

Work Plan
In-Situ Treatment of Areas of Residual Contamination
Boomsnub/Airco Superfund Site
Hazel Dell, Washington

Prepared for

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LIST OF ACRONYMS

bgs	Below ground surface
EA	EA Engineering, Science, and Technology, Inc.
EPA	U.S. Environmental Protection Agency
ft	Feet
ft ²	Square feet
gpm	Gallons per minute
µg/L	Micrograms per liter
psi	Pounds per square inch
QA/QC	Quality assurance/quality control
QASP	Quality Assurance and Sampling Plan
Site	Boomsnub/Airco Superfund Site
TCE	Trichloroethene
TOPPS	Toe-of-Plume Pilot Study
VOC	Volatile organic compound
ZVI	Zero valent iron

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1. INTRODUCTION

This Work Plan presents the activities planned for the in-situ remediation of two areas of residual contamination near the original downgradient extent of the groundwater plume at the Boomsnub/Airco Superfund Site (Site) located in Hazel Dell, Washington (Figure 1). A groundwater extraction and treatment system has been in operation at the Site since 1991. This system pumps groundwater from the alluvial aquifer and removes trichloroethene (TCE) and chromium, the primary chemicals of concern (COC) for the Site, prior to discharging the water back into the alluvial aquifer via an infiltration gallery located upgradient of the plumes. The contaminant plumes originally extended west approximately 4,500 feet (ft) downgradient from the source areas.

The groundwater extraction and treatment system has made significant progress in reducing plume size and contaminant concentrations in the groundwater. The chromium and TCE concentration isopleths for the Spring 2012 sampling event at the Site are shown on Figure 2. Currently, impacts in the western (downgradient) end of the original plume area have been reduced to two small areas of residual contamination which the extraction system does not effectively address. The two areas of residual contamination are near wells MW-35 and AMW-27. For ease of discussion, the Site has been divided geographically into several well groupings, as shown on Figure 3. Former extraction well MW-35 is located within the original Toe-of-Plume area of the Site. Active extraction well AMW-27 is located within the Church-of-God area of the Site.

Chromium concentrations in wells MW-35 and AMW-27 are below the Site cleanup level of 80 micrograms per liter ($\mu\text{g/L}$). Only TCE concentrations exceed the Site cleanup level of 5 $\mu\text{g/L}$. The screened intervals for these two wells are partially within a lower permeability silt layer. Experience with other Site extraction wells indicates that contaminants in the silt layer may not be effectively removed by pumping alone. Therefore, use of an in-situ treatment is proposed in these two localized areas.

Participants in the remedial activities at the Site are the U.S. Environmental Protection Agency (EPA) and Linde. Linde's consultant, EA Engineering, Science, and Technology, Inc. (EA), is responsible for implementing field efforts and other activities at the Site on behalf of Linde. EA will provide and coordinate the resources necessary to meet the objectives described in this document. Analytical support for this project will be provided by Columbia Analytical Services, Inc./ALS of Kelso, Washington.

A Quality Assurance and Sampling Plan (QASP) for the Site was prepared by EA in August 2004 (EA 2004). General procedures relating to sample quality are presented in the QASP and will be adhered to during sampling activities, with the exceptions noted in this document. Health and safety procedures to be followed during field activities are described in the Health and Safety Plan for the Site (EA 2007b).

This document is organized in six sections:

- The project approach and rationale are discussed in Section 2.
- The scope of work, including procedures for field sampling, is described in Section 3.
- The in-situ treatment technology and application are discussed in Section 4.
- The project schedule is presented in Section 5.
- A list of references cited is provided in Section 6.

Appendix A provides graphs showing historical TCE concentrations and pumping rates for relevant extraction wells. Appendix B provides a copy of the Material Safety Data Sheet for the treatment product proposed for use.

2. APPROACH AND RATIONALE

2.1 PROJECT OBJECTIVE

The project objective is to implement an in-situ remedy to achieve the groundwater cleanup level for TCE in two areas of residual contamination in order to reduce the overall size of the plume and aid in closure of the Toe-of-Plume area.

2.2 GEOLOGY AND HYDROGEOLOGY

In descending order from the ground surface, the geologic units at the Site include the alluvial aquifer, silt layer, aquitard, and Troutdale formation. The upper portion of the alluvial aquifer consists of sand with varying amounts of silt. The silt content tends to increase with depth in this unit. The alluvial aquifer ranges in thickness from about 60 to 140 ft. The groundwater flow direction in the alluvial aquifer at the Site is well established, with groundwater moving to the west-northwest. A network of extraction wells was installed along the centerline of the Site plumes to capture impacted groundwater. These extraction wells have created an artificial gradient toward the pumping wells.

A silt layer occurs at the base of the alluvial aquifer and generally consists of 10 to 20 ft of silt and clayey silt that grade into the aquitard. The aquitard consists of clay and silty clay. The thickness of the aquitard varies across the Site, generally ranging from about 10 to 30 ft. The silt unit and aquitard serve as a major barrier to vertical groundwater flow between the alluvial aquifer and the underlying Troutdale aquifer.

In the original Toe-of-Plume area near MW-35, boring logs indicate generally sandy soils to a depth of approximately 85 ft where an increase in silt content appears to indicate the beginning of the silt layer. In the vicinity of well AMW-27 in the Church-of-God area, boring logs indicate generally sandy soils to depths ranging from about 75 to 85 ft where an increase in silt content indicates the beginning of the silt layer.

2.3 PROBLEM DEFINITION

As of Spring 2012, two localized areas of residual contamination remain downgradient of the main TCE plume at the Site (Figure 2). One of these locations is in the Toe-of-Plume area near well MW-35 and the other is in the Church-of-God area near AMW-27. Both areas of residual contamination contain TCE at concentrations exceeding the Site cleanup level of 5 µg/L. Chromium in these areas is below the cleanup level of 80 µg/L.

Research and experience has shown that the effectiveness of pump-and-treat technology decreases significantly over time. Residual concentrations of contaminants can remain in the groundwater above cleanup criteria, persisting for long periods of time as described in the “Pump-and-Treat Groundwater Remediation Guide for Decision Makers and Practitioners” (EPA 1996). Additionally, Site experience has shown that pumping alone may not be sufficient to reduce contaminant concentrations to levels below the cleanup level within the silt layer. For

wells with screened intervals partially intersecting the silt layer, under pumping conditions contaminant concentrations are diluted by clean water from the more permeable sandy alluvial aquifer. Under non-pumping conditions, TCE may diffuse out of the silt layer, resulting in increased concentrations in groundwater samples from the well.

