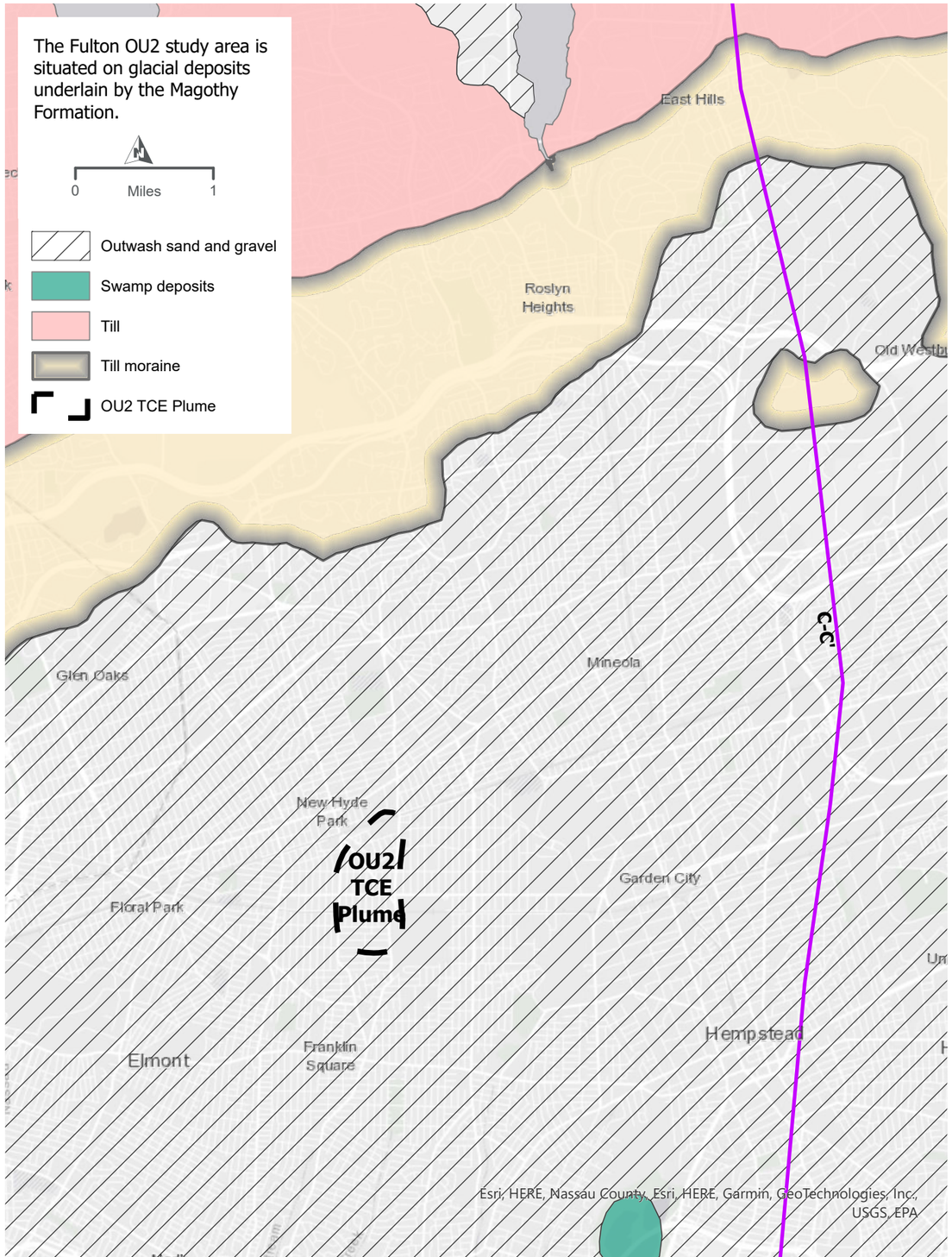
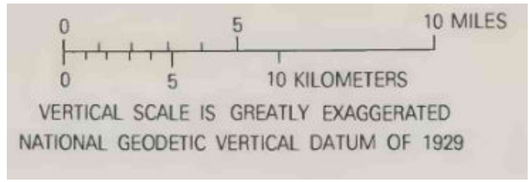
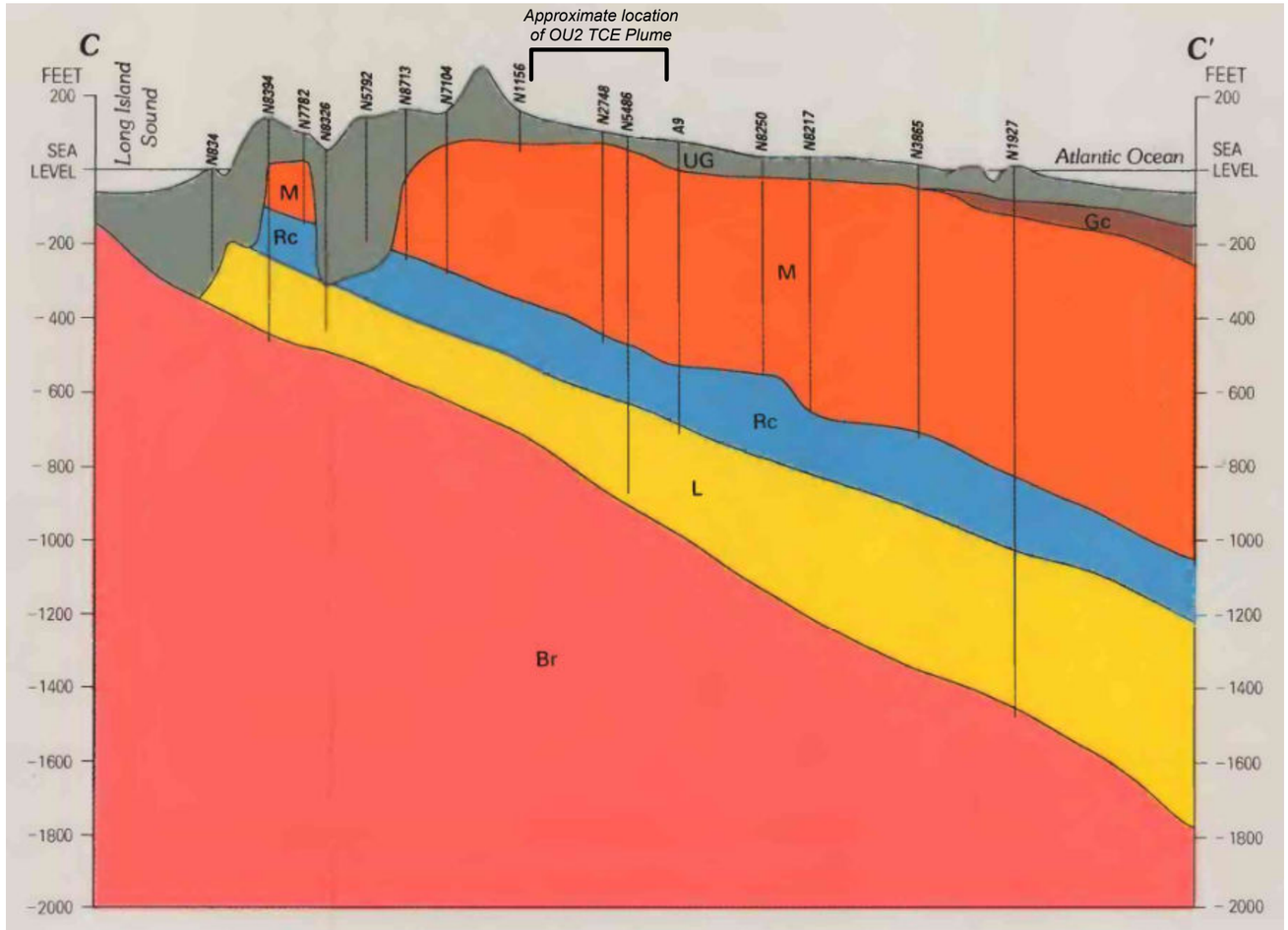
0 Feet 1,000

LAND USE AND LAND COVER
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-10





DATA SOURCE:
Hydrologic framework of Long Island, New York
Hydrologic Atlas 709
By: Douglas A. Smolensky, Herbert T. Buxton, and Peter K. Shernoff



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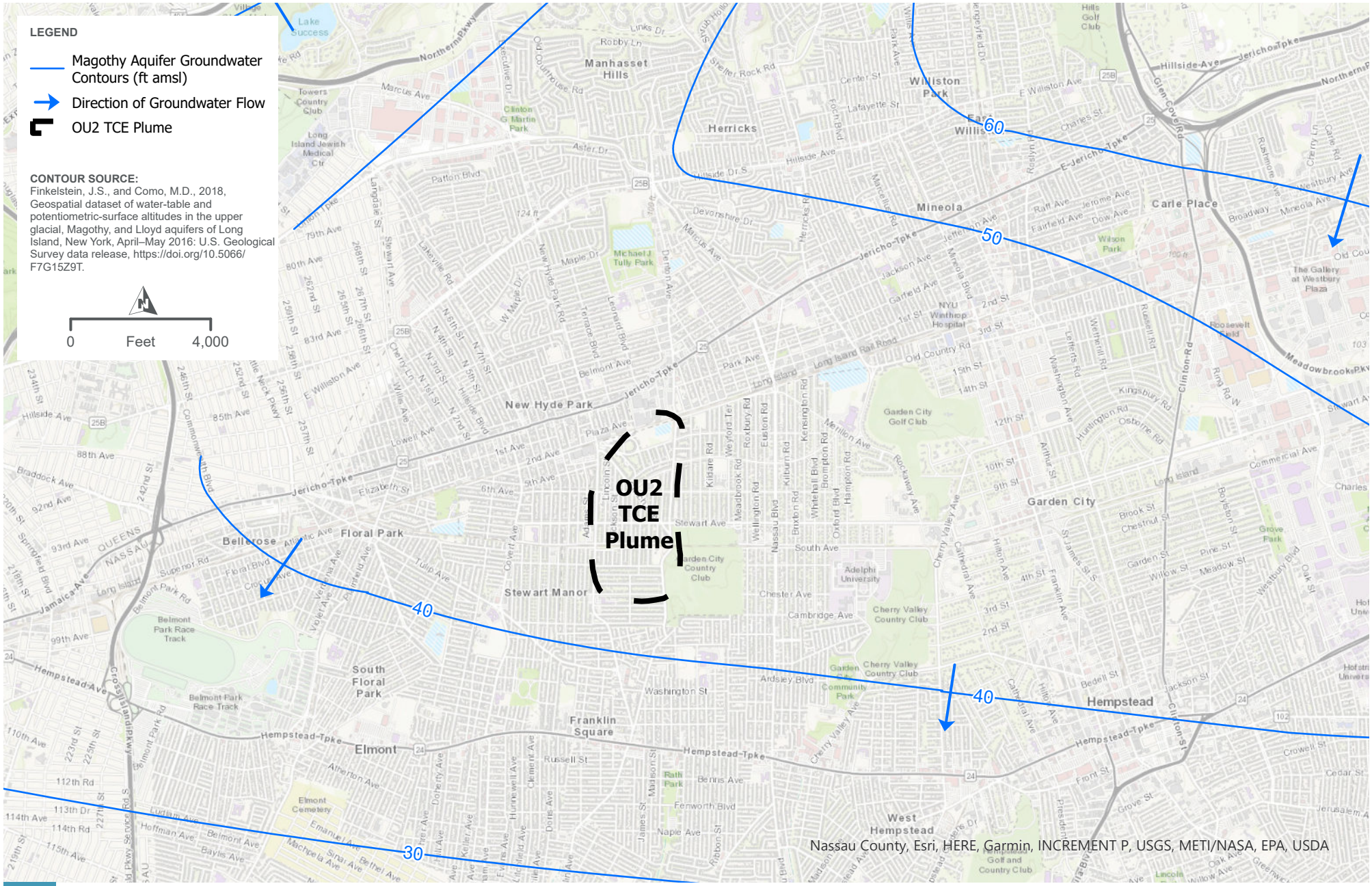
PLAN VIEW AND CROSS SECTION GEOLOGY
FULTON AVE SUPERFUND SITE OU2
FIGURE 2-11



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REGIONAL POTENTIOMETRIC SURFACE OF MAGOTHY AQUIFER

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-12

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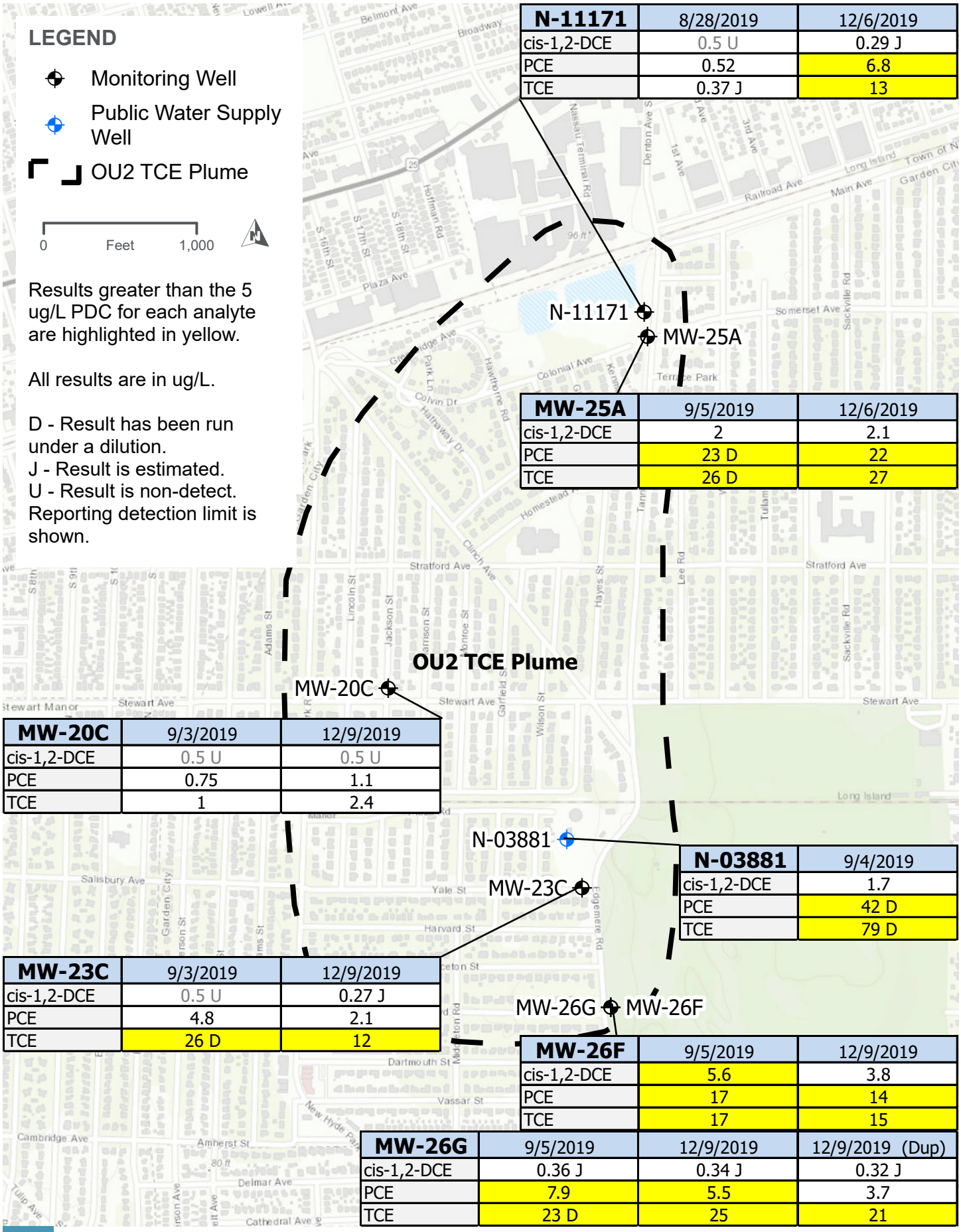
SURFACE WATER AND RECHARGE LOCATIONS

FULTON AVE SUPERFUND SITE OU2

FIGURE 2-13



N-11171	8/28/2019	12/6/2019
cis-1,2-DCE	0.5 U	0.29 J
PCE	0.52	6.8
TCE	0.37 J	13

MW-25A	9/5/2019	12/6/2019
cis-1,2-DCE	2	2.1
PCE	23 D	22
TCE	26 D	27

MW-20C	9/3/2019	12/9/2019
cis-1,2-DCE	0.5 U	0.5 U
PCE	0.75	1.1
TCE	1	2.4

N-03881	9/4/2019
cis-1,2-DCE	1.7
PCE	42 D
TCE	79 D

MW-23C	9/3/2019	12/9/2019
cis-1,2-DCE	0.5 U	0.27 J
PCE	4.8	2.1
TCE	26 D	12

MW-26F	9/5/2019	12/9/2019
cis-1,2-DCE	5.6	3.8
PCE	17	14
TCE	17	15

MW-26G	9/5/2019	12/9/2019	12/9/2019 (Dup)
cis-1,2-DCE	0.36 J	0.34 J	0.32 J
PCE	7.9	5.5	3.7
TCE	23 D	25	21

