FLOYD | SNIDER
strategy ▪ science ▪ engineering

Two Union Square
601 Union Street, Suite 600
Seattle, WA 98101
tel: 206.292.2078 fax: 206.682.7867

Memorandum

To: Sunny Becker, Washington State Department of Ecology
Copies: Scott Adamek, City of Bothell
From: Kristin Anderson, Floyd|Snider
Date: January 3, 2025
Project ID: CoB-OnCall Ultra
Re: **Ultra Custom Care Cleaners Site Supplemental Groundwater Monitoring**

This memorandum presents the results of recent supplemental groundwater monitoring performed at the Ultra Custom Care Cleaners Site (Site) to evaluate groundwater contaminant conditions during implementation of the Site cleanup action and provide recommendations to optimize the remaining cleanup action components.

BACKGROUND

The Site encompasses the Source Property where former dry cleaning operations caused releases of the dry cleaning solvent tetrachloroethene (PCE) in soil, as well as downgradient properties where groundwater is impacted by PCE and its chlorinated volatile organic compound (CVOC) breakdown products including vinyl chloride. The cleanup action for the Site, as described in the Cleanup Action Plan (CAP; Floyd|Snider 2022) and Engineering Design Report (EDR; Floyd|Snider 2023) utilizes two primary treatment technologies to address contamination resulting from former dry cleaning operations at the Site:

- Soil excavation in three areas at the Source Property, with supplemental mixing of zero-valent iron (ZVI) in the saturated zone to approximately 15 feet below ground surface (bgs) within the deepest excavation area
- Treatment of downgradient shallow and deep groundwater using in situ treatment barriers composed of colloidal activated carbon (Plumestop), ZVI and *Dehalococcoides* bacterial cultures (Bio-Dechlor Inoculum [BDI Plus]), supplemented with targeted treatment zones using soluble organic carbon and BDI Plus

The excavation scope, including ZVI soil mixing, was completed in December 2023 on the Source Property, which is owned by the City of Bothell (City). However, the implementation of downgradient in situ treatment barriers has been delayed while the City secures easements to access two privately owned properties where in situ treatment barriers will be installed per the CAP.

In October 2024, additional groundwater samples were collected at key monitoring well locations at the Site in coordination with Ecology to assess groundwater PCE, vinyl chloride, and geochemical conditions after excavation and ZVI soil mixing. ZVI was expected to cause rapid and complete abiotic degradation of source PCE contamination, with less pronounced effects on vinyl chloride, which is less effectively degraded by ZVI. The addition of ZVI was also expected to produce reducing conditions (i.e., a tendency toward accepting electrons) in groundwater. The effects of soil mixing were also expected to be localized because ZVI is relatively immobile and does not have a tendency to migrate with groundwater.

GROUNDWATER SAMPLE COLLECTION

Groundwater sampling was conducted in accordance with a sampling plan approved by Ecology via email on August 26, 2024.

Groundwater samples were collected from key wells within the groundwater CVOC Areas of Concern at the Site, based on their proximity to the planned in situ treatment barriers:

- BB-2
- UCCMW-7
- UCCMW-18
- UCCMW-29
- UCCMW-31D
- UCCMW-34D
- UCCMW-36D

The locations of the wells, planned locations of in situ treatment barriers, and groundwater key CVOC and geochemical conditions are shown on Figure 4.2 of the EDR, which is provided as Attachment 1 to this memorandum.

Wells were sampled and analyzed for targeted CVOCs and natural attenuation parameters using low-flow sampling methodology and approved laboratory methods provided in the EDR Quality Assurance Project Plan (QAPP). Field samples and field quality control samples collected per the QAPP were analyzed for the following:

- CVOCs PCE, trichloroethene, *cis*-1,2-dichloroethene (DCE), and *trans*-1,2-DCE by USEPA Method 8260D and vinyl chloride by USEPA Method 8260D SIM
- Sulfate by ASTM D516-11
- Nitrate and nitrite by USEPA Method 353.2
- Sulfide by SM 4500-52
- Dissolved gases (ethene, ethane, and methane) by RSK 175

Additionally, samples were collected and analyzed for the following:

- Total iron by USEPA Method 200.7
- Dissolved iron by USEPA Method 6010D

Key groundwater stabilization and geochemical field parameters were also monitored and recorded during sampling including pH, dissolved oxygen (DO), oxidation–reduction potential (ORP), conductivity, and temperature.