Wells MW-35 and AMW-27 are both screened partially within the low permeability silt layer. Therefore, use of an in-situ treatment is proposed to expedite reduction of TCE concentrations and allow closure of the downgradient portions of the former plume area.

2.3.1 2006 Toe-of-Plume Pilot Study

In 2006, a single area of residual contamination was identified in the original Toe-of-Plume area, immediately upgradient of extraction well MW-41. The area of residual contamination was believed to be located in the low permeability silt layer, at a depth of approximately 80 to 90 ft below ground surface (bgs). Extraction wells in the Toe-of-Plume area had been shut off several times, but had to be turned back on due to contaminant rebound that occurred following well shut off and groundwater equilibration. This pulse pumping was not sufficient to reduce contaminant concentrations to levels below the Site cleanup levels; therefore, it was determined that another means of treatment was needed to complete remediation of the area of residual contamination.

A Toe-of-Plume Pilot Study (TOPPS) in-situ treatment was initiated in September 2006 in an effort to reduce TCE and chromium contamination in groundwater in this localized area. A proprietary material called EHC-M[®] was injected into the aquifer upgradient of well MW-41. Since the in-situ treatment was implemented, chromium and TCE concentrations in the TOPPS monitoring wells have remained below the cleanup level, indicating that the TOPPS treatment was effective (EA 2007a, EA 2010).

2.3.2 Toe-of-Plume Area and MW-35

In the Toe-of-Plume area, groundwater contamination at concentrations exceeding the Site cleanup levels is limited to TCE in the vicinity of former extraction well MW-35 (Figure 3). Well MW-35 is screened from 79 to 89 ft bgs. The area of residual contamination in the MW-35 area is believed to be located in the silt layer which occurs at a depth of approximately 85 ft to 95 ft bgs in this area. The boring log for MW-35 shows that the well is partially screened in the silt layer.

Wells near the area of residual contamination at MW-35 include former extraction wells AMW-42 and MW-48 (Figure 3). The historical monitoring data (1999 through the present) for TCE concentrations in groundwater samples collected from these wells are presented in Table 1. The pumping history, as well as TCE concentration data, is presented graphically in Appendix A. The data for these three wells are summarized below:

- Former extraction well AMW-42 (screened primarily in the silt layer) was pumped from 1999 through February 2005. TCE concentrations in groundwater samples from this well have been below the cleanup level since 2001.
- Former extraction well MW-35 (screened partially in sand with silt near the bottom of the screened interval) was pumped starting in 2000. TCE concentrations in groundwater samples from the well initially dropped below the cleanup level in August 2004. In February 2005, the pump in this well was turned off. In August 2005, the TCE concentration increased to 5.0 µg/L, equal to the cleanup level. Since that time, the TCE concentration has been fluctuating above and below the cleanup level. The most recent TCE concentration was 6.2 µg/L, detected in April 2012.
- Former extraction well MW-48 (screened in sand) was pumped from 1999 through May 2004. TCE concentrations in groundwater from this well have been below cleanup level since it was installed.

Historically, the primary flow of contaminants in the Toe-of-Plume area appeared to follow a path from MW-35 through AMW-42 to MW-41 (Figure 3). Analytical results from a direct push investigation conducted by EPA and ICF Kaiser in 1999 (ICF Kaiser 1999) indicated no contamination 30 ft north and south of the primary path of contamination (through MW-35, AMW-42, and MW-41). The investigation results also indicated that the contamination occurred in a 5 to 10 ft thick layer at a depth between 80 and 90 ft bgs, which is similar to the depth of the silt layer. Extraction well pumping and the TOPPS treatment appear to have eliminated all but the one residual area of TCE contamination in the Toe-of Plume area around MW-35.

Based on the available information, the resulting area of residual contamination is estimated to be approximately 100 square feet (ft²) in area and up to 15 ft in thickness. Figure 4 illustrates the predicted range and location of the area of residual contamination in the vicinity of well MW-35. In-situ treatment of this residual area of TCE contamination will aid in the closure of the Toe-of-Plume area.

2.3.3 Church-of-God Area and Well AMW-27

In the western Church-of-God area, groundwater contamination at concentrations exceeding the Site cleanup levels is limited to TCE in the vicinity of former extraction well AMW-27 and possibly in the vicinity of silt monitoring well AMW-61 (Figure 4). The area of residual contamination is believed to be located in the silt layer at a depth of approximately 75 to 95 ft bgs. Well AMW-27 is screened from 78 to 88 ft bgs. The boring log for AMW-27 shows that the well is almost completely screened within the silt layer. Monitoring well AMW-61 was installed during an investigation of the characteristics of the silt layer (EA 2005) and is screened within the silt layer (from 92 to 97 ft bgs).

Church-of-God wells near the area of residual contamination at AMW-27 and AMW-61 include extraction wells MW-25D, MW-26D, and MW-49. Chromium concentrations in groundwater in

this area are below the cleanup level. Active extraction wells AMW-27, MW-25D, MW-26D, and MW-49 will be shut off and monitored before in-situ treatment in this area, as described in Sections 3.3 and 3.5. The historical monitoring data (1999 through the present) for TCE concentrations in groundwater samples collected from these wells are presented in Table 1. The pumping history, as well as TCE concentration data, is presented graphically in Appendix A. The data for these wells are summarized below:

- Active extraction well AMW-27 has been pumped from 1998 to the present. Due to the low permeability of the soil within the screened interval, the maximum pumping rate for this well has typically been less than 1 gallon per minute (gpm). TCE concentrations in groundwater samples from this well have been gradually decreasing, but remain above the Site cleanup level. The most recent TCE concentration was 12 µg/L, detected in April 2012.
- Monitoring well AMW-61 was installed in 2005 to allow collection of groundwater samples from the silt layer. This well has only been sampled five times since it was installed. The TCE concentration has been above the Site cleanup level in all samples. The most recent TCE concentration was 6.0 µg/L, detected in October 2010. This well is currently on a biennial sampling frequency, and was sampled in October 2012; however, results from this recent sampling event are not yet available.
- Extraction well MW-25D (screened from 68 to 78 ft bgs, in sand) has been pumped from 1996 to the present. TCE concentrations in groundwater samples from this well initially dropped below the cleanup level in October 2002. The well was temporarily turned off in March 2005. In October 2006 and February 2007, the TCE concentration increased above the cleanup level. The pump was turned back on in March 2007, and remains on. TCE concentrations in samples collected from May 2007 to the present have been below the cleanup level. The most recent TCE concentration was 1.3 µg/L, detected in April 2012.
- Extraction well MW-26D (screened from 83 to 93 ft bgs, in silty sand) has been pumped from 1996 to the present. TCE concentrations in groundwater samples from this well decreased to levels below the Site cleanup level in May 2004, and have remained below the cleanup level. The most recent TCE concentration was 0.76 µg/L, detected in April 2012.
- Extraction well MW-49 (screened from 71 to 81 ft bgs, in sand) has been pumped from 2001 to the present. TCE concentrations in groundwater samples from this well decreased to levels below the Site cleanup level in October 2008, and have remained below the cleanup level. The most recent TCE concentration was 1.4 µg/L, detected in April 2012.