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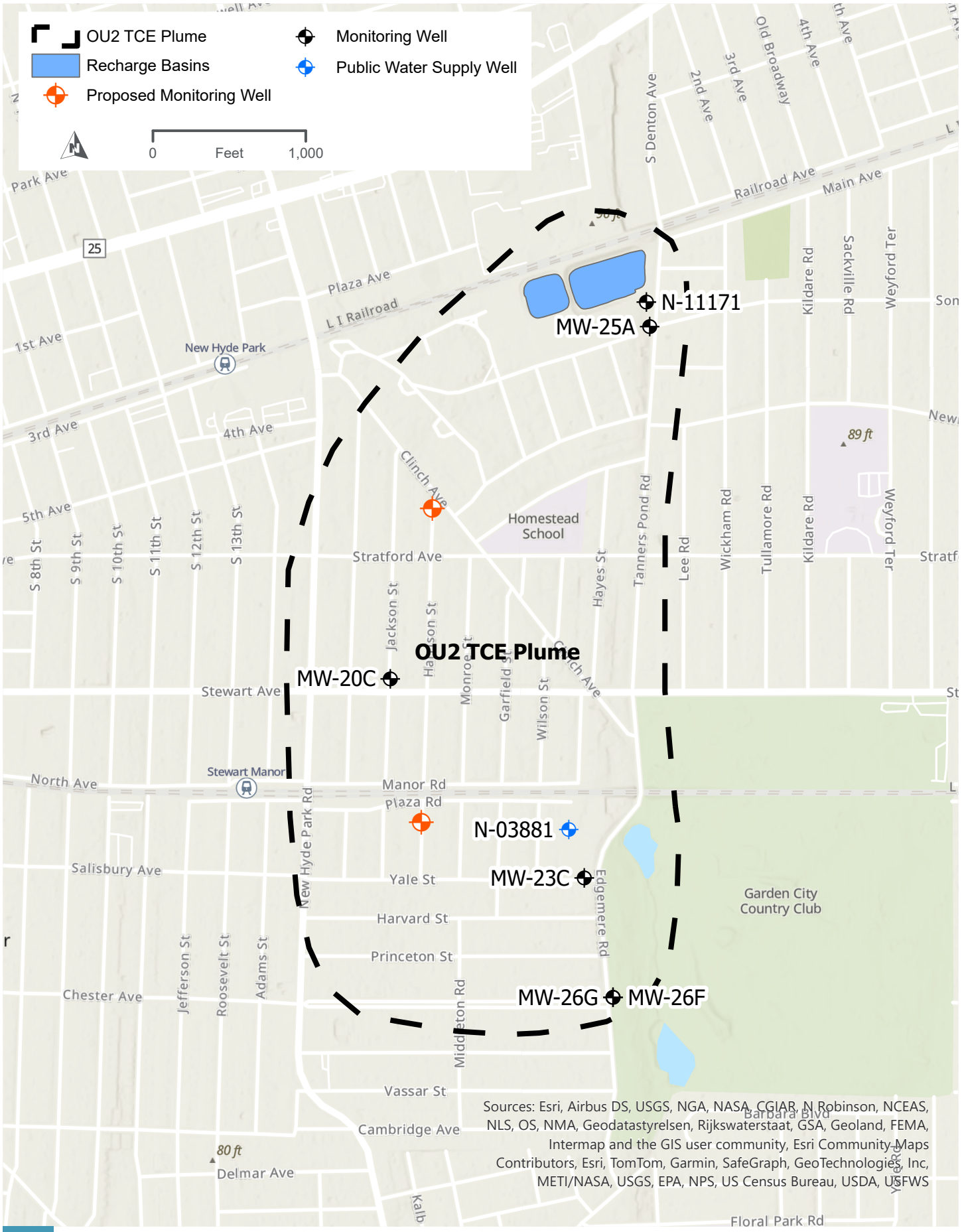
DISTRIBUTION OF VOCS EXCEEDING THE POTENTIAL DELINEATION CRITERIA IN GROUNDWATER SAMPLES

FULTON AVE SUPERFUND SITE OU2

FIGURE 3-1



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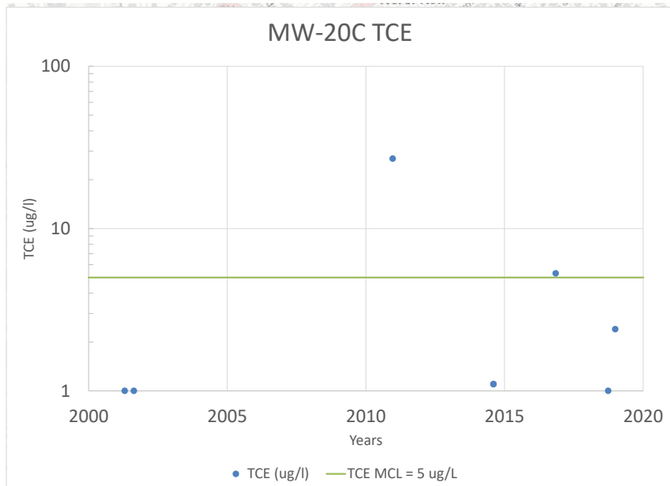
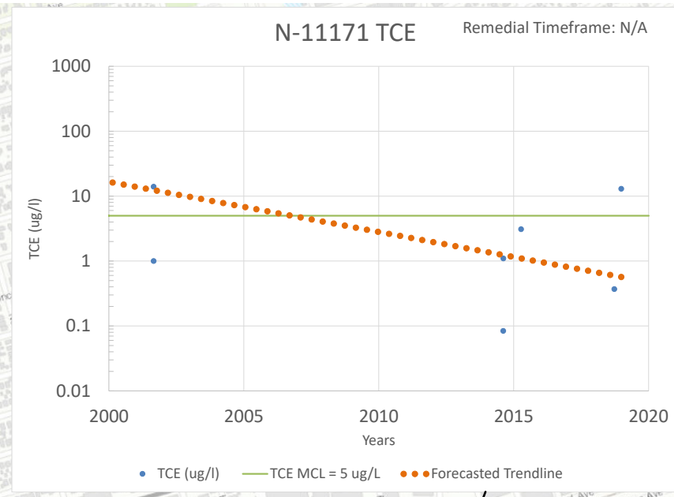
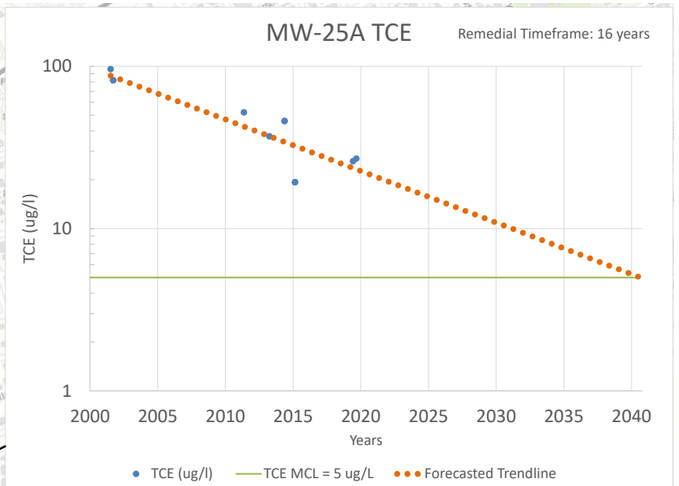
ALTERNATIVE 2 - ICS WITH LTM

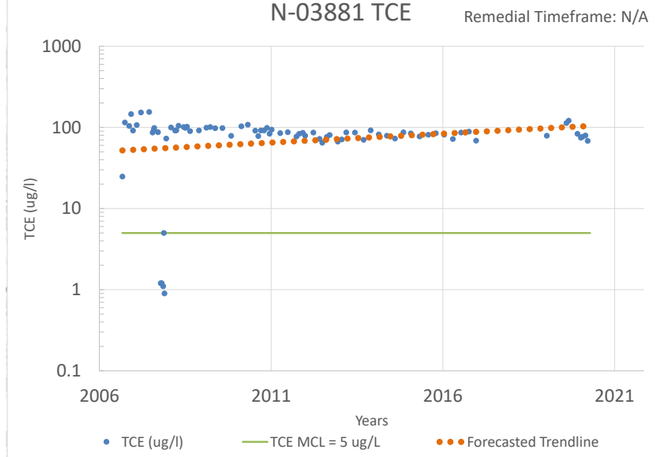
FULTON AVE SUPERFUND SITE OU2

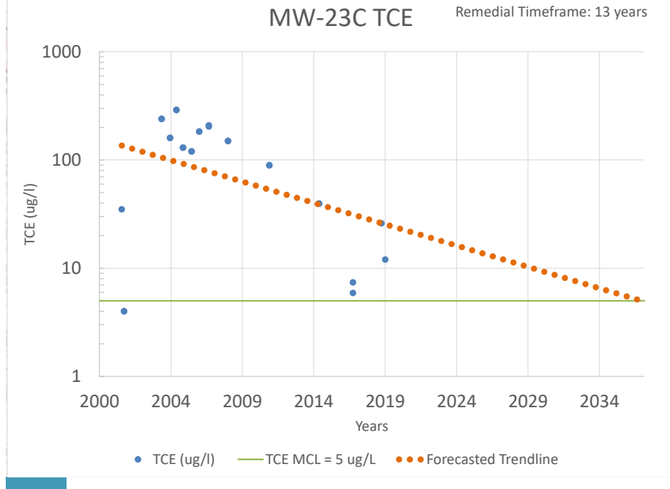
FIGURE 8-1

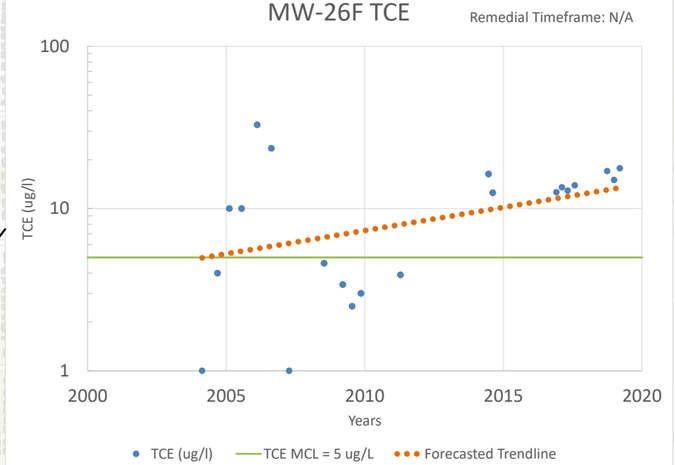


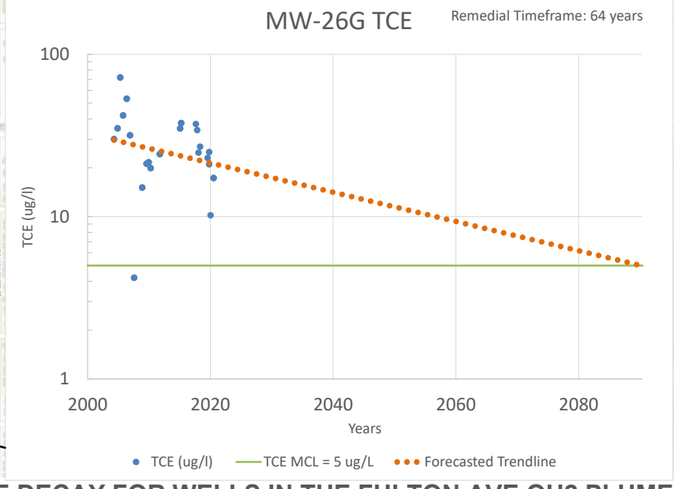








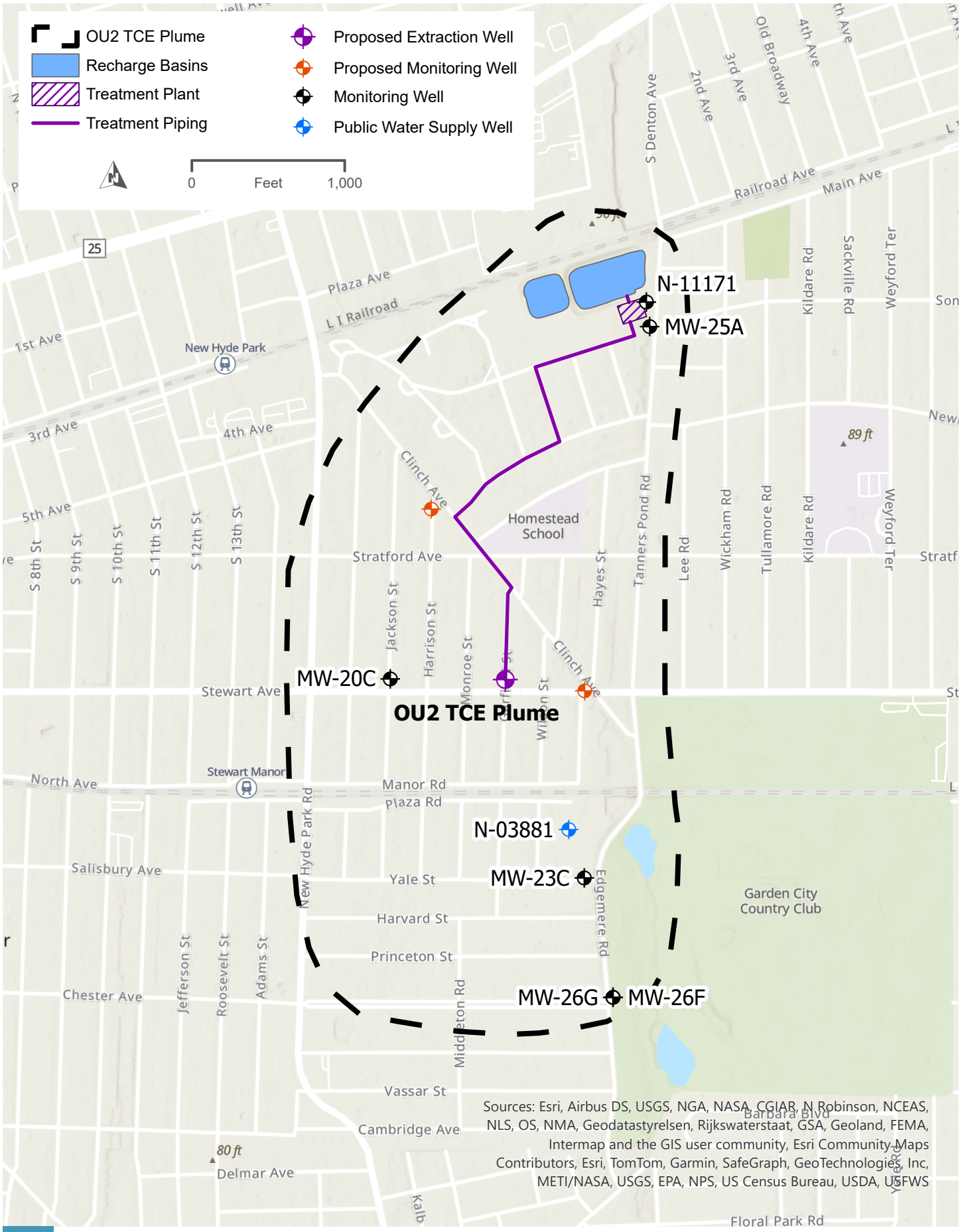




FIRST ORDER RATES OF TCE DECAY FOR WELLS IN THE FULTON AVE OU2 PLUME

FULTON AVE SUPERFUND SITE OU2

FIGURE 8-2



ALTERNATIVE 3 - CORE OF THE PLUME GROUNDWATER REMEDIATION: GROUNDWATER EXTRACTION, TREATMENT, GROUNDWATER DISCHARGE, ICS, AND LTM
FULTON AVE SUPERFUND SITE OU2