A Stage 2A Data Quality Review was performed on the laboratory analytical data in accordance with the QAPP. All data, as qualified, were determined to be acceptable for use. Laboratory analytical reports are provided in Attachment 2.

GROUNDWATER ANALYTICAL RESULTS

The results of groundwater sampling were overall consistent with the effects expected due to ZVI soil mixing on the Source Property, which included reductions of PCE concentrations and more strongly reducing geochemical conditions in a localized area surrounding the soil mixing. A comparison of analytical results from the 2024 supplemental groundwater monitoring with the most recent prior sampling event completed in 2020 is presented in Table 1. Results for key parameters including PCE and vinyl chloride concentrations, iron, and geochemical field parameters (DO and ORP) are discussed in further detail in the following sections.

Tetrachloroethene

PCE decreased most significantly at shallow well UCCMW-18, which is immediately downgradient of the ZVI soil mixing area. In this area, PCE decreased from 130 micrograms per liter (µg/L; 26 times the cleanup level [CUL] of 5 µg/L) to 1.8 µg/L (less than the CUL). PCE also decreased from 9.2 µg/L to non-detect at shallow well UCCMW-29, which was the closest downgradient-adjacent well where PCE previously exceeded the CUL in 2020. The decrease at UCCMW-29 is also attributable to upgradient degradation of PCE. PCE was previously addressed by interim measures for groundwater treatment at UCCMW-7; however, a slight decrease from 1.4 µg/L (less than the CUL) to non-detect was also observed at this location.

Farther downgradient, more modest decreases in PCE concentrations occurred at shallow-to-deep transition zone and deep wells. This observed decrease may be influenced by degradation of some PCE source upgradient but may also be reflective of the overall variability of groundwater PCE conditions.

Vinyl Chloride

Vinyl chloride remained relatively stable compared to 2020 sampling. A decrease of vinyl chloride at UCCMW-18, where the detected concentration of 2.8 µg/L in 2020 was reduced to 0.55 µg/L in 2024, is likely due to ZVI soil mixing immediately upgradient resulting in decreases of PCE

source contamination through abiotic destruction, which does not produce CVOC breakdown products. However, the changes at other wells are most likely indicative of the overall variability of groundwater vinyl chloride conditions and the distribution of vinyl chloride CUL exceedances was unchanged from 2020.

Iron

The distribution of total and dissolved iron provide a general indication of the distribution of ZVI. Iron data were not collected in 2020; however, iron concentrations are expected to be relatively consistent across the Site, and large deviations from the average can, therefore, be used to determine locations that may be influenced by ZVI.

Iron was most elevated relative to average concentrations (ranging from not detected to less than 200 µg/L) at UCCMW-18, where total and dissolved iron were 20,000 and 18,000 µg/L, respectively. Lesser iron concentrations that were still elevated relative to other Site wells, indicating minor potential ZVI influence, were also observed at UCCMW-7 and UCCMW-29.

Geochemistry

Geochemical indicators of reducing conditions include relatively little DO (generally less than approximately 0.5 milligrams per liter [mg/L]) and generally negative ORP (measured in millivolts [mV]). The most significant change in geochemistry occurred at UCCMW-29, where in 2024 DO decreased from 7.29 mg/L in 2020 to 0.53 µg/L and a corresponding decrease in ORP from 118.7 to -122.3 mV also occurred. These effects are attributed to the influence of upgradient ZVI soil mixing. More modest decreases in DO were also measured at BB-2 and UCCMW-34D; however, these were not accompanied by corresponding decreases in ORP and are likely indicative of natural variability in groundwater rather than effects of ZVI.