Based on the available information, the resulting area of residual contamination is estimated to be approximately 3,000 ft² in area and up to 20 ft in thickness. Figure 4 illustrates the predicted range and location of the area of residual contamination.

Unlike the Toe-of-Plume area, the Church-of-God area will not be closed once the area of residual contamination is treated. The current leading edge of the plume is at the eastern edge of the Church-of-God area. Treating the area of residual contamination now will allow for faster closure of the Church-of-God area once the eastern edge reaches cleanup levels.

2.4 TECHNOLOGY DESCRIPTION

The TOPPS conducted in 2006 showed that an in-situ treatment technology can be applied to areas of residual contamination to effectively treat recalcitrant TCE and chromium contamination.

On the basis of the results of the pilot study, the chosen technology for the treatment of the two areas of residual contamination is reductive dechlorination of TCE by both biotic and abiotic means. This technology has been widely applied at the field scale and is commercially available for full site remediation activities. These in-situ treatments are often implemented by creating a treatment zone at, or downgradient of, a contaminant plume or area of residual contamination. A series of wells or hydraulic push boreholes are used to inject the product into the subsurface creating the zone of treatment. Further description of the planned in-situ treatment is described in Sections 3 and 4.

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3. SCOPE OF WORK

3.1 OVERVIEW

Prior to implementing the in-situ treatment, baseline sampling will be performed including collection of groundwater samples from existing wells near the two areas of residual contamination and collection of soil (for lithologic information only) and groundwater samples from direct push borings. The results of the baseline sampling will be used to refine the locations for in-situ treatments. Following the treatments (discussed in Chapter 4), groundwater monitoring of existing wells will be used to evaluate the effectiveness of the treatments. The scope of work consists of the following tasks:

- Utility clearance
- Baseline groundwater sampling
- Direct push sampling
- In-situ treatment injections (See Chapter 4)
- Groundwater monitoring
- Investigation-Derived Waste Handling
- Reporting

EA will coordinate with the property owners and/or authorized representatives in completing this project. Easement agreements are in place with Bonneville Power Authority, owner of the western portion of the original Toe-of-Plume area, and with the Church of God. Use of a temporary access agreement is anticipated for Parcel 144718-000, on the eastern side of the original Toe-of-Plume area.

Because the proposed treatment area at well AMW-27 is located in the middle of the parking lot and driving area for the King's Way Christian School on the Church-of-God property, the schedule for direct push sampling and treatment injections will be aligned with school holidays or breaks, to the extent possible.

3.2 UTILITY CLEARANCE

A utility locating service will be used to identify subsurface utilities prior to invasive activities at the direct push investigation locations and injection points. Locations will be adjusted, as necessary, based on the presence of underground or overhead utilities.

3.3 BASELINE GROUNDWATER SAMPLING

Sampling will be conducted to establish baseline data on groundwater conditions that can be compared to monitoring data following the injections. This will allow an evaluation of the effects on wells from the injection process, if any. The baseline sampling will be conducted after nearby extraction wells (AMW-27, MW-25D, MW-26D, and MW-49) have been shut off for at

least one month to allow contaminant concentrations to stabilize. The baseline sampling will be conducted around the same time period as the direct push sampling.

Groundwater sampling will be conducted using EPA-approved low-flow groundwater sampling methods, as presented in the Site QASP (EA 2004). The samples will be collected and handled in accordance with the procedures detailed in the Site QASP. Field parameters will be monitored and recorded during well purging and will include:

- pH
- Temperature
- Conductivity
- Dissolved oxygen
- Oxidation-reduction potential
- Turbidity

Groundwater samples will be collected from eight wells located near the two areas of residual contamination including the following:

Toe-of-Plume wells AMW-42, MW-35, and MW-48; and
Church-of-God wells AMW-27, AMW-61, MW-25D, MW-26D, and MW-49.

The samples will be collected into laboratory-provided, pre-cleaned, pre-preserved bottles. Each sample will be labeled and recorded on a chain-of-custody form following the procedures detailed in the Site QASP (EA 2004). Samples will be submitted for laboratory analysis of the following parameters:

- VOCs (EPA Method 8260C)
- Total iron (EPA Method 6010B)
- Dissolved iron (EPA Method 6010B)
- Arsenic, manganese (EPA Method 6020)
- Total organic carbon (EPA Method 415.1)
- Sulfate (EPA Method 300)
- Sulfide (EPA Method 376.1)

VOCs will be analyzed to determine TCE concentrations. The additional parameters will be analyzed to allow later evaluation of possible impacts to water quality due to use of the proposed treatment product. Total iron, dissolved iron, and total organic carbon are temporarily released into groundwater by the treatment product and therefore will be monitored. Arsenic, manganese, and iron could be released from the soil matrix due to the reducing conditions created by the treatment product. Sulfate and sulfide may be created as a byproduct of biological degradation.

Quality assurance/quality control (QA/QC) samples will include one duplicate sample, one matrix spike/matrix spike duplicate, and one trip blank. In addition, one rinsate sample will be collected for each day of sampling when using a non-dedicated sampling pump.

3.4 PRE-TREATMENT DIRECT PUSH INVESTIGATION

A pre-treatment direct push investigation will be performed to collect and establish baseline data for groundwater conditions and confirm the extent of impacted groundwater within the planned injection zone. The direct push investigation is planned to occur around the same time as the baseline well sampling. Soil and groundwater samples will be collected using direct push technology at up to eight locations; anticipated locations are shown on Figure 4. The locations may be modified based on field conditions or more recent results from well sampling.

The borings will be advanced and decommissioned by a licensed driller, in accordance with WAC 173-160, under EA oversight. Each boring will be advanced to a depth of approximately 95 ft bgs. Direct push rods and samplers will be decontaminated between boring locations by pressure washing. Soil core sleeves are disposable and will not be reused. Boreholes will be backfilled with bentonite when sampling is complete at each location. A Global Positioning System receiver will be used to record the coordinates of the sampling points.