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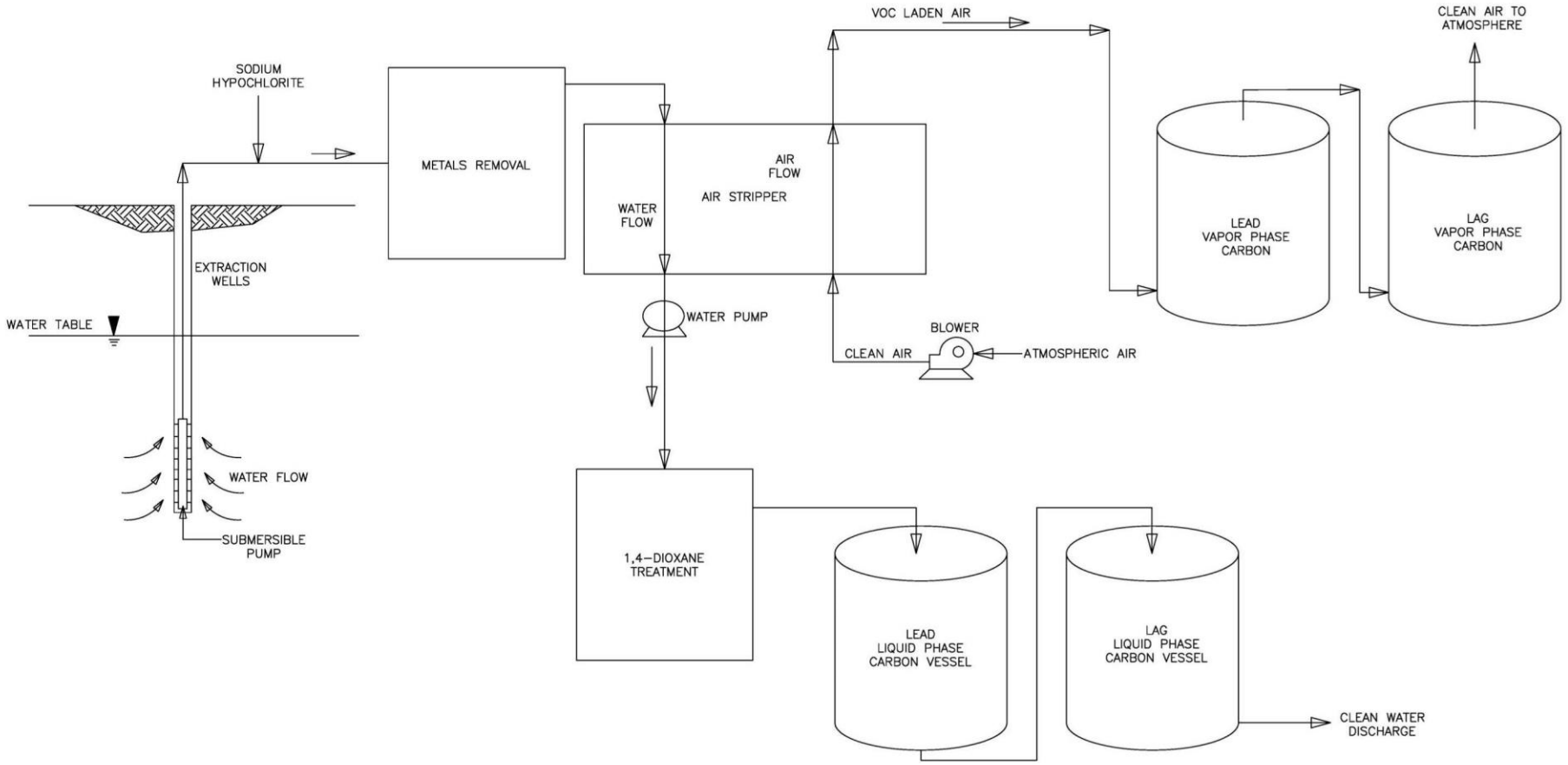
FIGURE 8-3



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TYPICAL GROUNDWATER TREATMENT SYSTEM PROCESS FLOW DIAGRAM
FULTON AVE SUPERFUND SITE OU2
FIGURE 8-4

PATH: \\nj-mahwah\ActiveProjects\6706\20000051\10042584\4.0_Data_Ref_Info\4.2_WIP\Analysis Outputs\VOCs_TrendCharts

Appendix A

Cost Estimate

Summary of Costs			2024
Site:	Fulton Avenue Superfund Site - Operable Unit 2	**Date:**	August 14, 2024
Location:	Nassau County, New York		
Phase:	Feasibility Study (-30% - +50%)		

Description	**Alternative 1**	**Alternative 2**	**Alternative 3**
	No Action	ICs with LTM	Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM
Estimated Project Duration with LTM for FS (Years)	-	30	30
Capital Cost	$ -	$ 816,000	$ 12,766,000
Total O&M Cost (NPV)	$ -	$ 1,952,000	$ 24,731,000
Total Periodic Cost (NPV)	$ -	$ 432,000	$ 1,127,000
Total Present Value of Options	**$ -**	**$ 3,200,000**	**$ 38,624,000**

HDR APTIM
a Joint Venture

Table A-1 - Alternative 1 Cost Breakdown

No Action

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: No Action

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
1	**TOTAL CAPITAL COST**				**$ -**	

O&M COST:

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
2	**Long-Term Monitoring and Reporting**					
2.1	LTM	0	LS	$ -	$ -	
	Sub-Total				**$ -**	
	Project Management	5%			$ -	
	Contingency	10%			$ -	5% scope + 5% bid.
	Sub-Total				**$ -**	

PERIODIC COSTS:

Item No.	Description	Year	Quantity	Unit	Unit Cost	Total	Notes
3	**ICs**						
3.1	ICs	5	0	LS	$ -	$ -	
	Sub-Total					**$ -**	
	Project Management		5%			$ -	
	Contingency		10%			$ -	5% scope + 5% bid.
	Sub-Total					**$ -**	

PRESENT VALUE ANALYSIS: Discount Rate 3%

Item No.	Cost Type	Year	Total Cost	Present Value	Notes
1	**CAPITAL COSTS:**	0	$ -	**$ -**	
2	**OPERATIONAL AND MAINTENANCE COSTS:**				
2.1	Long-Term Monitoring and Reporting		$ -	$ -	Annual cost for the life of the system
	Sub-Total			**$ -**	**NPV Assuming 3% Discount Rate**
3	**PERIODIC COSTS:**				
3.1	ICs	5	$ -	$ -	Every 5 years
	Sub-Total			**$ -**	**NPV Assuming 3% Discount Rate**
	TOTAL PRESENT VALUE OF ALTERNATIVE			**$ -**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Table A-2 - Alternative 2 Cost Breakdown

ICs with LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 2 consists ICs and long-term monitoring. It includes a pre-design investigation to deterine the area for ICs and to install wells to include in the long-term monitoring program.

Item No.	Description	Quantity	Unit		Unit Cost		Total	Notes
	Number of ~500 ft deep monitoring wells (PDI/LTM)	2						
1. CAPITAL COSTS:								
1.1	**Pre-Design Investigation**							
1.1.1	Site Preparation	1	LS	$	142,500	$	142,500	Includes Work Plan and Site Clearing
1.1.2	Well Driller Mob/Demob	1	LS	$	75,000	$	75,000	
1.1.3	Monitoring Well Installation	2	EA	$	185,400	$	370,800	2.5-inch diameter; 500 ft deep.
1.1.4	Baseline Groundwater Sampling & Analyses (VOCs and Metals only)	1	EA	$	22,500	$	22,500	Includes 2 new and 7 existing wells
1.1.5	Pre-Construction Survey	1	LS	$	30,000	$	30,000	Aerial/Topographic Survey.
1.1.6	Data Reduction, Evaluation, and Reporting	1	LS	$	35,000	$	35,000	
	Sub-Total					**$**	**675,800**	
Sub-Total						**$**	**675,800**	Sub-Total All Construction Costs.
	Contingency	15%				$	101,000	10% scope + 5% bid.
Sub-Total						**$**	**776,800**	
Project Management		5%				$	39,000	
TOTAL CAPITAL COST						**$**	**816,000**	

2. OPERATIONAL AND MAINTENANCE COSTS:

Item No.	Description	Quantity	Unit		Unit Cost	Total	Notes
2.1	**Annual Site-Wide Long-Term Monitoring**						
2.1.1	Site Management Plan (Year 1)	1	EA		30,000	**$ 30,000**	SMP prepared prior to first sampling event.
2.1.2	Annual Site-Wide Long-Term Monitoring (Year 1-5)	4	EA	$	55,500	**$ 222,000**	Quarterly Sampling
2.1.3	Annual Site-Wide Long-Term Monitoring (Year 6-10)	2	EA	$	55,500	**$ 111,000**	Semi-Annual Sampling
2.1.4	Annual Site-Wide Long-Term Monitoring (Year 11-30)	1	EA	$	55,500	**$ 55,500**	Annual Sampling

3. PERIODIC COSTS:

3.1	**Once in Every 5 Years**						
3.1.1	Well Maintenance	9	EA	$	10,000	$90,000	
3.1.2	Institutional Controls	1	LS	$	25,000	$25,000	
	Sub-Total					**$ 115,000**	
Contingency		10%				$ 12,000	5% scope + 5% bid.
Sub-Total						**$ 127,000**	
Project Management		5%				$ 6,000	
TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30						**$ 133,000**	

PRESENT VALUE ANALYSIS: Rate of Return 7% Inflation Rate 3%

Item No.	Cost Type	Year	Total Cost	Present Value	Notes
1	**CAPITAL COSTS:**	0	$ 816,000	**$ 816,000**	
2	**OPERATIONAL &AND MAINTENANCE COSTS:**				
2.1	Site Management Plan		$ 30,000	$ 29,000	Initial SMP
2.2	Annual Site-Wide Long-Term Monitoring (Year 1-5)		$ 222,000	$ 992,000	Annual cost for year 1-5
2.3	Annual Site-Wide Long-Term Monitoring (Year 6-10)		$ 111,000	$ 410,000	Annual cost for year 6-10
2.4	Annual Site-Wide Long-Term Monitoring (Year 11-30)		$ 55,500	$ 521,000	Annual cost for year 11-30
	Sub-Total			**$ 1,952,000**	**Net Present Value**
3	**PERIODIC COSTS:**				
3.1	TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30		$ 133,000	$ 432,000	Once every 5 years
	Sub-Total			**$ 432,000**	**Net Present Value**
	TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 3,200,000**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Table A-3 - Alternative 3 Cost Breakdown

Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 3 consists of:
1. Installation of one groundwater extraction well in the highest concentration of the downgradient portions of the OU2 contaminated groundwater plume
2. Treatment plant with metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and AOP for 1,4-dioxane treatment
3. Discharge to groundwater via new recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.
4. ICs
5. LTM

Item No.	Description	Quantity	Unit		Unit Cost		Total	Notes
	Number of ~500 ft deep monitoring wells (PDI/LTM)	2						
	Number of ~450 ft deep extraction wells	1						
	Total Number of 500 GPM (0.72 MGD) Treatment Plants	**1**						
	Total Number of New Recharge Basins	**1**						
1. CAPITAL COSTS:								
1.1	**Pre-Design Investigation**							
1.1.1	Site Preparation	1	LS	$	142,500	$	142,500	Includes Work Plan and Site Clearing
1.1.2	Well Driller Mob/Demob	1	LS	$	75,000	$	75,000	
1.1.3	Monitoring Well Installation	2	EA	$	185,400	$	370,800	2.5-inch diameter; 500 ft deep.
1.1.4	Groundwater Sampling & Analyses (VOCs and Metals only)	1	EA	$	22,500	$	22,500	Includes 2 new and 7 existing wells
1.1.5	Pre-Construction Survey	1	LS	$	30,000	$	30,000	Aerial/Topographic Survey.
1.1.6	Pilot/Treatiability Test	1	LS	$	100,000	$	100,000	Air stripper, AOP and carbon evaluation.
1.1.7	Data Reduction, Evaluation, and Reporting	1	LS	$	75,000	$	75,000	Includes reducing data generating, isoconcentration maps, and producing report
	Sub-Total					**$**	**815,800**	
1.2	**Extraction Well - Site Preparation**							
1.2.1	Site Clearing	1	LS	$	10,000	$	10,000	
1.2.2	Property Acquisition	1	EA	$	1,300,000	$	1,300,000	For extraction well and booster pump station
1.2.3	Pre-Construction Submittals/Permits	1	LS	$	25,000	$	25,000	
1.2.4	Baseline Groundwater Sampling	1	EA	$	22,500	$	22,500	
	Sub-Total					**$**	**1,357,500**	
1.3	**Extraction Well - Installation**							
1.3.1	Mobilization (Well Installation)	1	LS	$	125,000		$125,000	
1.3.2	Extraction Well Installation (~ 450 feet bgs)	1	EA	$	591,400		$591,400	
1.3.3	Aquifer Pump Test	1	LS	$	350,000	$	350,000	72-hour pump test at extraction well. Nine locations set up with transducers. Water to frac tank for IDW handling (below). Includes reporting.
1.3.4	IDW	2,160,000	Gallons	$	0.20	$	432,000	Pumping tests. Assumes 500 gpm for 72 hours and discharge to sewer system through temporary treatment.
1.3.5	Extraction Well Electrical, Instrumentation and Permitting	1	EA	$	346,500		$346,500	
	Sub-Total					**$**	**1,844,900**	
1.4	**Treatment - ~500 GPM (0.72 MGD)**							
1.4.1	Land Acquisition for Treatment Plant	1	EA	$	-		$0	Property of Nassau County
1.4.2	~ 500 GPM (0.72 MGD) Plant Building Construction	1	EA	$	459,100		$459,100	
1.4.3	Site Work	1	EA	$	146,700		$146,700	
1.4.4	Electrical & Instrumentation	1	EA	$	1,025,000		$1,025,000	
1.4.5	Process Equipment	1	EA	$	2,126,900		$2,126,900	
1.4.6	Start-Up and Reporting	1	EA	$	321,000		$321,000	
	Sub-Total					**$**	**4,078,700**	
1.5	**Discharge - Existing Recharge Basin (up to 500 gpm)**							
1.5.1	Land Cost	0.8	Acre	$	-		$0	
1.5.2	Site Preparation	1	LS	$	50,000		$50,000	Mobilization, Soil E & D Control, Site Civil
1.5.3	Recharge Basin Rehabilitation	339,800	Cubic Ft	$	0.65		$220,870	
1.5.4	Miscellaneous Cost	1	LS	$	77,315		$77,315	
	Sub-Total					**$**	**348,185**	
1.6	**Conveyance System**							
1.6.1	Pipe Conveyance	1	LS	$	1,626,800		$1,626,800	
1.6.2	Pumps and Booster Stations	1	LS	$	500,000		$500,000	
	Sub-Total					**$**	**2,126,800**	
	Sub-Total					**$**	**10,571,885**	Sub-Total All Construction Costs.
	Contingency	15%				$	1,586,000	10% scope + 5% bid.
	Sub-Total					**$**	**12,157,885**	
	Project Management	5%				$	608,000	
	TOTAL CAPITAL COST					**$**	**12,766,000**	

Table A-3 - Alternative 3 Cost Breakdown

Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 3 consists of:
1. Installation of one groundwater extraction well in the highest concentration of the downgradient portions of the OU2 contaminated groundwater plume
2. Treatment plant with metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and AOP for 1,4-dioxane treatment
3. Discharge to groundwater via new recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.
4. ICs
5. LTM

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes
2. OPERATIONAL AND MAINTENANCE COSTs:						
2.1	**Annual O & M (Extraction & Treatment)**					
2.1.1	Annual Power (Extraction)	1	EA	$ 70,000	$70,000	
2.1.2	Annual Power (Pump Stations)	1	EA	$ 70,000	$70,000	
2.1.3	Annual Operational Labor	1	EA	$ 136,700	$136,700	
2.1.4	Annual Power (Treatment)	1	EA	$ 343,800	$343,800	
2.1.5	Annual Material/Chemicals Usage	1	EA	$ 315,800	$315,800	
2.1.6	Annual System Maintenance	1	EA	$ 51,400	$51,400	
2.1.7	Treatment Plant Monitoring	1	EA	$ 116,600	$116,600	
	Sub-Total				**$ 1,104,300**	
2.2	**Recharge Basin Maintenance**					
2.2.1	Recharge Basin Maintenance (~500 GPM)	1	EA	$ 20,400	$20,400	
	Sub-Total				**$ 20,400**	
	Sub-Total				**$ 1,124,700**	Sub-Total Annual O & M Costs.
	Contingency	10%			$ 112,000	5% scope + 5% bid.
	Sub-Total				**$ 1,236,700**	
	Project Management	5%			$ 62,000	
	Total Annual O & M (Extraction and Treatment) (0-30)				**$ 1,298,700**	
2.3	**Annual Site-Wide Long-Term Monitoring**					
2.1.1	Site Management Plan (Year 1)	1	EA	30,000	**$ 30,000**	SMP prepared prior to first sampling event.
2.3.1	Annual Site-Wide Long-Term Monitoring (Year 1-5)	4	EA	$ 55,500	**$ 222,000**	
2.3.2	Annual Site-Wide Long-Term Monitoring (Year 6-10)	2	EA	$ 55,500	**$ 111,000**	
2.3.3	Annual Site-Wide Long-Term Monitoring (Year 11-30)	1	EA	$ 55,500	**$ 55,500**	
3. PERIODIC COSTS:						
3.1	**Once in Every 2 Years**					
3.1.1	Extraction Well Pump Rehabilitation	1	EA	$ 15,000	$15,000	stopped here
	Contingency	15%			$ 2,000	10% scope + 5% bid.
	Sub-Total				**$ 17,000**	
	Project Management	5%			$ 1,000	
	Technical Support	3%			$ 1,000	
	TOTAL PERIODIC COSTS @ EVERY 2 YEARS				**$ 19,000**	
3.2	**Once in Every 5 Years**					
3.2.1	Well Maintenance	1	EA	$ 80,000	$80,000	
3.2.2	Bag Filter Pump Replacement	1	EA	$ 25,000	$25,000	
3.2.3	Air Stripper Cleaning	1	EA	$ 24,400	$24,400	
3.2.4	Replace Interconnection Piping and Valves	1	LS	$ 15,000	$15,000	
3.2.5	Institutional Controls	1	LS	$ 25,000	$25,000	
	Sub-Total				**$ 169,400**	
	Contingency	10%			$ 17,000	5% scope + 5% bid.
	Sub-Total				**$ 186,400**	
	Project Management	5%			$ 9,000	
	TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30				**$ 195,400**	
3.3	**Once in Every 10 Years**					
3.3.1	Extraction Well Pump Replacement	10	1	EA	$ 85,000	$85,000
3.3.2	Pump Stations - Pump Replacement	10	1	LS	$ 100,000	$100,000
3.3.3	Recharge Basin Rehabilitation	10	1	LS	$ 8,000	$8,000
	Sub-Total					**$ 193,000**
	Contingency		10%			$ 19,000
	Sub-Total					**$ 212,000**
	Project Management		5%			$ 11,000
	TOTAL PERIODIC COSTS @ YEAR 10, 20 and 30					**$ 223,000**