RECOMMENDATIONS FOR IN SITU TREATMENT IMPLEMENTATION

The effects of ZVI soil mixing, as described in previous sections, were observed in the vicinity of in situ treatment Barrier 1 and Barrier 2 and supplemental treatment zones TZ 1 and TZ 2. Recommendations for each of these treatment components are presented in the following sections. A summary of key groundwater condition changes and recommendations for in situ treatment implementation are additionally presented in Figure 1.

Barrier 1

The primary treatment components for Barrier 1, as detailed in the EDR, include PlumeStop, sulfidated micro ZVI (S-mZVI), and BDI Plus applied over a treatment depth of 9 to 22 feet bgs. This barrier was designed to trap, or sorb, dissolved source PCE using PlumeStop and allow rapid abiotic degradation by S-mZVI. BDI Plus was added with the goal of supplementing existing bacterial colonies Site-wide.

Although ZVI soil mixing was highly effective in decreasing PCE, it is expected that diffusion of sorbed contamination to groundwater will continue to occur in this area of the plume that was historically most contaminated by PCE. Additionally, the depth of the soil mixing was limited to approximately 15 feet, and PCE flux was measured in deeper intervals to 22 feet bgs during pre-engineering design sampling. Therefore, application of PlumeStop with S-mZVI and BDI Plus as described in the EDR is still recommended to provide ongoing sorption and treatment of PCE.

TZ 1 and TZ 2

The primary treatment components for TZ 1 and TZ 2, as detailed in the EDR, are soluble organic carbon and BDI Plus applied over a treatment depth of 6 or 7 to 18 feet bgs. These supplemental treatment zones were originally located immediately upgradient of the Ranch Drive-In and Speedy Glass buildings within the Ranch Drive-In property, where monitoring results indicated that groundwater underlying the buildings had cleanup level exceedances for PCE or vinyl chloride. Organic carbon provides donor electrons to promote biotic degradation by reductive dechlorination, which is accomplished most efficiently by *Dehalococcoides* bacteria.

After ZVI soil mixing, PCE concentrations declined to less than the cleanup level or not detected at UCCMW-7 and UCCMW-29 upgradient of the buildings and vinyl chloride also decreased. Based on these results, relocation of TZ 1 and TZ 2 farther upgradient is recommended to increase dispersion of the mobile treatment material into the remaining vinyl chloride plume, which is present at relatively low concentrations.

Barrier 2

The primary treatment components for Barrier 2, as detailed in the EDR, include PlumeStop, S-mZVI, and BDI Plus applied over a treatment depth of 7 to 27 feet bgs.

As described above for TZ 1 and TZ 2, PCE concentrations declined to less than cleanup levels in the area upgradient of Barrier 2, and only vinyl chloride remains at concentrations exceeding the cleanup level. Given the absence of PCE, abiotic degradation of remaining contamination by S-mZVI is expected to be slow, and biotic reductive dechlorination is the preferred mechanism for treatment of vinyl chloride. Therefore, soluble organic carbon (Aquifix) is proposed in Barrier 2 to promote biotic degradation and a lesser amount of S-mZVI is proposed for the purposes of maintaining reducing geochemical conditions. PlumeStop and BDI Plus are proposed as described in the EDR to allow for sorption and treatment of the remaining vinyl chloride.

REFERENCES

Floyd|Snider. 2022. *Ultra Custom Care Cleaners Site Cleanup Action Plan.* Prepared for City of Bothell. November.