3.4.1 Soil Sampling

Soil core sleeves will be used to collect a 4-foot core of soil from the desired depth range. The soil core sleeves are pulled to the surface and cut open to allow logging of the boring. Soil will be logged in accordance with the United Soil Classification System to describe the lithology in the treatment zone and identify the depth of the less permeable silt layer where residual contamination tends to remain. In general, the soil will be continuously logged between 75 and 95 ft bgs.

3.4.2 Groundwater Sampling

A direct push sampler with a retractable screen (Geoprobe™ SP-16 or similar) will be used to collect groundwater samples. The 4-ft long sampler will be driven to the selected sample depth. Because the bottom of the sampler will be at the designated sample depth, the actual sample interval will extend 4 ft upward (i.e.; a sample designated at 85 ft bgs will actually be collected from approximately 81 to 85 ft bgs). The tool string will be pulled back approximately 4 ft to expose the screen. Groundwater samples will be collected using polyethylene tubing and a bottom check valve. Water will be pumped up into the tubing by oscillating the tubing up and down. At least one tubing volume of water will be discharged prior to sampling. The tubing will then be withdrawn from the borehole and VOC samples will be collected by draining water from the base of the tubing directly into laboratory-supplied, pre-preserved volatile organic analysis vials.

New disposable tubing will be used for sampling of each well. Pumping water from tight portions of the formation will be attempted for a maximum of 1 hour at any one location/depth. Water remaining in the tubing after VOC sample collection will be drained into a container for measurement of field parameters as listed in Section 3.3. Field parameters will be measured based on the availability of water.

It is anticipated that three groundwater samples will be collected from each location at depths of approximately 75, 85, and 95 ft bgs. The samples will be analyzed for VOCs by EPA Method 8260C.

Duplicate groundwater samples will be collected for every 10 samples and matrix spike/matrix spike duplicates will be collected for every 20 samples. One trip blank will be included with each cooler shipped, and one rinsate sample will be collected each day.

3.5 GROUNDWATER MONITORING

After the pumps are turned off at the extraction wells on the Church property, wells AMW-27, MW-25D, MW-26D, and MW-49 will be sampled periodically for VOCs (EPA Method 8260C) and total chromium (EPA Method 200.7) to monitor possible contaminant rebound. Well AMW-27 will be sampled on a quarterly basis and wells MW-25D, MW-26D, and MW-49 will be sampled on a semiannual basis for rebound monitoring. After one year of rebound monitoring, the sampling frequency will be re-evaluated. Note that following the product injections, the treatment monitoring schedule discussed below will also apply.

Groundwater monitoring will be conducted following the product injections to assess the performance of the treatment relative to achieving Site groundwater cleanup levels. Sampling will also be performed to monitor temporary water quality impacts due to use of the treatment product. Selected wells in the Toe-of-Plume and Church-of-God areas will be sampled on a quarterly basis for a period of one year following EHC[®] injection. The monitoring frequency will be re-evaluated on an annual basis. Groundwater sampling procedures are presented in Section 3.3. The wells will be monitored as follows:

- Groundwater samples will be collected from Toe-of-Plume wells AMW-42, MW-35, and MW-48 and Church-of-God wells AMW-27, AMW-61, MW-25D, MW-26D, and MW-49.
- The samples will be submitted for laboratory analysis of the parameters listed in Section 3.3, Baseline Groundwater Sampling.
- Field parameters will be measured, including those listed in Section 3.3 plus ferrous iron, analyzed using a Hach[™] field test kit.

Analyses for impacts to water quality (iron, sulfate, sulfide, arsenic, manganese, total organic carbon) may be discontinued after one year if no significant impacts to water quality are observed.

QA/QC samples for each event will include one duplicate sample, one matrix spike/matrix spike duplicate, and one trip blank. One rinsate sample will be collected for each day of sampling when using a non-dedicated sampling pump. It is anticipated that each sampling event will take two days and will require a two person field crew.

A QASP Addendum will be prepared in advance of the quarterly sampling events and submitted to EPA for approval. The QASP Addendum will identify the wells to be sampled, analyses to be performed, number of QA/QC samples required, and proposed sampling schedule.

3.6 INVESTIGATION-DERIVED WASTE HANDLING

Investigation-derived waste for this project includes drill cuttings, decontamination fluids, purge water, and disposable equipment (tubing, gloves, etc.). Drill cuttings from each boring will be contained in soil bins or drums and transported back to the Boomsnub site for temporary storage. Drill cuttings will be tested and properly disposed based on concentrations of TCE and chromium present. Decontamination fluids and groundwater will be contained in 55-gal drums or similar containers, and transported back to the Boomsnub treatment facility for treatment and discharge to the Linde infiltration gallery. Disposable equipment will be handled in accordance with the Site QASP.

3.7 REPORTING

Following completion of the baseline sampling and direct push investigation, EA will prepare a brief letter report providing the sampling results and identifying areas where treatment will be conducted. A Work Plan addendum will also be prepared and submitted concurrent with the letter report. The letter report and Work Plan addendum will be submitted to EPA for approval of the selected treatment locations.

Following completion of the in-situ treatment and first round of post-treatment groundwater monitoring, a brief report will be prepared. The report will include descriptions of the tasks performed and sampling results. Results of other groundwater monitoring events will either be incorporated into routine Site reports (such as the semiannual groundwater sampling reports) or provided in a brief letter report.

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4. TREATMENT

4.1 PRODUCT JUSTIFICATION

Reductive dechlorination of TCE has been chosen as the selected technology for the treatment of areas of residual contamination. This was based on the pilot study conducted in 2006. During the pilot study, EA evaluated products that use this technology for in-situ remediation. The alternatives were evaluated based on the following criteria:

- Life of product
- Effectiveness
- Implementability, and
- Cost

EHC[®]-M was selected for the 2006 pilot study. EHC[®]-M, produced and distributed by FMC Corporation, is a combination of controlled-release carbon and zero valent iron (ZVI) particles which stimulates reductive dechlorination of TCE. For this round of treatment, EHC[®] will be used in place of EHC[®]-M since the treatment of chromium is not required. Unlike EHC[®]-M, EHC[®] is not formulated to immobilize soluble metals via enhanced precipitation and adsorption.