Table A-3 - Alternative 3 Cost Breakdown

Core of Plume Groundwater Remediation and Discharge of Treated Water to Groundwater, ICs, and LTM

Site: Fulton Avenue Superfund Site - Operable Unit 2
Location: Nassau County, New York
Phase: Feasibility Study (-30% - +50%)
Base Year: 2024
Date: August 14, 2024

Description: Alternative 3 consists of:
1. Installation of one groundwater extraction well in the highest concentration of the downgradient portions of the OU2 contaminated groundwater plume
2. Treatment plant with metals removal system, air stripping, vapor phase GAC adsorption, liquid phase GAC adsorption, and AOP for 1,4-dioxane treatment
3. Discharge to groundwater via new recharge basin at the intersection of Colonial Avenue and Tanners Pond Road.
4. ICs
5. LTM

Item No.	Description	Quantity	Unit	Unit Cost	Total	Notes

PRESENT VALUE ANALYSIS: Rate of Return 7% Inflation Rate 3%

Item No.	Cost Type	Year	Total Cost	Present Value	Notes
1	**CAPITAL COSTS:**	0	$ 12,766,000	**$ 12,766,000**	
2	**OPERATIONAL & MAINTENANCE COSTS:**				
2.1	Total Annual O & M (Extraction and Treatment) (0-30)		$ 1,298,700	$ 22,779,000	Annual cost for the life of the system
2.2	Site Management Plan (Year 1)		$ 30,000	$ 29,000	Initial SMP
2.3	Annual Site-Wide Long-Term Monitoring (Year 1-5)		$ 222,000	$ 992,000	Annual cost for year 1-5
2.4	Annual Site-Wide Long-Term Monitoring (Year 6-10)		$ 111,000	$ 410,000	Annual cost for year 6-10
2.5	Annual Site-Wide Long-Term Monitoring (Year 11-30)		$ 55,500	$ 521,000	Annual cost for year 11-30
	Sub-Total			**$ 24,731,000**	**Net Present Value**
3	**PERIODIC COSTS:**				
3.1	TOTAL PERIODIC COSTS @ EVERY 2 YEARS		$ 19,000	$ 164,000	Every 2 years
3.2	TOTAL PERIODIC COSTS @ YEAR 5, 10, 15, 20, 25 and 30		$ 195,400	$ 635,000	Every 5 years
3.3	TOTAL PERIODIC COSTS @ YEAR 10, 20 and 30		$ 223,000	$ 328,000	Every 10 years
	Sub-Total			**$ 1,127,000**	**Net Present Value**
	TOTAL PRESENT VALUE OF ALTERNATIVE			**$ 38,624,000**	

***** The annual and periodic costs over the life of the system changes on an annual basis as noted. For simplicity, the total O&M and periodic costs over the 30 years are presented.

Appendix B

Natural Attenuation Evaluation

Memo

Date:	Friday, March 15, 2024
Project:	Fulton Avenue Superfund Site OU2 RI/FS
To:	USEPA
From:	HDR-APTIM JV
Subject:	Natural Attenuation Evaluation

This technical memorandum presents the results of a natural attenuation evaluation of trichloroethene (TCE) in the Operable Unit 2 (OU2) of the Fulton Avenue Superfund Site. Data from the Fulton Avenue OU2 Remedial Investigation (RI), previous New York State Department of Environmental Conservation (NYSDEC) investigations and Municipal/County water supply monitoring were used. The memorandum discusses the evaluation process, data analysis and conclusions on the occurrence and extent of TCE attenuation by natural processes at the site.

The evaluation employed several EPA guidance documents and tools related for evaluating natural attenuation at Superfund Sites, including: *Use of Monitored Natural Attenuation at Superfund, RCRA, Corrective Action, and Underground Storage Tank Sites* OSWER Directive Number 9200.4-17P (EPA, 1999), *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater* EPA 600/R-98/128 (EPA, 1998) and other supporting literature. References are provided at the end of the memorandum.

Evaluation Process

As discussed in EPA 600/R-98/128, natural attenuation of TCE and other chlorinated solvents is affected by several destructive and nondestructive processes, including biodegradation, sorption, dispersion and volatilization. The document further indicates that biodegradation, volatilization and discharge to surface water are the key processes that impact natural attenuation of a plume under steady state conditions. Of these processes, biodegradation is the most important destructive mechanism and plays a key role in determining the degree of natural attenuation that occurs at a site and whether or not monitored natural attenuation (MNA) should be considered when evaluating remedial action for the site. EPA discusses a three-tiered approach to evaluate the potential efficacy of a MNA remedy in OSWER Directive 9200.4-17.P The three tiers, or "lines-of-evidence" are:

1. Historical groundwater chemistry data demonstrates a clear and meaningful trend of decreasing contaminant mass and/or concentration over time.
2. Hydrogeologic and geochemical data indirectly demonstrate the type of natural attenuation processes active and the rate at which processes will reduce contaminant concentrations to required levels.
3. Data from field or microcosm studies directly demonstrates the occurrence of a particular natural attenuation process and its ability to degrade the contaminants of concern. (EPA 1999, OSWER Directive 9200.4-17P)

The natural attenuation of TCE within the Fulton Avenue OU2 plume was evaluated based on available data, which included field measurement of physical/chemical parameters such as pH, dissolved oxygen and oxidation-reduction potential (ORP), and laboratory analysis for geochemical and groundwater chemistry parameters. Microcosm studies were not performed, either during the RI or in previous studies.

Trend analysis (see Line of Evidence #1 section below) was based on all available data, which included previous studies and monitoring of groundwater quality from 1953 through 2020, and RI monitoring from 2011 through 2020. Evaluation of data for evidence of known TCE breakdown products from both biotic and abiotic degradation mechanisms was based on data from the two most recent rounds of RI sampling (September 2019 and December 2019).

Screening to evaluate indirect evidence of anaerobic biodegradation, the dominant attenuation mechanism for chlorinated solvents, was based on the September and December 2019 RI results and methods presented in EPA 600/R-98/128. The screening process included review of available site data, numerical ranking of individual parameters that impact anerobic degradation and totaling the individual ranks to provide an overall value that indicates the likelihood of TCE degradation at core Fulton Avenue OU2 wells (see Line of Evidence #2 section below).

Line of Evidence #1: Decreasing Trend with Time

TCE Concentrations

TCE data were plotted against time to evaluate the first potential line of evidence; demonstration of a decreasing trend in contaminant concentrations. Tables, summarizing TCE results, and concentration versus time graphs are presented in **Attachment 1**. A summary of whether or not decreasing trends were observed is provided below.

Eight core wells, MW-20C, MW-23C, MW-24A, MW-25A, MW-26F, MW-26G, N-03881 and N-11171, were evaluated. The evaluation indicated the following:

- Decreasing trends were found at four wells; MW-23C, MW-25A, MW-26G and N-11171:
  - All of these wells are located on the eastern edge of OU2.
  - Concentrations at MW-23C ranged 290 ug/L to less than 10 ug/L. Concentrations were estimated to reach the remediation goal (RG) of 5 ug/L in 2027, based on current trends.
  - Concentrations at MW-25A showed a similar range and is estimated to meet the RG in 2031.
  - MW-26G concentrations also showed a similar range, but the estimated time to meet the RG in 2078 based on its current trend.
  - Well N-11171 concentrations ranged from 261 ug/L to less than 1 ug/L. The long term trend indicates that the RG has been met, however, data fluctuations resulted in the most recent result exceeding the RG.
- Increasing trends were found at four wells; MW-20C, MW-24A, MW-26F and N-03881:
  - Well MW-20C concentrations were generally below 10 ug/L and showed a slightly increasing trend.
  - Well MW-24A concentrations ranged from less than 1 ug/L to more than 100 ug/L and showed a more strongly increasing trend.

- Well MW-26F concentrations ranged from 1 ug/L to 32.8 ug/L and showed a similar increasing trend to MW-24A.
- Well N-03881 concentrations ranged from 155 ug/L to approximately 68 ug/L and shows a slow rate of increase.

Breakdown Products

Reductive dechlorination is the dominant process in the natural attenuation of CVOCs. During this process, the bioremediation of TCE and other chlorinated ethenes take place under anaerobic aquifer conditions. Microorganisms that produce hydrogen (H_2) as a natural byproduct of fermentation reactions, use the H_2 as an electron donor, and replace chlorine atoms in the oxidized CVOC. This process acts as a respiratory mechanism to derive metabolically useful energy (EPA, 2000; AFCEE, 2004). If groundwater contains enough organic electron donors and the appropriate strains of microorganisms (e.g. Dehalococcoides), this process can proceed until all the chlorine atoms are removed. TCE can be dechlorinated completely to 1,2-DCE, vinyl chloride and finally to ethene, a harmless end product. As discussed in the EPA CLU-IN website discussion of anerobic biodegradation, if appropriate strains of microorganisms are not present, degradation can stop and result in a buildup of DCE or vinyl chloride.

The process of reductive dechlorination has been shown to preferentially produce specific daughter compounds. For example, while all three DCE isomers (1,1-DCE and cis- and trans-1,2-DCE) can theoretically be produced, it has been found that the cis-1,2-DCE isomer is the most common. Cis-1,2-DCE, was detected in seven of the eight monitoring wells reviewed, at low to trace concentrations ranging from 0.27 µg/L to 5.6 µg/L. The highest concentration of 5.6 µg/L was detected at MW-26F.

The next intermediate along the dechlorination path is vinyl chloride. The anaerobic reductive dechlorination of the more highly chlorinated (more oxidized) chlorinated hydrocarbons, such as PCE and TCE, occurs more readily than the dechlorination of chlorinated hydrocarbons that already are somewhat reduced (less oxidized), such as DCE and VC. Reductive dichlorination of DCE and VC typically cannot occur without the presence of Dehalococcoides or other species. Vinyl chloride was not detected at any of the eight monitoring wells.

The presence of 1,2 DCE indicates that reductive dichlorination of TCE is taking place to some degree at the Fulton Avenue OU2 site. However, the absence of vinyl chloride indicates that the process is incomplete.

Abiotic degradation of TCE tends to favor dichloro-elimination reactions that form acetylene (EPA, 2009). Abiotic processes can also degrade chlorinated ethenes to glycolate, acetate, formate and carbon dioxide (Darlington et al., 2008). Acetylene and carbon dioxide, however, were not analyzed for in any sample collected during the OU2 RI.

Line of Evidence #2: Indirect Evidence of Attenuation Mechanisms

EPA developed a screening process to evaluate a site's potential for anaerobic biodegradation by ranking the field data using a point system (EPA, 1998; Table 2.3). For example, if a sample shows indication of a parameter that contributes to a reductive pathway (e.g., low dissolved oxygen concentrations), the parameter is assigned a point value (e.g., 3). If a sample shows indication of a parameter that may suppress the reductive pathway (e.g., outside pH range), the parameter is

assigned a lower or negative point value (e.g., -2). The point values are then summed for each sample and the total score is interpreted for potential anaerobic biodegradation based on ranges (EPA, 1998; Table 2.4):

- Score 0 to 5 = Inadequate evidence for anaerobic biodegradation of CVOCs;
- Score 6 to 14 = Limited evidence;
- Score 15 to 20 = Adequate evidence; and
- Score > 20 = Strong evidence.

This process was applied to the data collected during the Fulton Avenue RI to evaluate whether or not natural biodegradation is taking place. Results are presented on **Attachment 2.**

The evaluation process was conducted for the eight core wells within the Fulton Avenue OU2 study area. However, it was concluded that the low score of "inadequate evidence" at N-03881 was a result of data limitations (e.g. pH, DO, ORP) and may not accurately represent it's actual potential for anaerobic biodegradation. Evaluation of the remaining seven wells generally resulted in "inadequate evidence" to "limited evidence" of anaerobic biodegradation as shown in the following table. One sampling event for MW-26F scored in the adequate range indicating local conditions may be more favorable for biodegradation in that portion of the aquifer. However these conditions did not correlate with a long term decreasing trend in TCE concentrations.

Preliminary Screening Results for Anaerobic Degradation Processes at Fulton Avenue OU2

Well ID	Score		Interpretation		Long Term Trend
	September 2019	December 2019	September 2019	December 2019	
MW-20C	6	4	limited	inadequate	Decreasing
MW-23C	8	8	limited	limited	Increasing
MW-24A	8	8	limited	limited	Decreasing
MW-25A	6	5	limited	inadequate	Increasing
MW-26F	12	17	limited	adequate	Increasing
MW-26G	8	10	limited	limited	Decreasing
N-11171	9	9	limited	limited	Decreasing
N-03881	4	Not sampled	inadequate	-	Increasing

In addition to the data limitations for N-03881, data for a number of parameters were not available for all of the wells, including carbon dioxide, hydrogen and sulfide. The lack of these results may skew the point totals low by up to 4 points out of a total of 42 possible points, based on the point values for those scoring parameters. Those results would not have significantly changed the overall scoring. Point totals for the eight wells evaluated ranged from 4 to 17.

Comparison to the results of long term trend analysis indicate that there is no correlation between reducing trends and results of the anerobic degradation screening process.

Conclusions

An evaluation of the potential for the natural attenuation of TCE within the Fulton Avenue OU2 study area was performed in accordance with EPA guidance. The evaluation indicated the following:

- Trend analysis of concentration vs time data indicate that natural attenuation of TCE is variable throughout Fulton Avenue OU2, and that where it is occurring, it may take up to another 54 years to meet RG s based on the current trend.
- cis-1,2-DCE was the only TCE breakdown product detected in Fulton Avenue OU2. The presence of DCE indicates that some level of biological degradation is occurring.
- Vinyl chloride was not detected in Fulton Avenue OU2, indicating that any natural biodegradation of TCE may be occurring does not proceed beyond cis-1,2-DCE.
- Some abiotic degradation of TCE may be occurring, however, based on the ferrous iron concentrations it is most likely to a limited degree.
- Although reducing conditions do appear to be present in portions of the aquifer, the overall result of screening indicates that there is only limited evidence of the natural attenuation of TCE in Fulton Avenue OU2.

In general, while some natural attenuation is likely happening in Fulton Avenue OU2, there is not enough evidence to indicate that the processes are proceeding to completion and that it is happening consistently throughout the study area. A standalone MNA remedy would likely not fully achieve a remedial action objective of meeting MCLs or NYSDEC ambient water quality criteria in a reasonable amount of time.