_____. 2023. *Ultra Custom Care Cleaners Site Engineering Design Report.* Prepared for City of Bothell. July.

LIST OF ATTACHMENTS

Table

Table 1
Summary of Groundwater Quality Data 2020–2024

	Analyte Class	CVOCs					Conventionals			
	Analyte	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	trans-1,2-Dichloroethene	Vinyl chloride	Nitrate	Nitrite	Sulfate	Sulfide
	CAS No.	127-18-4	79-01-6	156-59-2	156-60-5	75-01-4	14797-55-8	14797-65-0	14808-79-8	18496-25-8
	CUL	5	5	70	100	0.2	--	--	--	--
	Unit	µg/L	µg/L	µg/L	µg/L	µg/L	mg-N/L	mg-N/L	mg/L	mg/L
Sample Name	Sample Date									
BB-2										
BB-2-031120	3/11/2020	**80**	0.97	0.60	0.40 U	0.046				
BB-2-092024	9/20/2024	**64**	2.4	1.7	0.40 U	0.15	0.32	0.020 U	10	0.050 UJ
UCCMW-7										
UCCMW-7-031020	3/10/2020	1.4	1.3	13	0.20 U	**1.9**				
UCCMW-7-092024	9/20/2024	0.20 U	0.20 U	4.2	0.20 U	**1.3**	0.15	0.020 U	18	0.050 UJ
UCCMW-18										
UCCMW-18-031120	3/11/2020	**130**	1.7	19	1.0 U	**2.8**				
UCCMW-99-031120	3/11/2020	**130**	1.9	19	1.0 U	**2.5**				
UCCMW-18-092024	9/20/2024	1.8	1.0	2.1	0.20 U	**0.55**	0.36	0.020 U	54	0.050 UJ
UCCMW-29										
UCCMW-29-071320	7/13/2020	**9.2**	0.20 U	0.20 U	0.20 U	0.020 U				
UCCMW-29-092024	9/20/2024	0.20 U	0.20 U	0.20 U	0.20 U	0.020 U	0.099	0.020 U	5.0 U	0.050 UJ
UCCMW-31D										
UCCMW-31D-071320	7/13/2020	**25**	0.20 U	6.6	0.20 U	**0.24**				
UCCMW-31D-092024	9/20/2024	**21**	0.27	12	0.20 U	**1.8**	0.31	0.020 U	25	0.050 UJ
UCCMW-34D										
UCCMW-34D-072120	7/21/2020	**18**	0.20 U	0.20 U	0.20 U	0.020 U				
UCCMW-34D-092024	9/20/2024	**13**	0.20 U	0.20 U	0.20 U	0.020 U	1.4	0.020 U	26	0.050 UJ
UCCMW-36D										
UCCMW-36D-071320	7/13/2020	**24**	0.20 U	19	0.20 U	**0.93**				
UCCMW-99-071320	7/13/2020	**24**	0.20 U	20	0.20 U	**0.92**				
UCCMW-36D-092024	9/20/2024	**21**	1.7	11	0.20 U	**0.27**	0.052	0.020 U	23	0.050 UJ

Notes:

Analytical results and CULs are rounded to two significant figures; field parameter measurements are values presented by the instrument.
Blank cells are intentional.
-- Not available.
RED/BOLD Analyte was detected at a concentration the exceeds the CUL.

Abbreviations:

°C Degrees Celsius
CAS Chemical Abstracts Service
CUL Cleanup level
CVOC Chlorinated volatile organic compound
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
mg-N/L Milligrams of nitrogen per liter
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected; concentration is an estimate.
U Analyte was not detected at the associated reporting limit.
UJ Analyte was not detected at the associated reporting limit, which is an estimate.