4.2 PRODUCT DESCRIPTION

EHC[®] is made up of food grade organic carbon and ZVI for the reduction of persistent organic and/or inorganic contaminants. Application methods include direct mixing, hydraulic fracturing, pneumatic fracturing, and injection of slurries or liquids. Following placement of EHC[®] into the subsurface environment, a number of processes combine to create reducing conditions, stimulating dechlorination of organic solvents and other recalcitrant compounds.

EHC[®]'s hydrophilic organic component is nutrient rich and has high surface area to support the growth of bacteria in the groundwater environment. As bacteria grow, indigenous heterotrophic bacteria consume dissolved oxygen, reducing the oxidation-reduction potential in the groundwater. As they are growing, the bacteria also ferment carbon and release a variety of volatile fatty acids. The fatty acids diffuse into the groundwater plume and serve as electron donors for other bacteria. The small ZVI particles (<5 to 45 µm) provide reactive surface areas, stimulating direct chemical dechlorination and an additional drop in the oxidation-reduction potential in the groundwater due to chemical oxygen scavenging.

The described physical, chemical, and biological processes combine to create a reduced environment, stimulating chemical and microbiological dechlorination. When injected, the fibrous organic carbon and ZVI will remain in the area of injection and will create a zone of influence of low oxidation-reduction conditions that extend beyond its physical space. Longevity of product in the subsurface is not known, but evidence of reducing conditions (reduced dissolved oxygen content) within the 2006 pilot study area was observed until late

2008, approximately 2 to 2.5 years following the pilot study. Iron content was elevated into 2009.

4.3 PRODUCT INJECTION

Based on the pilot study, EA elected to proceed with an area treatment design. Direct push injection technology will be used to inject the EHC[®] across the targeted treatment areas which will be defined during the direct push investigation. The number and placement of injection points in each area of residual contamination will be determined after the results of the direct push investigation have been reviewed. The zone of treatment is estimated to be from approximately 80 to 95 ft bgs at MW-35, and 75 to 95 ft at AMW-27.

Based on the measured dissolved oxygen concentrations, oxidation-reduction potential, and contaminant concentrations in the alluvial aquifer in the treatment areas, along with an estimated combined treatment area of 3,100 ft², approximately 8,400 pounds of EHC[®] will be applied in the two areas of residual contamination. This amount may change based on the results of the direct push investigation. Assuming a radius of influence of 5 ft, the injection points will be spaced a maximum of 10 ft apart and the rows will be staggered to achieve coverage perpendicular to groundwater flow. Using a vertical spacing of 2 ft, approximately 20-23 pounds of EHC[®] will be injected per injection layer (11 layers per injection point).

4.3.1 Slurry Preparation

The EHC[®] slurry will be prepared on site using a mixing tank with a paddle-mixer at the bottom. The slurry will be transferred to a feed tank connected to the injection pump. This process allows for the slurry to be prepared continuously while the injections are being performed. The following steps outline the slurry preparation process:

1. Fill mixing tank with approximately 15 gallons of water and add one 50 pound bag of EHC[®] to make one batch of slurry.
2. Transfer the slurry mixture to the feed tank and inject following the procedures in Section 4.3.2.

4.3.2 Injection Approach

The EHC[®] slurry will be injected in a top-down fashion using a direct push drill rig with an injection tip that directs the slurry horizontally. An injection pump designed to handle solids and capable of generating at least 400 pounds per square inch (psi) of pressure at a flow rate of 5 gpm will be used to inject the slurry at pressures ranging from 10 to 150 psi, although higher pressures are sometimes required to initiate the injection. The following steps outline the process for slurry injection:

1. Verify that extraction wells in the vicinity of the treatment are turned off using lockout/tagout procedures prior to commencing slurry injection.

2. Advance the direct push rod to the designated start depth and inject one batch of slurry made to the specifications in Section 4.3.1. The depth of injection may be adjusted based on the results of the direct push investigation.
3. Advance the direct push rod in 2 ft intervals, injecting one batch of slurry per interval and clearing the tip with approximately 20 gallons of water before proceeding to the next interval.

A Global Positioning System receiver will be used to record the coordinates of the injection points.

4.3.3 Health and Safety

EHC[®] is non-hazardous and safe to handle. A copy of the EHC[®] material safety data sheet is provided in Appendix B. When working with EHC[®], personnel will use level D personal protective equipment, including safety glasses, steel toe boots, nitrile gloves, hearing protection (when direct push drill rig is operating), and hard hat. Dust masks will be required when in close contact with dry EHC[®].

The EHC[®] will be injected into the alluvial aquifer which is not a source of potable drinking water. Downgradient monitoring wells will be sampled for potential impacts to water quality as described in Section 3.5.

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5. PROJECT SCHEDULE AND DELIVERABLES

The proposed schedule for the project is as follows:

Task	Number of Calendar Days	Proposed Date
Prepare In-Situ Work Plan		
Submit Draft Work Plan to EPA	1 day	13 November 2012
Receive EPA Comments on Draft Work Plan	4 weeks after receipt of Draft Work Plan	11 December 2012
Submit Final Work Plan to EPA	2 weeks after receipt of comments	25 December 2012
Shut off Extraction Wells (AMW-27, MW-25D, MW-26D, and MW-49)	1 day	30 November 2012
Winter Quarterly Sampling Event/ Baseline Groundwater Sampling	3 days	29-31 January 2013
Pre-Treatment Direct Push Investigation	9 days	18-28 February*
Receive Laboratory Results	30 days after receipt of samples	1 April 2013
Prepare Work Plan Addendum		
Submit Draft Work Plan Addendum to EPA	4 weeks after receipt of laboratory results	29 April 2013
Receive EPA Comments on Draft Work Plan Addendum	4 weeks after receipt of Draft Work Plan Addendum	27 May 2013
Submit Final Work Plan Addendum to EPA	2 weeks after receipt of comments	10 June 2013
Perform Injections	Summer 2013*. To be determined, following approval of Explanation of Significant Differences from EPA.	
Draft Report to EPA	Following injections and completion of first round of groundwater monitoring.	
Note: * = Dates for the direct push investigation and treatment injections will be aligned with the King’s Way Christian School breaks, as much as possible. Scheduled breaks include: Winter break (18 – 22 February), Spring break (29 March – 5 April), and Summer break (starts 15 June).		

Quarterly sampling of wells will occur in conjunction with other Site monitoring, with samples typically collected in January, April, July, and October. The proposed dates for the Winter (January) sampling event are provided in the table above; the baseline sampling is tentatively scheduled to occur simultaneously. A schedule for the remaining 2013 sampling events will be provided to EPA at the beginning of the year.