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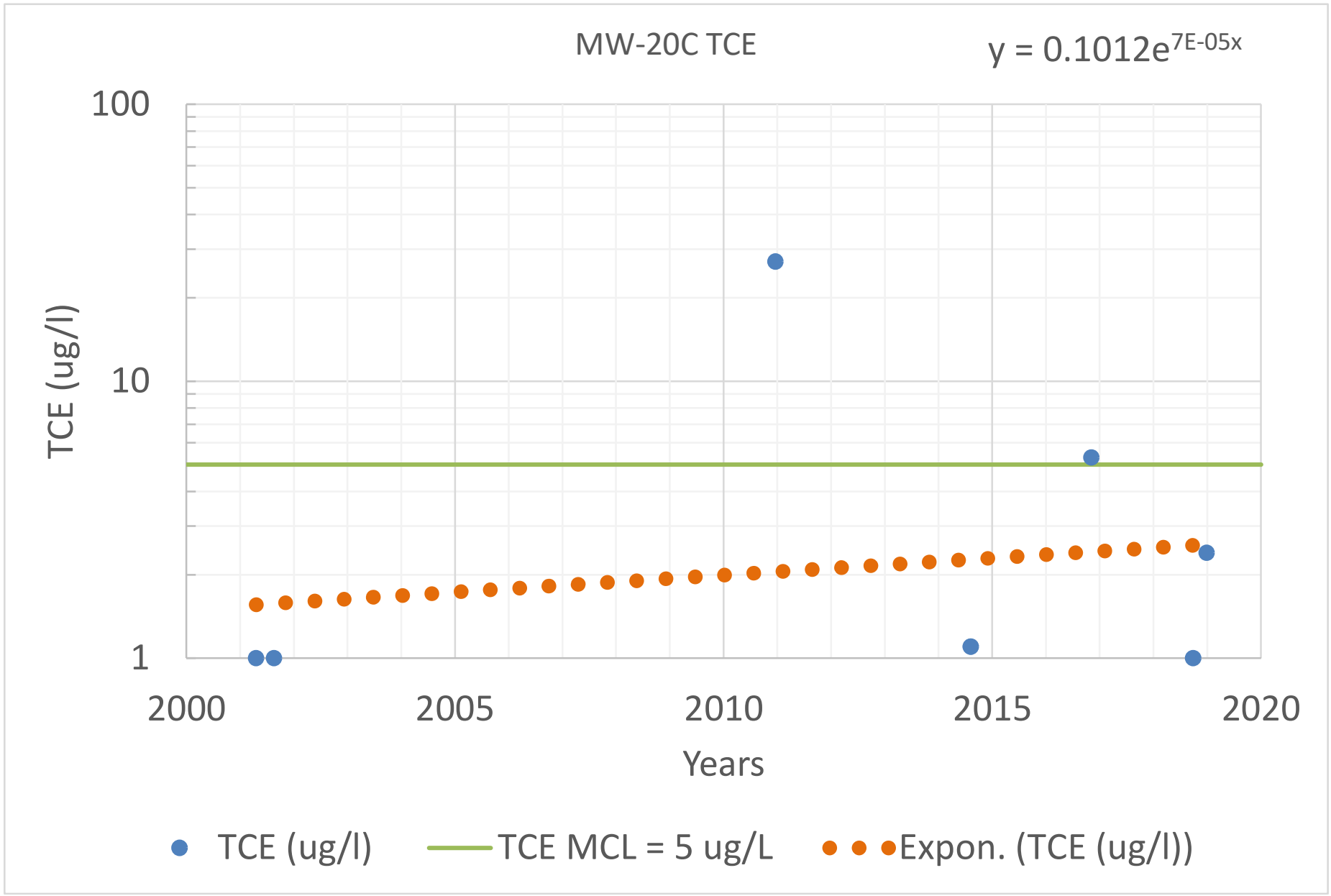
Attachment 1

TCE Historical Data and Trend Charts

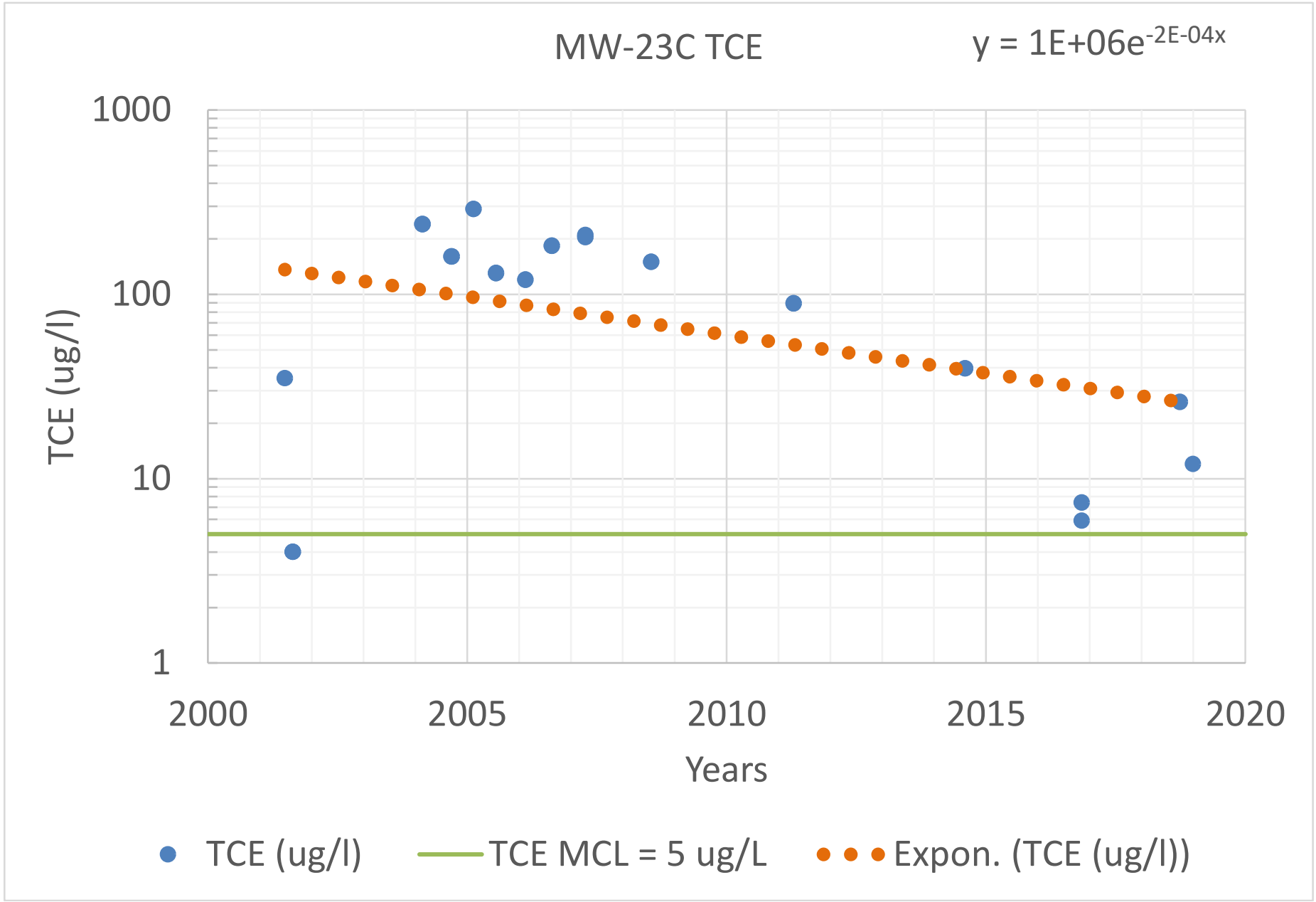
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1a
MW-20C TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-20C	MW20C_400-410_20010514	5/14/2001	1	
MW-20C	MW20C_400-410_20010918	9/18/2001	1	
MW-20C	MW20C_405_20010918	9/18/2001		U
MW-20C	FUL_WG_MW-20C_300-300_N_20110707	7/7/2011	27	
MW-20C	MW20C_405_20150430	4/30/2015	1.1	
MW-20C	ACTDJB93700201505151449004	4/30/2015	1.1	
MW-20C	ACTDJC50336201806072040005	9/7/2017	5.3	
MW-20C	MW-20C-GW-405-20190903-0	9/3/2019	1	
MW-20C	MW-20C-GW-405-20191209-0	12/9/2019	2.4	


MW-20C TCE
y = 0.1012e7E-05x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

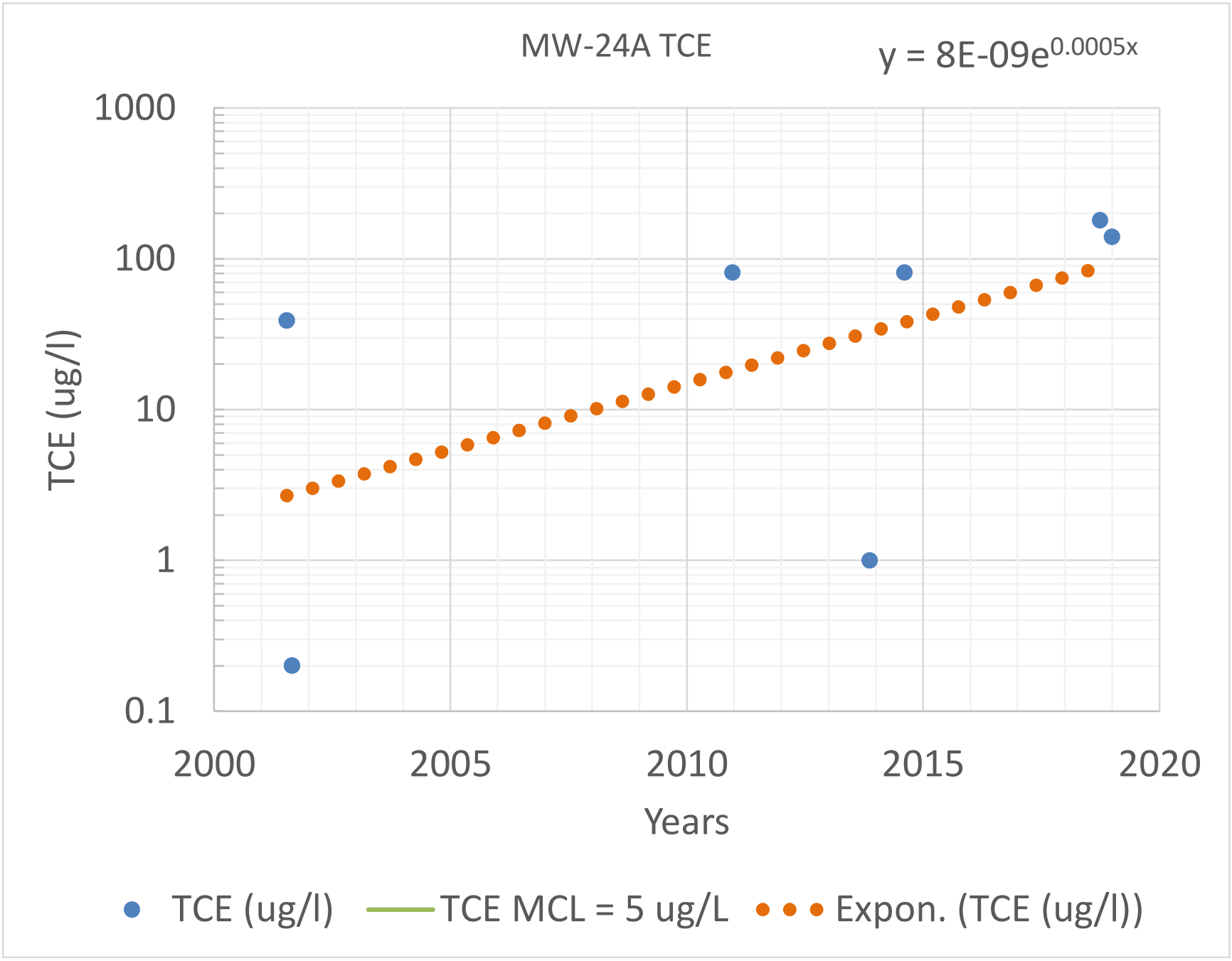
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1b
MW-23C TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-23C	MW23C_398-408_20010723	7/23/2001	35	
MW-23C	MW23C_398-408_20010920	9/20/2001	4	
MW-23C	MW23C_403_20010920	9/20/2001	4	
MW-23C	MW23C_398-408_20040505	5/5/2004	240	
MW-23C	MW23C_403_20040505	5/5/2004	240	
MW-23C	MW23C_20041206	12/6/2004	160	
MW-23C	MW23C_398-408_20041206	12/6/2004	160	
MW-23C	MW23C_20050518	5/18/2005	290	
MW-23C	MW23C_398-408_20050518	5/18/2005	290	
MW-23C	MW23C_20051031	10/31/2005	130	
MW-23C	MW23C_398-408_20051031	10/31/2005	130	
MW-23C	MW23C_20060606	6/6/2006	120	
MW-23C	MW23C_398-408_20060606	6/6/2006	120	
MW-23C	MW23C_20061219	12/19/2006	183	
MW-23C	MW23C_398-408_20061219	12/19/2006	183	
MW-23C	MW23C_20070822	8/22/2007	204	
MW-23C	MW23C_398-408_20070822	8/22/2007	209	
MW-23C	MW23C_20081222	12/22/2008	150	
MW-23C	MW23C_398-408_20081222	12/22/2008	150	
MW-23C	MW23C_20111110	11/10/2011	89.3	
MW-23C	MW23C_398-408_20111110	11/10/2011	89.3	
MW-23C	MW23C_403_20150430	4/30/2015	39.6	
MW-23C	ACTDJB93700201505151449006	4/30/2015	39.6	
MW-23C	ACTDJC50488201806072052001	9/8/2017	7.4	
MW-23C	ACTDJC50488201806072052007	9/8/2017	5.9	
MW-23C	MW-23C-GW-403-20190903-0	9/3/2019	26	D
MW-23C	MW-23C-GW-403-20191209-0	12/9/2019	12	


MW-23C TCE
y = 1E+06e-2E-04x
1000
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

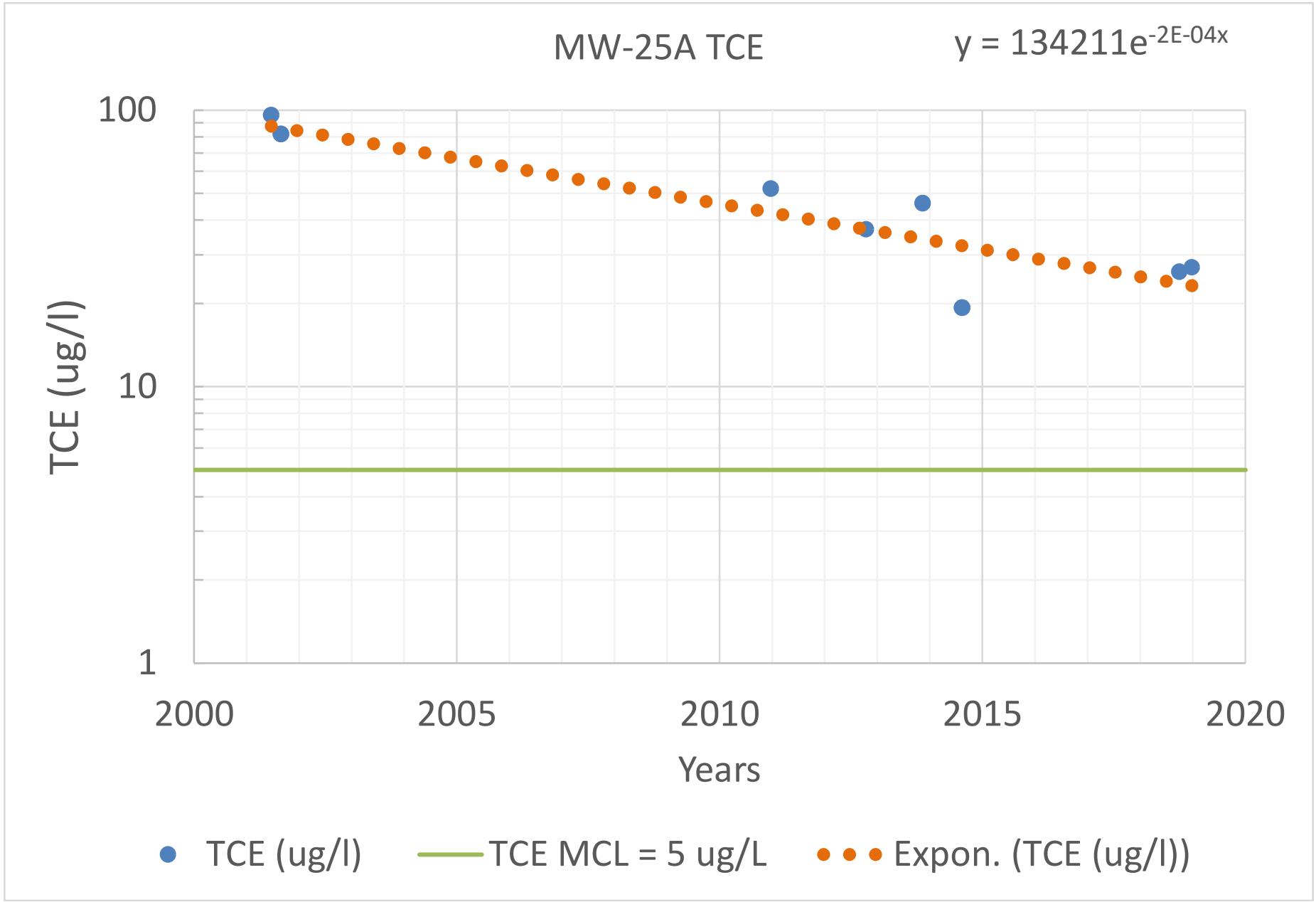
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1c
MW-24A TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-24A	MW24A_340-350_20010813	8/13/2001	39	
MW-24A	MW24A_345-355_20010813	8/13/2001	39	
MW-24A	MW24A_340-350_20010925	9/25/2001	0.2	
MW-24A	MW24A_345_20010925	9/25/2001	0.2	
MW-24A	FUL_WG_MW-24A_300-300_N_20110708	7/8/2011	81	
MW-24A	FUL_WG_MW-24A_297-297_N_20140724	7/24/2014	1	U
MW-24A	ACTDJB93787201505151447006	5/1/2015	81.2	
MW-24A	MW-24A-GW-350-20190905-0	9/5/2019	180	D
MW-24A	MW-24A-GW-350-20191211-0	12/11/2019	140	