Table 1
Summary of Groundwater Quality Data 2020–2024

	Analyte Class	Dissolved Gases			Total Metals	Dissolved Metals	Field Parameters					
	Analyte	Ethane	Ethene	Methane	Iron	Iron	Dissolved Oxygen	ORP	pH	Specific Conductance	Temperature	Turbidity
	CAS No.	74-84-0	74-85-1	74-82-8	7439-89-6	7439-89-6	--	--	pH	--	--	--
	CUL	--	--	--	--	--	--	--	--	--	--	--
	Unit	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	mV	pH	µS/cm	°C	NTU
Sample Name	Sample Date											
BB-2												
BB-2-031120	3/11/2020	0.22 UJ	0.29 UJ	2.0 J			2.84	97.8	6.49			3.24
BB-2-092024	9/20/2024	0.56 U	0.58 U	90	58	56 U	0.31	80.7	6.22	295.3	18.6	0.98
UCCMW-7												
UCCMW-7-031020	3/10/2020	0.22 UJ	0.29 UJ	1,000 J			0.53	-42.9	6.23			2.7
UCCMW-7-092024	9/20/2024	0.56 U	0.58 U	590	6,700	6,900	0.28	-9.1	6.39	345.4	18.2	1.18
UCCMW-18												
UCCMW-18-031120	3/11/2020	0.22 UJ	2.3 J	1,300 J								
UCCMW-99-031120	3/11/2020	0.22 UJ	2.2 J	1,400 J			0.55	-48.3	6.21			5.7
UCCMW-18-092024	9/20/2024	0.56 U	0.68	1,800	20,000	18,000	0.42	-75.9	6.24	331.3	19.3	3.66
UCCMW-29												
UCCMW-29-071320	7/13/2020	0.22 U	0.29 U	83			7.29	118.7	6.55			9.74
UCCMW-29-092024	9/20/2024	0.56 U	0.58 U	330	670	230	0.53	-122.3	7.47	258.8	16.9	11.07
UCCMW-31D												
UCCMW-31D-071320	7/13/2020	3.3 U	4.3 U	1,200			0.28	90.1	6.21			15.98
UCCMW-31D-092024	9/20/2024	0.56 U	0.58 U	68	50 U	56 U	0.42	101.1	6.28	308.7	17.3	1.26
UCCMW-34D												
UCCMW-34D-072120	7/21/2020	6.7 U	8.7 U	2,600			2.02 JS	57.5	6.18			2.2
UCCMW-34D-092024	9/20/2024	0.56 U	0.58 U	59	50 U	56 U	0.32	84.3	6.13	284.4	16.2	1.45
UCCMW-36D												
UCCMW-36D-071320	7/13/2020	2.2 U	2.9 U	840			0.44	74.9	6.17			2.22
UCCMW-99-071320	7/13/2020	2.2 U	2.9 U	860								
UCCMW-36D-092024	9/20/2024	0.56 U	0.58 U	61	180	150	0.39	67.2	6.25	342.2	17	1.15

Notes:

Analytical results and CULs are rounded to two significant figures; field parameter measurements are values presented by the instrument.

Blank cells are intentional.

-- Not available.

RED/BOLD Analyte was detected at a concentration the exceeds the CUL.