The schedule for baseline sampling and the direct push investigation are tentative, and may be adjusted based on property owner schedules, Site conditions (ex. flooding/soft ground), and subcontractor availability.

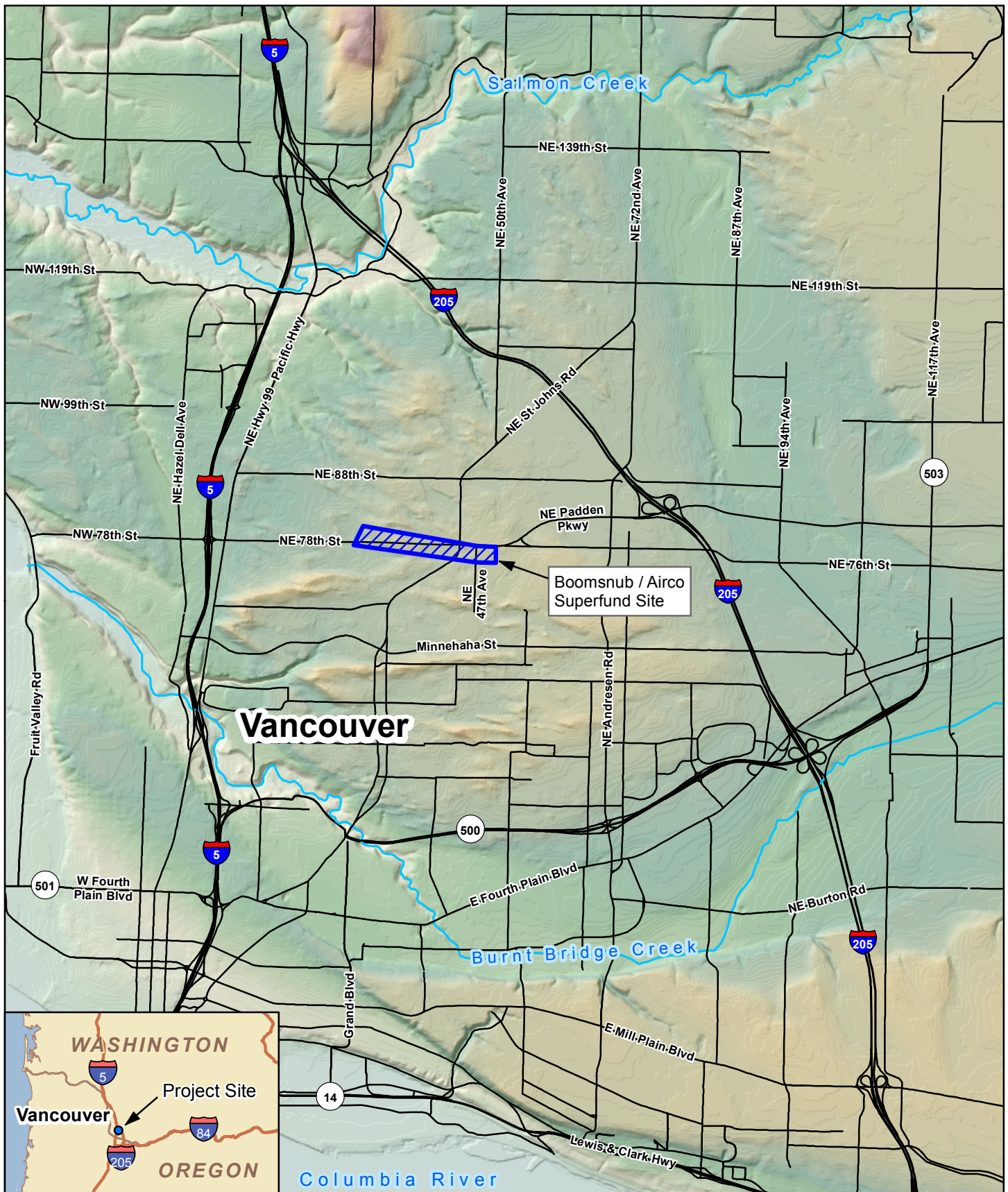
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6. REFERENCES

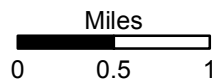
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- EPA. 1996. Pump-and-Treat Groundwater Remediation Guide for Decision Makers and Practitioners. EPA/625/R-95/005. U.S. Environmental Protection Agency Office of Research and Development. July 1996.
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Figures



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 720 Sixth Street South, Suite 100
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 Fax: (425) 451-7800