MW-24A TCE
y = 8E-09e0.0005x
1000
100
10
1
0.1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

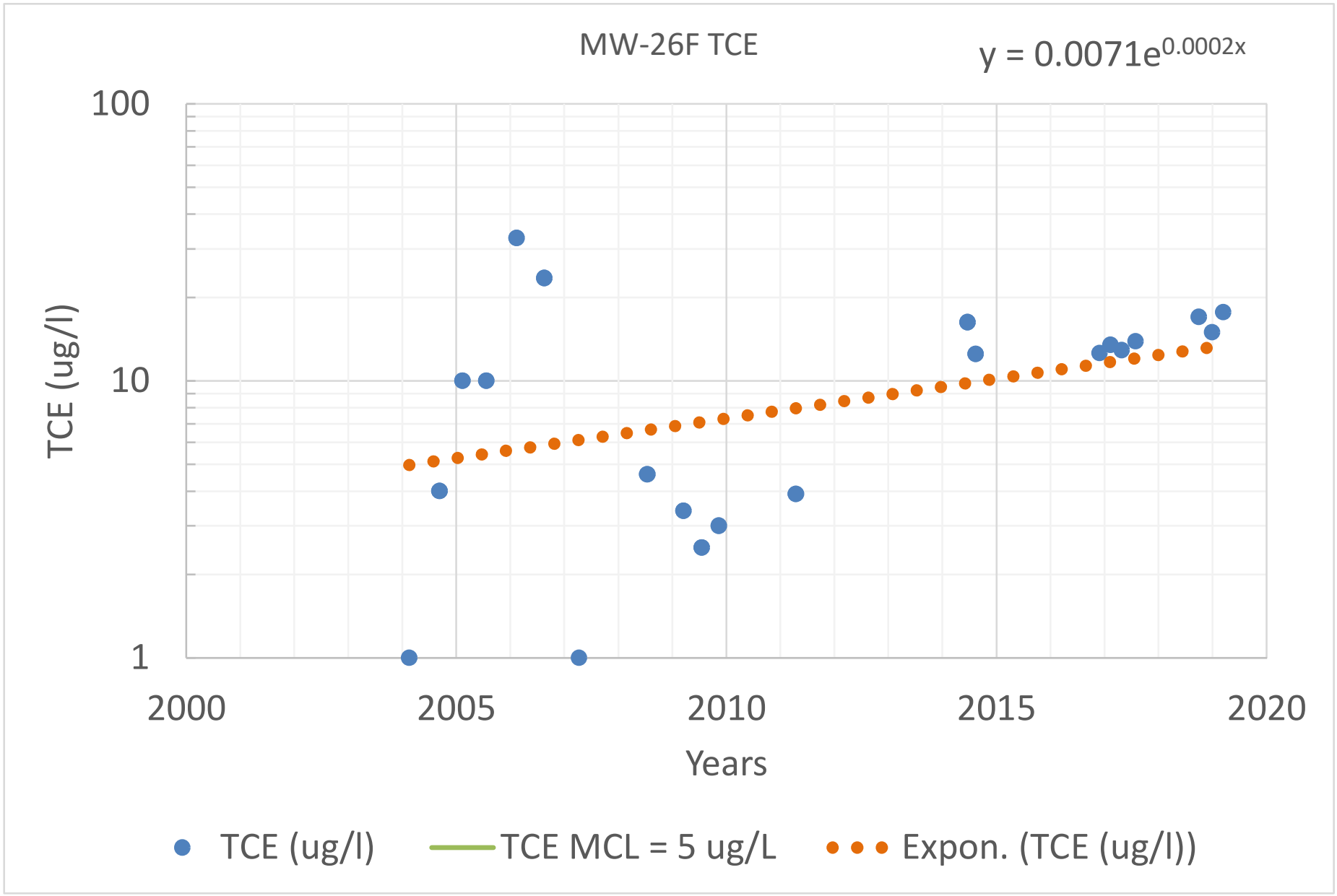
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1d
MW-25A TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-25A	MW25A_340-350_20010719	7/19/2001	96	
MW-25A	MW25A_340-350_20010927	9/27/2001	82	
MW-25A	MW25A_345_20010927	9/27/2001	82	
MW-25A	FUL_WG_MW-25A_300-300_N_20110711	7/11/2011	52	
MW-25A	FUL_WG_MW-25A_297-297_N_20130604	6/4/2013	37	
MW-25A	FUL_WG_MW-25A_297-297_FD_20140723	7/23/2014	46	
MW-25A	FUL_WG_MW-25A_297-297_N_20140723	7/23/2014	46	
MW-25A	MW25A_345_20150506	5/6/2015	19.3	
MW-25A	ACTDJB94107201505151508003	5/6/2015	19.3	
MW-25A	MW-25A-GW-345-20190905-0	9/5/2019	26	D
MW-25A	MW-25A-GW-345-20191206-0	12/6/2019	27	


MW-25A TCE
y = 134211e-2E-04x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

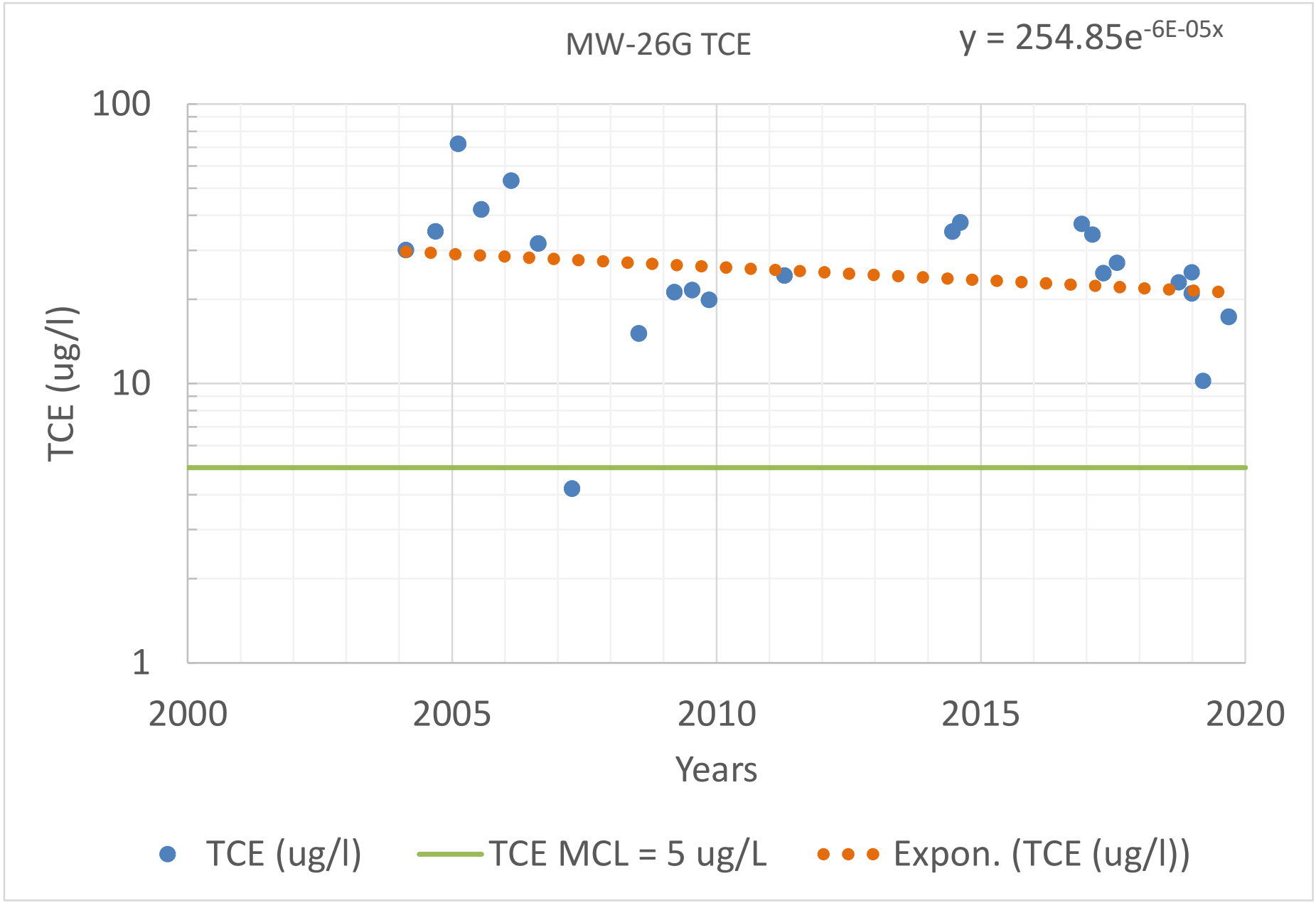
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1e
MW-26F TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-26F	MW26_410.5-410.5_20040503	5/3/2004	1	
MW-26F	MW26F_405-415_20040503	5/3/2004		U
MW-26F	MW26_410.5-410.5_20041203	12/3/2004	4	
MW-26F	MW26F_20041203	12/3/2004	4	
MW-26F	MW26_410.5-410.5_20050516	5/16/2005	10	
MW-26F	MW26F_20050516	5/16/2005	10	
MW-26F	MW26_410.5-410.5_20051031	10/31/2005	10	
MW-26F	MW26F_20051031	10/31/2005	10	
MW-26F	MW26_410.5-410.5_20060605	6/5/2006	32.8	
MW-26F	MW26F_20060605	6/5/2006	32.8	
MW-26F	MW26_410.5-410.5_20061218	12/18/2006	23.5	
MW-26F	MW26F_20061218	12/18/2006	23.5	
MW-26F	MW26_410.5-410.5_20070820	8/20/2007	1	
MW-26F	MW26F_20070820	8/20/2007		U
MW-26F	MW26_410.5-410.5_20081217	12/17/2008	4.6	
MW-26F	MW26F_20081217	12/17/2008	4.6	
MW-26F	MW26_410.5-410.5_20090831	8/31/2009	3.4	
MW-26F	MW26F_20090831	8/31/2009	3.4	
MW-26F	MW26_410.5-410.5_20100107	1/7/2010	2.5	
MW-26F	MW26F_20100107	1/7/2010	2.5	
MW-26F	MW26_410.5-410.5_20100510	5/10/2010	3	
MW-26F	MW26F_20100510	5/10/2010	3	
MW-26F	MW26_410.5-410.5_20111107	11/7/2011	3.9	
MW-26F	MW26F_20111107	11/7/2011	3.9	
MW-26F	MW26F_20150309	3/9/2015	16.3	
MW-26F	ACTDJB89617201508180243004	3/9/2015	16.3	
MW-26F	MW26F_410.5_20150506	5/6/2015	12.5	
MW-26F	ACTDJB94107201505151508008	5/6/2015	12.5	
MW-26F	ACTDJC52396201806072220007	10/2/2017	12.6	
MW-26F	ACTDJC57685201806072333012	12/18/2017	13.5	J
MW-26F	ACTDJC61943201805221738008	3/8/2018	12.9	
MW-26F	ACTDJC67971201904151527008	6/13/2018	13.9	
MW-26F	MW-26F-GW-410-20190905-0	9/5/2019	17	
MW-26F	MW-26F-GW-410-20191209-0	12/9/2019	15	
MW-26F	MW26F-410.5-022720	2/27/2020	17.7	


MW-26F TCE
y = 0.0071e^0.0002x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1f
MW-26G TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
MW-26G	MW26_443-443_20040503	5/3/2004	30	
MW-26G	MW26G_438-448_20040503	5/3/2004	30	
MW-26G	MW26_443-443_20041203	12/3/2004	35	
MW-26G	MW26G_20041203	12/3/2004	35	
MW-26G	MW26_443-443_20050516	5/16/2005	72	
MW-26G	MW26G_20050516	5/16/2005	72	
MW-26G	MW26_443-443_20051031	10/31/2005	42	
MW-26G	MW26G_20051031	10/31/2005	42	
MW-26G	MW26_443-443_20060605	6/5/2006	53.2	
MW-26G	MW26G_20060605	6/5/2006	53.2	
MW-26G	MW26_443-443_20061218	12/18/2006	31.7	
MW-26G	MW26G_20061218	12/18/2006	31.7	
MW-26G	MW26_443-443_20070820	8/20/2007	4.2	
MW-26G	MW26G_20070820	8/20/2007	4.2	
MW-26G	MW26_443-443_20081217	12/17/2008	15.1	
MW-26G	MW26G_20081217	12/17/2008	15.1	
MW-26G	MW26_443-443_20090831	8/31/2009	21.2	
MW-26G	MW26G_20090831	8/31/2009	21.2	
MW-26G	MW26_443-443_20100107	1/7/2010	21.6	
MW-26G	MW26G_20100107	1/7/2010	21.6	
MW-26G	MW26_443-443_20100510	5/10/2010	19.9	
MW-26G	MW26G_20100510	5/10/2010	19.9	
MW-26G	MW26_443-443_20111107	11/7/2011	24.3	
MW-26G	MW26G_20111107	11/7/2011	24.3	
MW-26G	MW26G_20150309	3/9/2015	34.9	
MW-26G	ACTDJB89617201508180243005	3/9/2015	34.9	
MW-26G	MW26G_443_20150506	5/6/2015	37.7	
MW-26G	ACTDJB94107201505151508009	5/6/2015	37.7	
MW-26G	ACTDJC52396201806072220008	10/2/2017	37.2	
MW-26G	ACTDJC57685201806072333013	12/18/2017	34.1	J
MW-26G	ACTDJC61943201805221738009	3/8/2018	24.8	
MW-26G	ACTDJC67971201904151527009	6/13/2018	27	
MW-26G	MW-26G-GW-443-20190905-0	9/5/2019	23	D
MW-26G	MW-26G-GW-443-20191209-0	12/9/2019	25	
MW-26G	MW-26G-GW-443-20191209-1	12/9/2019	21	
MW-26G	MW26H-478.5-022720	2/27/2020	10.2	
MW-26G	DUP090120	9/1/2020	17.3	
MW-26G	MW-26G-443-090120	9/1/2020	17.3	


MW-26G TCE
y = 254.85e-6E-05x
100
10
1
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1g
N-03881 TCE Data