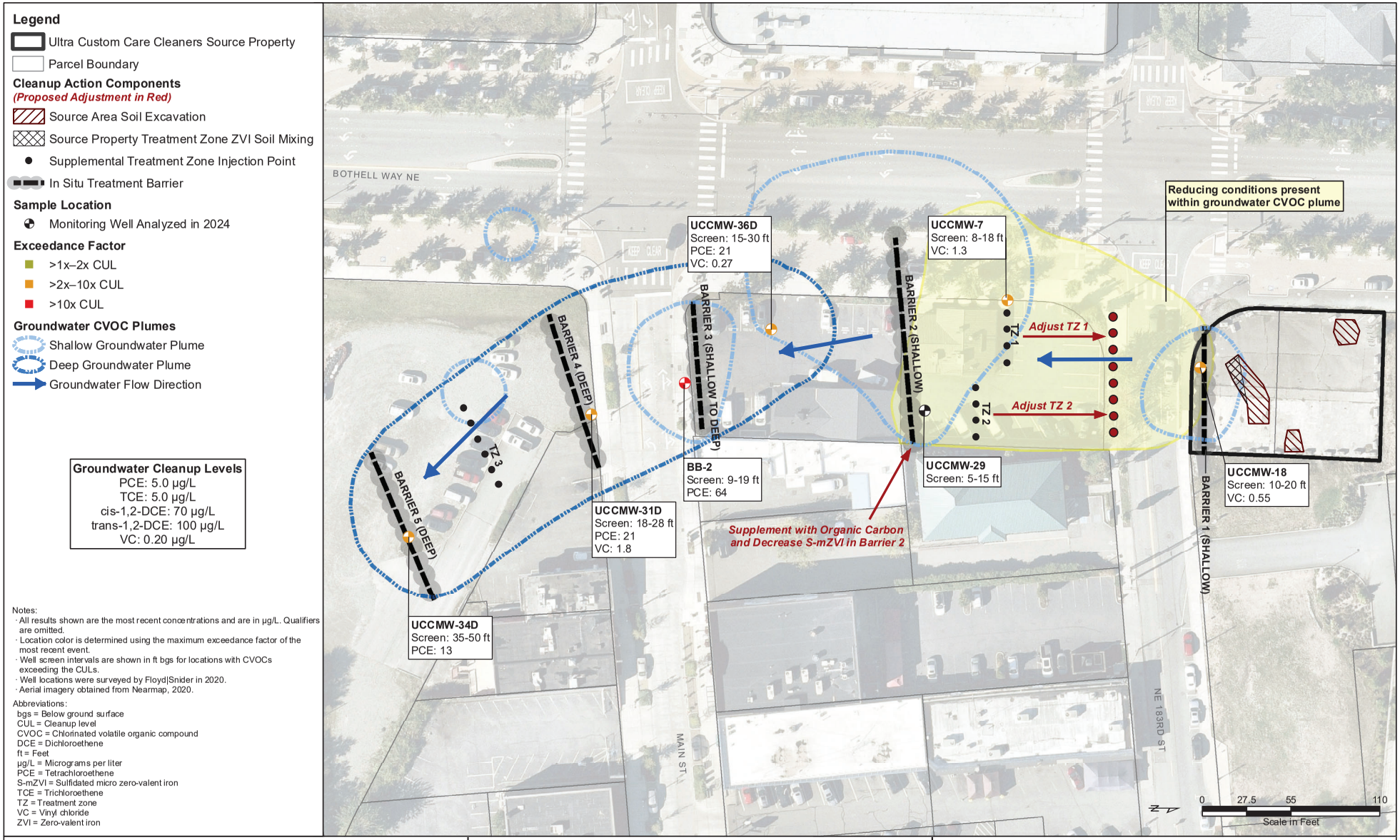
Abbreviations:

°C Degrees Celsius
CAS Chemical Abstracts Service
CUL Cleanup level
CVOC Chlorinated volatile organic compound
µg/L Micrograms per liter
µS/cm Microsiemens per centimeter
mg/L Milligrams per liter
mg-N/L Milligrams of nitrogen per liter
mV Millivolts
NTU Nephelometric turbidity units
ORP Oxidation-reduction potential

Qualifiers:

J Analyte was detected; concentration is an estimate.
U Analyte was not detected at the associated reporting limit.
UJ Analyte was not detected at the associated reporting limit, which is an estimate.