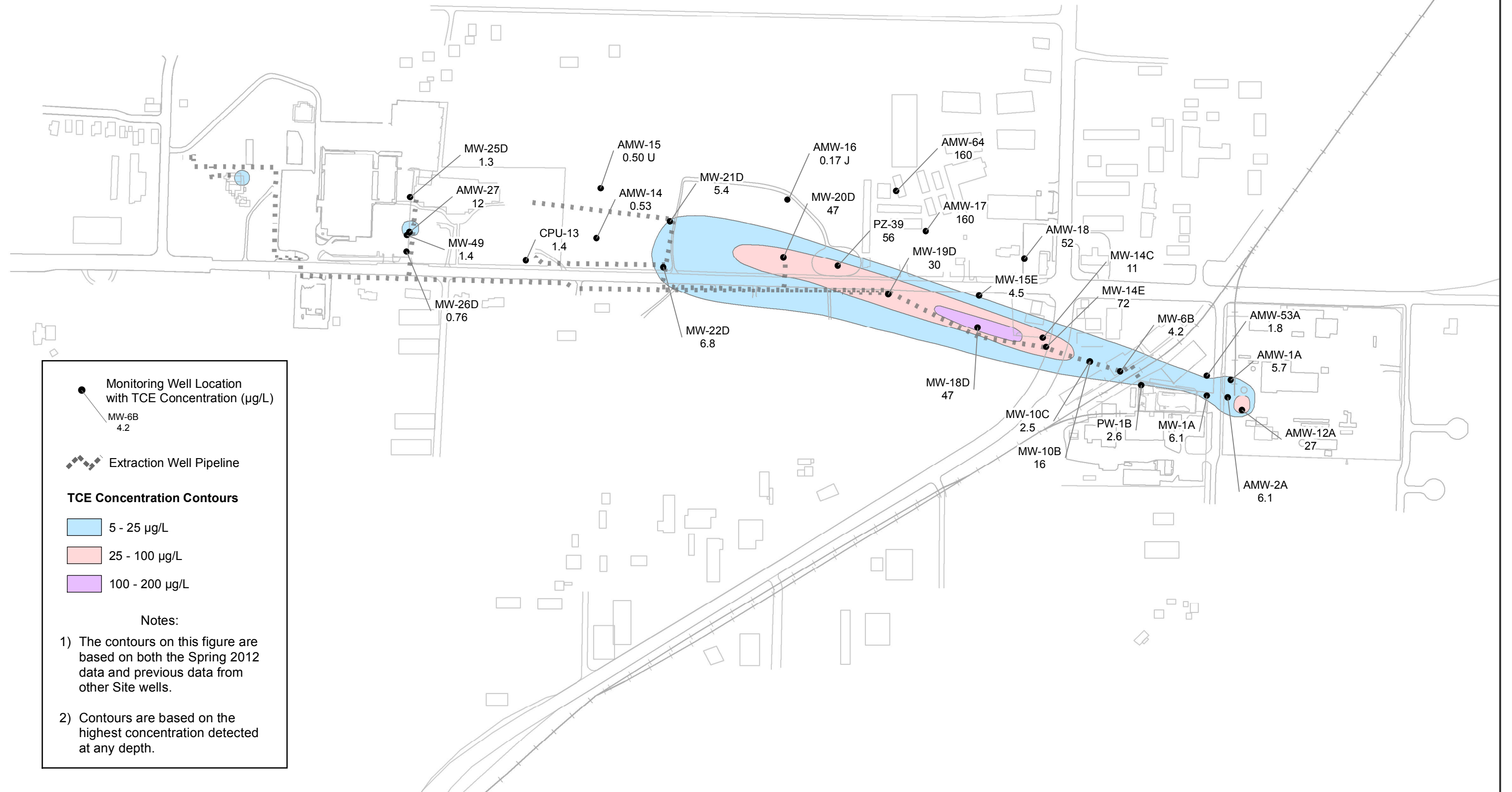


BOOMSNUB / AIRCO SUPERFUND SITE
 HAZEL DELL, WASHINGTON

FIGURE 1
 SITE LOCATION MAP

EA Project No. 14495.05

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EA Engineering, Science, & Technology, Inc.
720 Sixth Street South, Suite 100
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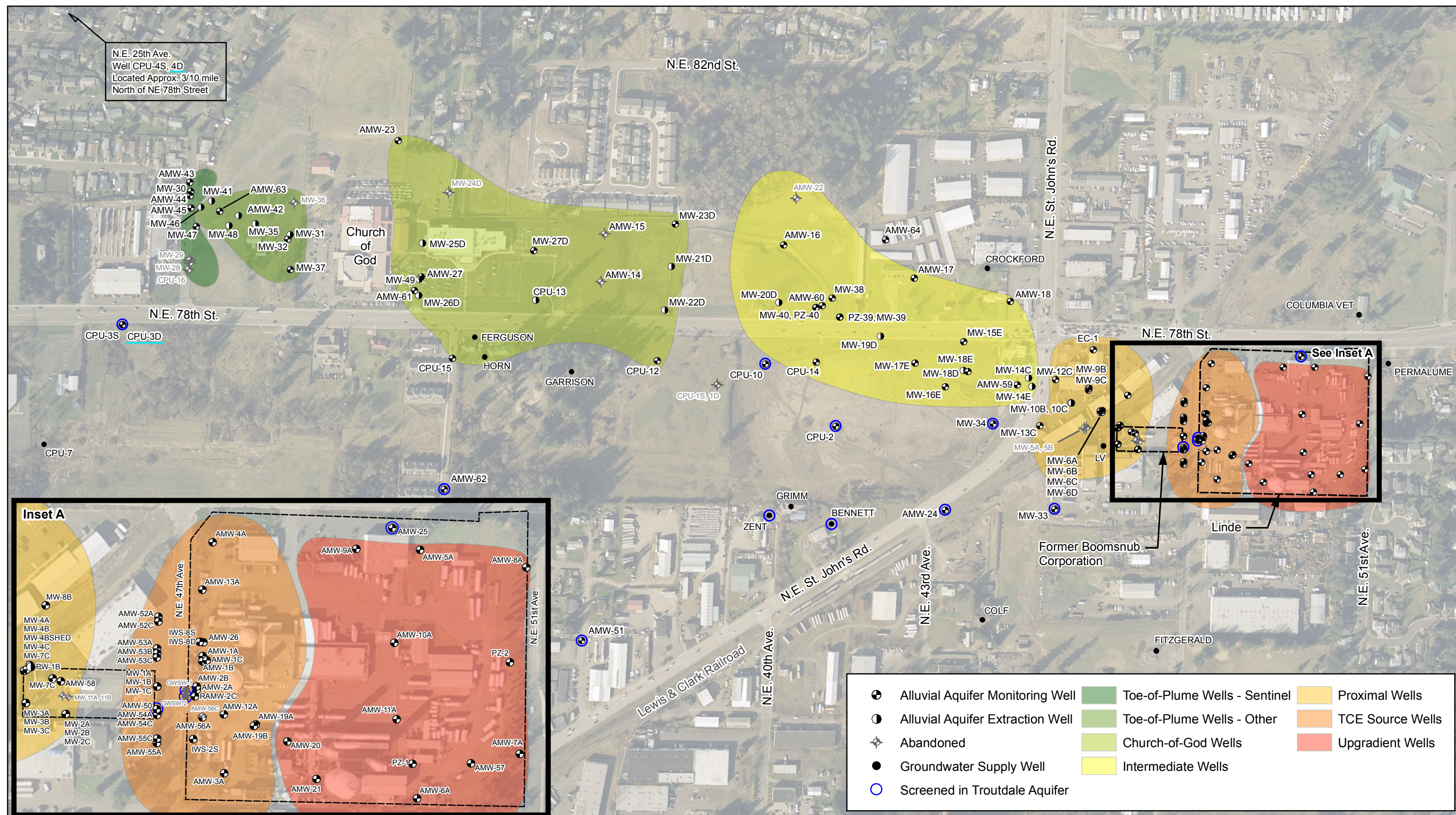
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BOOMSNUB / AIRCO SUPERFUND SITE HAZEL DELL, WASHINGTON

EA Project No. 14495.05
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FIGURE 2
CONTOUR MAP OF TRICHLOROETHENE
CONCENTRATIONS IN THE ALLUVIAL AQUIFER (OU-3)
SPRING 2012