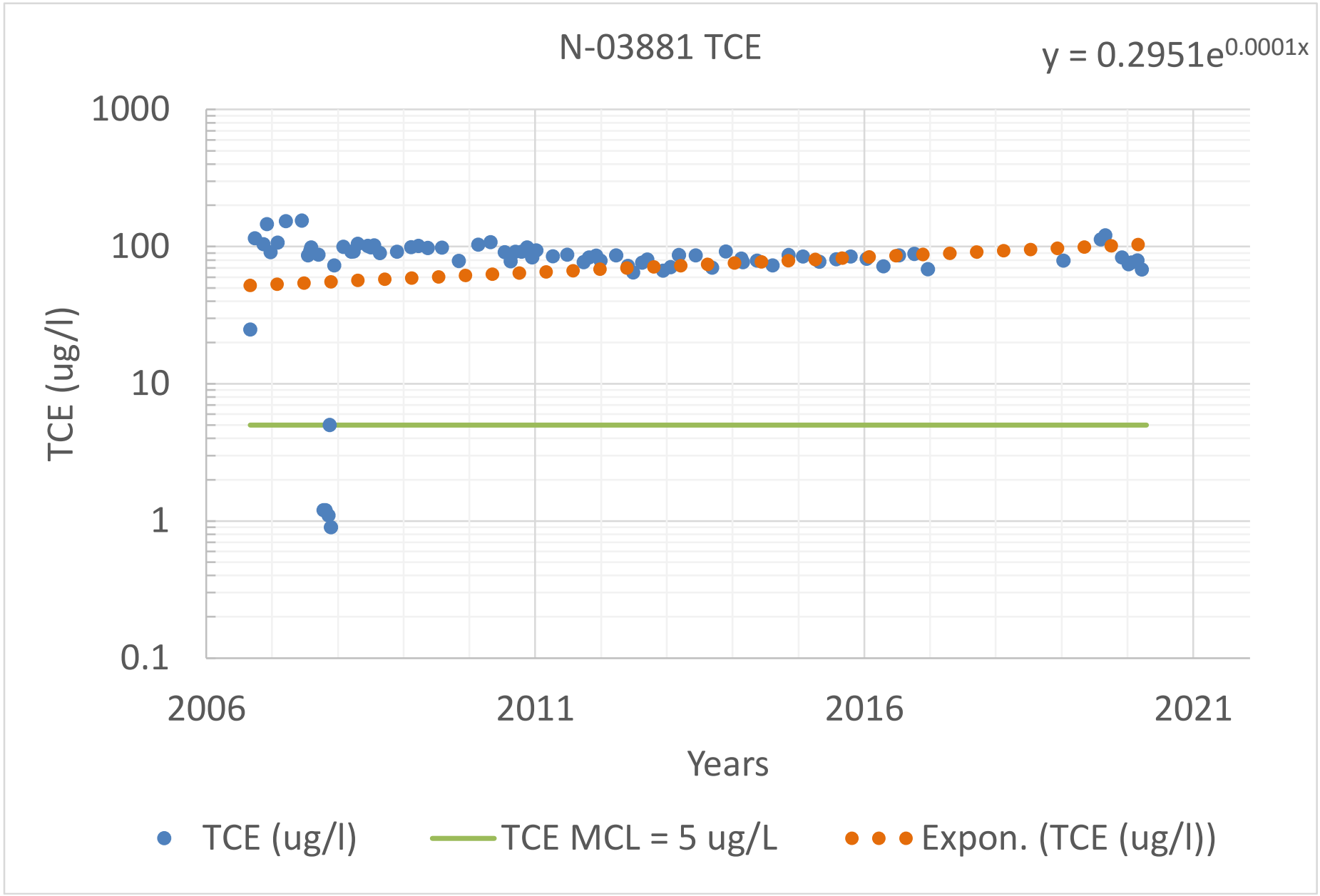
Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-03881	FUL_GCTY_N-03881_WG_19530301	3/1/1953		
N-03881	FUL_GCTY_N-03881_WG_19540701	7/1/1954		
N-03881	FUL_GCTY_N-03881_WG_19550301	3/1/1955		
N-03881	FUL_GCTY_N-03881_WG_19571101	11/1/1957		
N-03881	FUL_GCTY_N-03881_WG_19611001	10/1/1961		
N-03881	FUL_GCTY_N-03881_WG_19620401	4/1/1962		
N-03881	FUL_GCTY_N-03881_WG_19630501	5/1/1963		
N-03881	FUL_GCTY_N-03881_WG_19640101	1/1/1964		
N-03881	FUL_GCTY_N-03881_WG_19650101	1/1/1965		
N-03881	FUL_GCTY_N-03881_WG_19651101	11/1/1965		
N-03881	FUL_GCTY_N-03881_WG_19661001	10/1/1966		
N-03881	FUL_GCTY_N-03881_WG_19671010	10/10/1967		
N-03881	FUL_GCTY_N-03881_WG_19680503	5/3/1968		
N-03881	FUL_GCTY_N-03881_WG_19690320	3/20/1969		
N-03881	FUL_GCTY_N-03881_WG_19701005	10/5/1970		
N-03881	FUL_GCTY_N-03881_WG_19710319	3/19/1971		
N-03881	FUL_GCTY_N-03881_WG_19720112	1/12/1972		
N-03881	FUL_GCTY_N-03881_WG_19721228	12/28/1972		
N-03881	FUL_GCTY_N-03881_WG_19731207	12/7/1973		
N-03881	FUL_GCTY_N-03881_WG_19740226	2/26/1974		
N-03881	FUL_GCTY_N-03881_WG_19740315	3/15/1974		
N-03881	FUL_GCTY_N-03881_WG_19750121	1/21/1975		
N-03881	FUL_GCTY_N-03881_WG_19750228	2/28/1975		
N-03881	FUL_GCTY_N-03881_WG_19760106	1/6/1976		
N-03881	FUL_GCTY_N-03881_WG_19760810	8/10/1976		
N-03881	FUL_GCTY_N-03881_WG_19770412	4/12/1977		
N-03881	FUL_GCTY_N-03881_WG_19770425	4/25/1977		
N-03881	FUL_GCTY_N-03881_WG_19771116	11/16/1977	4	U
N-03881	FUL_GCTY_N-03881_WG_19771214	12/14/1977	4	U
N-03881	FUL_GCTY_N-03881_WG_19780404	4/4/1978		
N-03881	FUL_GCTY_N-03881_WG_19780511	5/11/1978	4	U
N-03881	FUL_GCTY_N-03881_WG_19780928	9/28/1978		
N-03881	FUL_GCTY_N-03881_WG_19781003	10/3/1978	1	U
N-03881	FUL_GCTY_N-03881_WG_19781202	12/2/1978	4	U
N-03881	FUL_GCTY_N-03881_WG_19790202	2/2/1979		
N-03881	FUL_GCTY_N-03881_WG_19790327	3/27/1979		
N-03881	FUL_GCTY_N-03881_WG_19791127	11/27/1979	1	U
N-03881	FUL_GCTY_N-03881_WG_19800115	1/15/1980		
N-03881	FUL_GCTY_N-03881_WG_19800820	8/20/1980		
N-03881	FUL_GCTY_N-03881_WG_19800829	8/29/1980	4	U
N-03881	FUL_GCTY_N-03881_WG_19801007	10/7/1980	3	
N-03881	FUL_GCTY_N-03881_WG_19810106	1/6/1981		
N-03881	FUL_GCTY_N-03881_WG_19810526	5/26/1981		
N-03881	FUL_GCTY_N-03881_WG_19810527	5/27/1981	4	
N-03881	FUL_GCTY_N-03881_WG_19811020	10/20/1981	4	
N-03881	FUL_GCTY_N-03881_WG_19820112	1/12/1982		
N-03881	FUL_GCTY_N-03881_WG_19820316	3/16/1982	4	
N-03881	FUL_GCTY_N-03881_WG_19820921	9/21/1982	6	
N-03881	FUL_GCTY_N-03881_WG_19830111	1/11/1983		
N-03881	FUL_GCTY_N-03881_WG_19830117	1/17/1983	10	
N-03881	FUL_GCTY_N-03881_WG_19831004	10/4/1983	11	
N-03881	FUL_GCTY_N-03881_WG_19840103	1/3/1984		
N-03881	FUL_GCTY_N-03881_WG_19840730	7/30/1984	16	
N-03881	FUL_GCTY_N-03881_WG_19841205	12/5/1984	15	
N-03881	FUL_GCTY_N-03881_WG_19850107	1/7/1985	18	
N-03881	FUL_GCTY_N-03881_WG_19850528	5/28/1985	18	
N-03881	FUL_GCTY_N-03881_WG_19860603	6/3/1986	20	
N-03881	FUL_GCTY_N-03881_WG_19860721	7/21/1986	20	
N-03881	FUL_GCTY_N-03881_WG_19980508	5/8/1998	3.7	
N-03881	FUL_GCTY_N-03881_WG_20000314	3/14/2000		
N-03881	FUL_GCTY_N-03881_WG_20000414	4/14/2000	1.7	
N-03881	FUL_GCTY_N-03881_WG_20000717	7/17/2000	1.8	
N-03881	FUL_GCTY_N-03881_WG_20000907	9/7/2000	0.5	
N-03881	FUL_GCTY_N-03881_WG_20010131	1/31/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20010420	4/20/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20010525	5/25/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20010612	6/12/2001	2.2	
N-03881	FUL_GCTY_N-03881_WG_20010725	7/25/2001	4.2	
N-03881	FUL_GCTY_N-03881_WG_20010816	8/16/2001	0.5	U

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1g
N-03881 TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-03881	FUL_GCTY_N-03881_WG_20010920	9/20/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20011023	10/23/2001	9.7	
N-03881	FUL_GCTY_N-03881_WG_20011121	11/21/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20011205	12/5/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20011213	12/13/2001	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020123	1/23/2002	31	
N-03881	FUL_GCTY_N-03881_WG_20020307	3/7/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020328	3/28/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020411	4/11/2002	30	
N-03881	FUL_GCTY_N-03881_WG_20020531	5/31/2002	36	
N-03881	FUL_GCTY_N-03881_WG_20020613	6/13/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020619	6/19/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020625	6/25/2002	39	
N-03881	FUL_GCTY_N-03881_WG_20020718	7/18/2002	43	
N-03881	FUL_GCTY_N-03881_WG_20020820	8/20/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020912	9/12/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20020919	9/19/2002		
N-03881	FUL_GCTY_N-03881_WG_20021022	10/22/2002	46	
N-03881	FUL_GCTY_N-03881_WG_20021107	11/7/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20021218	12/18/2002	0.5	U
N-03881	FUL_GCTY_N-03881_WG_20021230	12/30/2002	36	
N-03881	FUL_GCTY_N-03881_WG_20030117	1/17/2003	44	
N-03881	FUL_GCTY_N-03881_WG_20030422	4/22/2003	37	
N-03881	FUL_GCTY_N-03881_WG_20030714	7/14/2003	45	
N-03881	FUL_GCTY_N-03881_WG_20030925	9/25/2003		
N-03881	FUL_GCTY_N-03881_WG_20031023	10/23/2003	50	
N-03881	FUL_GCTY_N-03881_WG_20040122	1/22/2004	55	
N-03881	FUL_GCTY_N-03881_WG_20040415	4/15/2004	69	
N-03881	FUL_GCTY_N-03881_WG_20040722	7/22/2004	89	
N-03881	FUL_GCTY_N-03881_WG_20040909	9/9/2004		
N-03881	FUL_GCTY_N-03881_WG_20041020	10/20/2004	91	
N-03881	FUL_GCTY_N-03881_WG_20050107	1/7/2005	88	
N-03881	FUL_GCTY_N-03881_WG_20050412	4/12/2005	100	
N-03881	FUL_GCTY_N-03881_WG_20050720	7/20/2005	89	
N-03881	FUL_GCTY_N-03881_WG_20050818	8/18/2005	96	
N-03881	FUL_GCTY_N-03881_WG_20050916	9/16/2005	100	
N-03881	FUL_GCTY_N-03881_WG_20050923	9/23/2005		
N-03881	FUL_GCTY_N-03881_WG_20051013	10/13/2005	89	
N-03881	FUL_GCTY_N-03881_WG_20051117	11/17/2005	82	
N-03881	FUL_GCTY_N-03881_WG_20060124	1/24/2006	86	
N-03881	FUL_GCTY_N-03881_WG_20060208	2/8/2006	5	U
N-03881	FUL_GCTY_N-03881_WG_20060303	3/3/2006	82	
N-03881	FUL_GCTY_N-03881_WG_20060425	4/25/2006	98	
N-03881	FUL_GCTY_N-03881_WG_20060515	5/15/2006	93	
N-03881	FUL_GCTY_N-03881_WG_20060615	6/15/2006	110	
N-03881	FUL_GCTY_N-03881_WG_20060721	7/21/2006	110	
N-03881	FUL_GCTY_N-03881_WG_20060804	8/4/2006	110	
N-03881	FUL_GCTY_N-03881_WG_20060823	8/23/2006		
N-03881	FUL_GCTY_N-03881_WG_20060914	9/14/2006	24.8	
N-03881	FUL_GCTY_N-03881_WG_20061012	10/12/2006	115	
N-03881	FUL_GCTY_N-03881_WG_20061130	11/30/2006	104	
N-03881	FUL_GCTY_N-03881_WG_20061220	12/20/2006	146	
N-03881	FUL_GCTY_N-03881_WG_20070111	1/11/2007	91.3	
N-03881	FUL_GCTY_N-03881_WG_20070221	2/21/2007	107	
N-03881	FUL_GCTY_N-03881_WG_20070409	4/9/2007	153	
N-03881	FUL_GCTY_N-03881_WG_20070711	7/11/2007	155	
N-03881	FUL_GCTY_N-03881_WG_20070817	8/17/2007	86.5	
N-03881	FUL_GCTY_N-03881_WG_20070831	8/31/2007	93.3	
N-03881	FUL_GCTY_N-03881_WG_20070905	9/5/2007	98.5	
N-03881	FUL_GCTY_N-03881_WG_20070917	9/17/2007		
N-03881	FUL_GCTY_N-03881_WG_20071017	10/17/2007	87.4	
N-03881	FUL_GCTY_N-03881_WG_20071116	11/16/2007	1.2	
N-03881	FUL_GCTY_N-03881_WG_20071128	11/28/2007	1.2	
N-03881	FUL_GCTY_N-03881_WG_20071214	12/14/2007	1.1	
N-03881	FUL_GCTY_N-03881_WG_20071221	12/21/2007	5	U
N-03881	FUL_GCTY_N-03881_WG_20071228	12/28/2007	0.9	
N-03881	FUL_GCTY_N-03881_WG_20080116	1/16/2008	73	
N-03881	FUL_GCTY_N-03881_WG_20080310	3/10/2008	99.7	
N-03881	FUL_GCTY_N-03881_WG_20080425	4/25/2008	91.5	