Figure



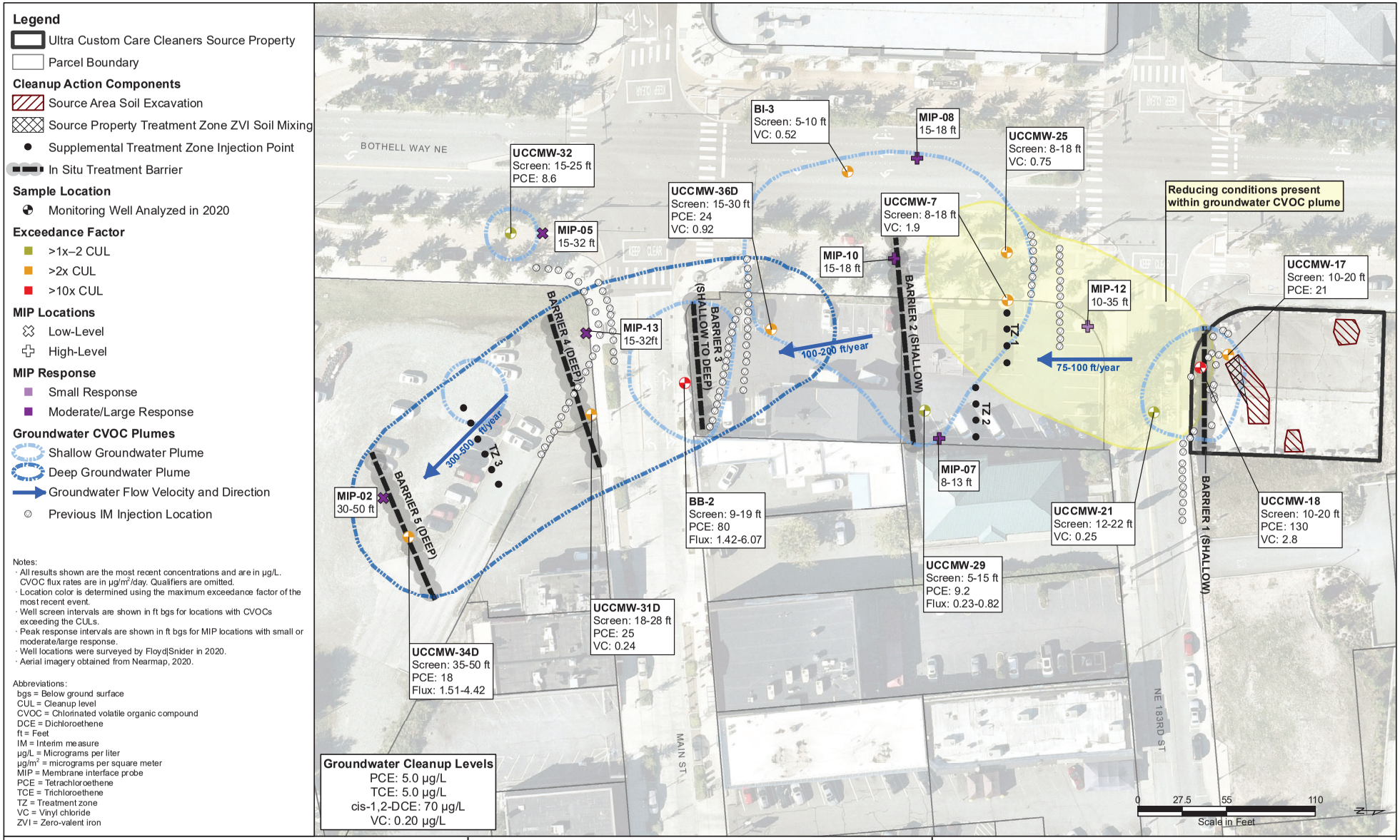
FLOYD | SNIDER
strategy · science · engineering

Supplemental Groundwater Monitoring
Ultra Custom Care Cleaners Site
Bothell, Washington

Figure 1
Summary of Groundwater Data and
In Situ Treatment Recommendations

I:\GIS\Projects\COBothell-Ultra\MXD\2024_GWMonitoring_Memo\01-MapDocuments\Figure 1 Summary of Groundwater Data and In Situ Treatment Recommendations.mxd
1/3/2025

Attachment 1
Engineering Design Report Figure 4.2



FLOYD | SNIDER
strategy • science • engineering

Engineering Design Report
Ultra Custom Care Cleaners Site
Bothell, Washington

Figure 4.2
Groundwater Design Data for CVOC Distribution, Geochemistry and Flow Velocity

I:\GIS\Projects\COBothell-Ultra\MXD\Engineering Design Report\Figure 4.2 Groundwater Design Data for CVOC Distribution, Geochemistry and Flow Velocity.mxd
7/12/2023

Attachment 2
Laboratory Analytical Report