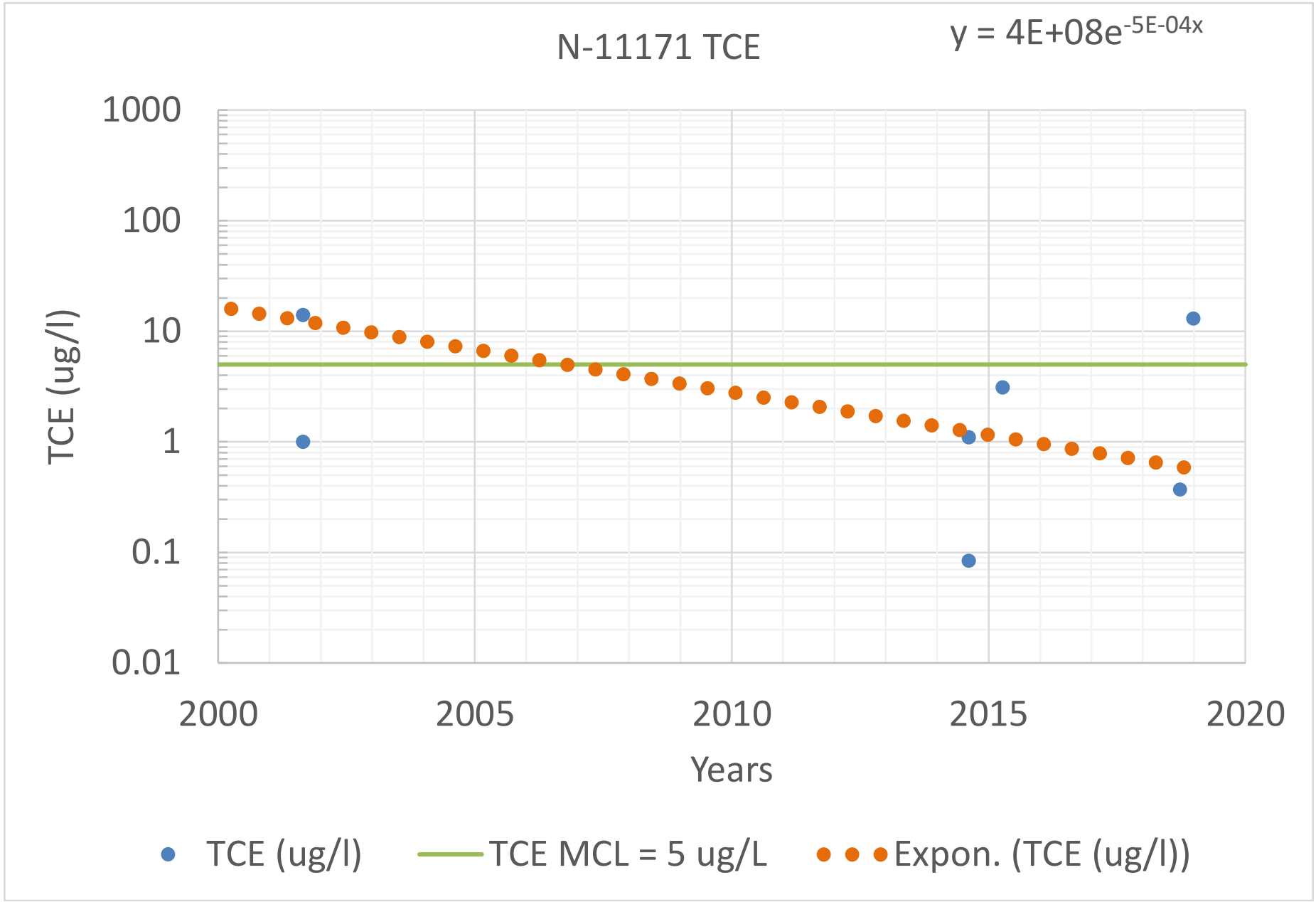
Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1g
N-03881 TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-03881	FUL_GCTY_N-03881_WG_20080508	5/8/2008	92	
N-03881	FUL_GCTY_N-03881_WG_20080602	6/2/2008	105	
N-03881	FUL_GCTY_N-03881_WG_20080730	7/30/2008	101	
N-03881	FUL_GCTY_N-03881_WG_20080818	8/18/2008	98.6	
N-03881	FUL_GCTY_N-03881_WG_20080905	9/5/2008	102	
N-03881	FUL_GCTY_N-03881_WG_20081009	10/9/2008	90	
N-03881	FUL_GCTY_N-03881_WG_20090116	1/16/2009	91.8	
N-03881	FUL_GCTY_N-03881_WG_20090409	4/9/2009	99	
N-03881	FUL_GCTY_N-03881_WG_20090522	5/22/2009	101	
N-03881	FUL_GCTY_N-03881_WG_20090716	7/16/2009	97.7	
N-03881	FUL_GCTY_N-03881_WG_20090831	8/31/2009		
N-03881	FUL_GCTY_N-03881_WG_20091005	10/5/2009	98	
N-03881	FUL_GCTY_N-03881_WG_20100111	1/11/2010	78.6	
N-03881	FUL_GCTY_N-03881_WG_20100505	5/5/2010	103	
N-03881	FUL_GCTY_N-03881_WG_20100716	7/16/2010	108	
N-03881	FUL_GCTY_N-03881_WG_20100812	8/12/2010		
N-03881	FUL_GCTY_N-03881_WG_20101006	10/6/2010	91	
N-03881	FUL_GCTY_N-03881_WG_20101110	11/10/2010	78.1	
N-03881	FUL_GCTY_N-03881_WG_20101208	12/8/2010	91.6	
N-03881	FUL_GCTY_N-03881_WG_20110113	1/13/2011	91.7	
N-03881	FUL_GCTY_N-03881_WG_20110214	2/14/2011	98.6	
N-03881	FUL_GCTY_N-03881_WG_20110315	3/15/2011	83.5	
N-03881	FUL_GCTY_N-03881_WG_20110408	4/8/2011	93.9	
N-03881	FUL_GCTY_N-03881_WG_20110713	7/13/2011	85	
N-03881	FUL_GCTY_N-03881_WG_20110810	8/10/2011		
N-03881	FUL_GCTY_N-03881_WG_20111005	10/5/2011	87.2	
N-03881	FUL_GCTY_N-03881_WG_20120109	1/9/2012	77.1	
N-03881	FUL_GCTY_N-03881_WG_20120209	2/9/2012	83.3	
N-03881	FUL_GCTY_N-03881_WG_20120321	3/21/2012	85.8	
N-03881	FUL_GCTY_N-03881_WG_20120416	4/16/2012	79.1	
N-03881	FUL_GCTY_N-03881_WG_20120716	7/16/2012	86.5	
N-03881	FUL_GCTY_N-03881_WG_20120814	8/14/2012		
N-03881	FUL_GCTY_N-03881_WG_20120924	9/24/2012	72.2	
N-03881	FUL_GCTY_N-03881_WG_20121024	10/24/2012	64.7	
N-03881	FUL_GCTY_N-03881_WG_20121214	12/14/2012	76.4	
N-03881	FUL_GCTY_N-03881_WG_20130114	1/14/2013	80.6	
N-03881	FUL_GCTY_N-03881_WG_20130415	4/15/2013	66.8	
N-03881	FUL_WG_N-03881_446-446_N_20130530	5/30/2013	71	
N-03881	FUL_GCTY_N-03881_WG_20130718	7/18/2013	86.8	
N-03881	FUL_GCTY_N-03881_WG_20130819	8/19/2013		
N-03881	FUL_GCTY_N-03881_WG_20131023	10/23/2013	86.4	
N-03881	FUL_GCTY_N-03881_WG_20140128	1/28/2014	70.3	
N-03881	FUL_GCTY_N-03881_WG_20140417	4/17/2014	92	
N-03881	FUL_WG_N-03881_446-446_N_20140716	7/16/2014	82	
N-03881	FUL_GCTY_N-03881_WG_20140724	7/24/2014	77	
N-03881	FUL_GCTY_N-03881_WG_20140815	8/15/2014		
N-03881	FUL_GCTY_N-03881_WG_20141015	10/15/2014	79	
N-03881	FUL_GCTY_N-03881_WG_20150114	1/14/2015	73	*
N-03881	FUL_GCTY_N-03881_WG_20150417	4/17/2015	86.9	*
N-03881	FUL_GCTY_N-03881_WG_20150709	7/9/2015	84.5	*
N-03881	FUL_GCTY_N-03881_WG_20150805	8/5/2015		
N-03881	FUL_GCTY_N-03881_WG_20151014	10/14/2015	77.3	*
N-03881	FUL_GCTY_N-03881_WG_20160120	1/20/2016	81	*
N-03881	FUL_GCTY_N-03881_WG_20160413	4/13/2016	84.6	*
N-03881	FUL_GCTY_N-03881_WG_20160715	7/15/2016	81.5	*
N-03881	FUL_GCTY_N-03881_WG_20160912	9/12/2016		
N-03881	FUL_GCTY_N-03881_WG_20161020	10/20/2016	72	
N-03881	FUL_GCTY_N-03881_WG_20170120	1/20/2017	86.3	
N-03881	FUL_GCTY_N-03881_WG_20170418	4/18/2017	88.7	
N-03881	FUL_GCTY_N-03881_WG_20170707	7/7/2017	68.6	
N-03881	N-03881-GW-426-466-20190904-0	9/4/2019	79	D
N-03881	FUL_GCTY_N-03881_WG_20200410	4/10/2020	113	
N-03881	FUL_GCTY_N-03881_WG_20200505	5/5/2020	121	
N-03881	FUL_GCTY_N-03881_WG_20200812	8/12/2020	83.4	
N-03881	FUL_GCTY_N-03881_WG_20200918	9/18/2020	74.6	
N-03881	FUL_GCTY_N-03881_WG_20201005	10/5/2020	76.6	
N-03881	FUL_GCTY_N-03881_WG_20201109	11/9/2020	79.4	
N-03881	FUL_GCTY_N-03881_WG_20201204	12/4/2020	68.1	


N-03881 TCE
y = 0.2951e^0.0001x
1000
100
10
1
0.1
TCE (ug/l)
2006
2011
2016
2021
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 1, Table 1h
N-11171 TCE Data

Location ID	Sample ID	Date	Result (ug/L)	Qualifier
N-11171	M6_19890522	5/22/1989	89.4	
N-11171	M6_19890616	6/16/1989	88.3	
N-11171	M6_19900711	7/11/1990	99	
N-11171	M6_19900820	8/20/1990	119	
N-11171	M6_19910418	4/18/1991	93.7	
N-11171	M6_19920115	1/15/1992	67.6	
N-11171	M6_19920520	5/20/1992	261	
N-11171	M6_19930706	7/6/1993	103	
N-11171	M6_19941102	11/2/1994	92.7	
N-11171	M6_19970206	2/6/1997		U
N-11171	M6_19980603	6/3/1998	2.5	
N-11171	M5_447-457_20010927	9/27/2001	1	
N-11171	M6_220_20010927	9/27/2001	14	
N-11171	M5_445_20150505	5/5/2015	0.084	
N-11171	ACTDJB93989201505151459004	5/5/2015	1.1	
N-11171	FUL_N11171_215-235_WG_N_20160113	1/13/2016	3.1	
N-11171	N-11171-GW-220-20190829-0	8/29/2019	0.37	J
N-11171	N-11171-GW-220-20191206-0	12/6/2019	13	


N-11171 TCE
y = 4E+08e-5E-04x
1000
100
10
1
0.1
0.01
TCE (ug/l)
2000
2005
2010
2015
2020
Years
TCE (ug/l)
TCE MCL = 5 ug/L
Expon. (TCE (ug/l))

Attachment 2

MNA Screening Scoresheets

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 2, Table 1
MNA Screening September 2019

Parameter	Scoring Concentration	Units	Interpretation	Point Value	MW-20C 9/3/2019		MW-23C 9/3/2019		MW-24A 9/3/2019		MW-25A 9/5/2019	MW-25A 9/3/2019	MW-26F 9/5/2019	MW-26F 9/3/2019	MW-26G 9/5/2019	MW-26G 9/3/2019	N-03881 9/4/2019	N-03881 9/3/2019	N-11171 8/28/2019	N-11171 8/28/2019
					Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded
Dissolved Oxygen	< 0.5	mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	0	3	0	3	0	3	0	3	0	3	0.46	3	NM	0	0	3
Dissolved Oxygen	> 5	mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	0	0	0	0	0	0	0	0	0	0	0.46	0	NM	0	0	0
Nitrate	< 1	mg/L	At higher concentrations may compete with reductive pathway	2	0.05 U	2	0.69	2	6.1	0	4.2	0	0.05 U	2	0.36	2	6.8	0	0.46	2
Iron II*	> 1	mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)- reducing conditions	3	0.25 J	0	2.5 J	3	0.09 J	0	0.2 J	0	0.1 UJ	0	0.3 J	0	0.1 UJ	0	4.4 J	3
Sulfate	< 20	mg/L	At higher concentrations may compete with reductive pathway	2	23	0	20	0	32	0	32	0	5.1	2	27	0	12	2	27	0
Sulfide	> 1	mg/L	Reductive pathway possible	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Methane	< 0.5	mg/L	VC oxidizes	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Methane	> 0.5	mg/L	Ultimate reductive daughter product, VC accumulates	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
ORP	< 50	mV	Reductive pathway possible	1	-121	1	-40	0	-124	1	14	1	-256	1	23	1	NM	0	-53	1
ORP	< -100	mV	Reductive pathway likely	2	-121	2	-40	0	-124	2	14	0	-256	2	23	0	NM	0	-53	0
pH	5 > pH < 9	SU	Optimal range for reductive pathway	0	11.37	0	6.61	0	7.24	0	6.55	0	9.33	0	6.52	0	NM	0	6.57	0
pH	5 < pH > 9	SU	Outside optimal range for reductive pathway	-2	11.37	-2	6.61	0	7.24	0	6.55	0	9.33	-2	6.52	0	NM	0	6.57	0
TOC	> 20	mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	4.2	0	1.5	0	1.7	0	1.5	0	2.9	0	1 U	0	1	0	1.4	0
Temperature	> 20	°C	At T >20°C biochemical process is accelerated	1	16.99	0	15.37	0	17.17	0	16.24	0	16.41	0	15.94	0	NM	0	16.27	0
Carbon Dioxide	> 2x background	mg/L	Ultimate oxidative daughter product	1	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Alkalinity[a]	> 2x background	mg/L	Results from interaction between CO_2 and aquifer minerals	1	73	0	61	0	61	0	38	0	110	0	36	0	14	0	47	0
Chloride[a]	> 2x background	mg/L	Daughter product of organic chlorine	2	64	0	49	0	20	0	35	0	28	0	34	0	18	0	52	0
Hydrogen	> 1	nM	Reductive pathway possible, VC may accumulate	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Hydrogen	< 1	nM	VC oxidized	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Volatile Fatty Acids	> 0.1	mg/L	Intermediates resulting from biodegradation of more complex compounds; carbon and energy source	2	2 U	0	2 U	0	2 U	0	2 U	0	2.1	2	2 U	0	2 U	0	2 U	0
BTEX	> 0.1	mg/L	Carbon and energy source; drives dechlorination	2	0.0005 U	0	0.0005 U	0	0.00015 J	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.0005 U	0
Tetrachloroethene	--	ug/L	Material released	0	0.75	0	4.8	0	19	0	23 D	0	17	0	7.9	0	42 D	0	0.52	0
Trichloroethene	--	ug/L	Material released	0	1	0	26 D	0	180 D	0	26 D	0	17	0	23 D	0	79 D	0	0.37 J	0
DCE[b]	--	ug/L	Daughter product of TCE	2	0.5 U	0	0.5 U	0	1.3	2	2	2	5.6	2	0.36 J	2	1.7	2	0.5 U	0
Vinyl Chloride[b]	--	ug/L	Daughter product of DCE	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0
Chloroethane[b]	--	ug/L	Daughter product of DCA or VC under reducing conditions	2	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0
Ethene/Ethane[b]	> 0.01	mg/L	Daughter product of VC/ethene	2	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Ethene/Ethane[b]	> 0.1	mg/L	Daughter product of VC/ethene	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Total Points Awarded						6		8		8		6		12		8		4		9

Fulton Avenue OU2 Natural Attenuation Evaluation
Attachment 2, Table 2
MNA Screening December 2019

Parameter	Scoring Concentration	Units	Interpretation	Point Value	MW-20C 12/9/2019		MW-23C 12/9/2019		MW-24A 12/9/2019		MW-25A 12/6/2019		MW-26F 12/9/2019		MW-26G 12/9/2019		MW-26G dup 12/9/2019		N-11171 12/6/2019	
					Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded	Measured Conc.	Points Awarded
Dissolved Oxygen	< 0.5	mg/L	Tolerated, suppresses the reductive pathway at higher concentrations	3	4.39	0	1.95	0	3.26	0	2.17	0	0.98	0	0.55	0	0.55	0	2.59	0
Dissolved Oxygen	> 5	mg/L	Not tolerated; however, VC may be oxidized aerobically	-3	4.39	0	1.95	0	3.26	0	2.17	0	0.98	0	0.55	0	0.55	0	2.59	0
Nitrate	< 1	mg/L	At higher concentrations may compete with reductive pathway	2	0.054	2	0.05	2	7	0	4.9	0	0.05	2	0.05	2	0.05	2	3.1	0
Iron II*	> 1	mg/L	Reductive pathway possible; VC may be oxidized under Fe(III)- reducing conditions	3	0.1	0	0.09	0	0.54 J	0	0.19 J	0	1.27	3	0.1	0	1.3 J	3	6.61 J	3
Sulfate	< 20	mg/L	At higher concentrations may compete with reductive pathway	2	22	0	7.9	2	31	0	30	0	6.4	2	19	2	22	0	32	0
Sulfide	> 1	mg/L	Reductive pathway possible	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Methane	< 0.5	mg/L	VC oxidizes	0	4.43	0	2640	0	137	0	527	0	3920	0	84.2	0	77.9	0	621	0
Methane	> 0.5	mg/L	Ultimate reductive daughter product, VC accumulates	3	4.43	3	2640	3	137	3	527	3	3920	3	84.2	3	77.9	3	621	3
ORP	< 50	mV	Reductive pathway possible	1	1	1	-57	1	-125	1	76	0	-208	1	-49	1	-49	1	-46	1
ORP	< -100	mV	Reductive pathway likely	2	1	0	-57	0	-125	2	76	0	-208	2	-49	0	-49	0	-46	0
pH	5 > pH < 9	SU	Optimal range for reductive pathway	0	10.86	0	9.97	0	6.49	0	5.93	0	8.63	0	6.95	0	6.95	0	5.91	0
pH	5 < pH > 9	SU	Outside optimal range for reductive pathway	-2	10.86	-2	9.97	-2	6.49	0	5.93	0	8.63	0	6.95	0	6.95	0	5.91	0
TOC	> 20	mg/L	Carbon and energy source; drives dechlorination; can be natural or anthropogenic	2	6.1	0	1 U	0	1.1	0	1 U	0	2	0	1 U	0	1 U	0	1	0
Temperature	> 20	°C	At T >20°C biochemical process is accelerated	1	13.55	0	13.99	0	12.42	0	13.87	0	13.78	0	13.86	0	13.86	0	11.4	0
Carbon Dioxide	> 2x background	mg/L	Ultimate oxidative daughter product	1	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Alkalinity[a]	> 2x background: 53.2 x 2 = 106.4	mg/L	Results from interaction between CO_2 and aquifer minerals	1	130	0	55	0	57	0	40	0	96	0	48	0	44	0	47	0
Chloride[a]	> 2x background: 17 x 2 = 34	mg/L	Daughter product of organic chlorine	2	24	0	75	0	19	0	29	0	28	0	27	0	30	0	44	0
Hydrogen	> 1	nM	Reductive pathway possible, VC may accumulate	3	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Hydrogen	< 1	nM	VC oxidized	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0	NM	0
Volatile Fatty Acids	> 0.1	mg/L	Intermediates resulting from biodegradation of more complex compounds; carbon and energy source	2	2 U	0	2 U	0	2 U	0	2 U	0	7	2	2 U	0	2 U	0	2 U	0
BTEX	> 0.1	mg/L	Carbon and energy source; drives dechlorination	2	0.00105	0	0.00037 J	0	0.0001 J	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.0005 U	0	0.00008 J	0
Tetrachloroethene	--	ug/L	Material released	0	1.1	0	2.1	0	20	0	22	0	14	0	5.5	0	3.7	0	6.8	0
Trichloroethene	--	ug/L	Material released	0	2.4	0	12	0	140	0	27	0	15	0	25	0	21	0	13	0
DCE[b]	--	ug/L	Daughter product of TCE	2	0.5 U	0	0.27 J	2	1.1	2	2.1	2	3.871	2	0.34 J	2	0.32 J	2	0.29 J	2
Vinyl Chloride[b]	--	ug/L	Daughter product of DCE	2	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5	0	0.5	0
Chloroethane[b]	--	ug/L	Daughter product of DCA or VC under reducing conditions	2	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5 U	0	0.5	0	0.5	0
Ethene/Ethane[b]	> 0.01	mg/L	Daughter product of VC/ethene	2	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0
Ethene/Ethane[b]	> 0.1	mg/L	Daughter product of VC/ethene	3	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0	0.002 U	0
Total Points Awarded						4		8		8		5		17		10		11		9