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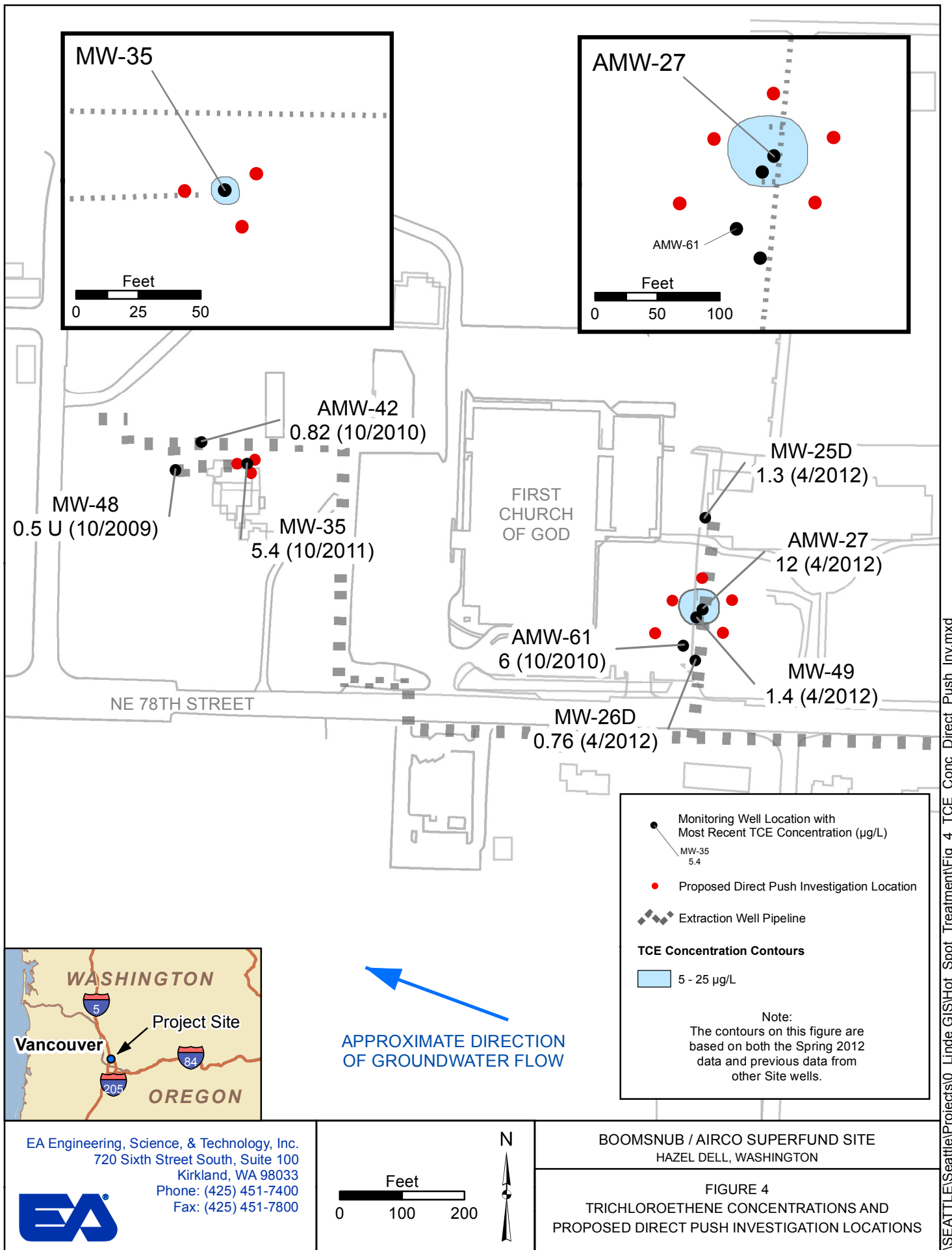
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BOOMSNUB / AIRCO SUPERFUND SITE
HAZEL DELL, WASHINGTON

EA Project No. 14495.05
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FIGURE 3
EXTRACTION AND MONITORING WELL
GROUPINGS



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Tables

TABLE 1. TRICHLOROETHENE MONITORING DATA
(1999 through Present)

Sample Date	Toe- of-Plume Area			Church-of-God Area				
	AMW-42	MW-35	MW-48	AMW-27	AMW-61	MW-25D	MW-26D	MW-49
May-99	65	72		43		43	16	
Jun-99	45			83		23	30	
Aug-99	15	93 E	1.00 U					
Sep-99	25	110 D	1.00 U					
Oct-99	25	80	0.50 U	69		17	36	
Nov-99	7.5	65 E						
Dec-99	15	93 D	1.00 U	63		21	32	
Jan-00	16	46	1.00 U					
Feb-00	16	48	1.00 U					
Mar-00	13	41	1.00 U	74		28	28	
Apr-00	13	14	1.00 U					
May-00	13	6.0	0.50 U	77		13	26	
Jun-00	13	4.5	1.00 U	76		13	29	
Jul-00	13	4.8						
Aug-00	8.6	8.2						
Sep-00	8.4	15						
Oct-00	7.4	18	0.50 U	18		17	28	
Nov-00	7.0	20						
Dec-00	5.1	24	1.00 U	72		15	25	
Jan-01		16						1.00 U
Feb-01	5.2	29	20	73		14	25	
Mar-01		30						
Apr-01		29						
May-01	5.0	28	0.50 U	78		15	23	0.50 U
Jun-01		12						
Jul-01		27						
Aug-01		31						
Sep-01		30						
Oct-01	3.9	29	0.50 U	63		9.4	52	21
Nov-01		14						
Dec-01	3.5	1.00 U	1.00 U	78		6.4	23	24
Jan-02		13						
Feb-02	2.7	12	1.00 U	76		5.4	15	24
Mar-02		16						
Apr-02		17						
May-02	3.2	15	0.5 U	71			15	28
Oct-02	2.6	20	0.50 U	68		3.0	11	24
Dec-02	2.3	18	0.50 U	65		2.5	9.5	23
Feb-03	2.2	15	0.50 U	70		3.0	9.7	24
May-03	1.9	13	0.50 U	62		3.4	7.5	17
Oct-03	2.0	11	0.50 U	81		2.8	5.6	17
May-04	1.6	12	0.50 U	52		2.2	3.8	12
Aug-04	1.6	1.9	0.50 U			3.0		
Oct-04	0.50 U	2.9	0.50 U	55			3.0	14
Nov-04	1.2	1.2	0.50 U					
Dec-04	1.1	1.0	0.50 U					
Jan-05					23			
Mar-05	0.50 U	2.0	0.50 U					
Apr-05	0.50 U	2.8	0.50 U	44	20	1.9	3.2 J	9.1

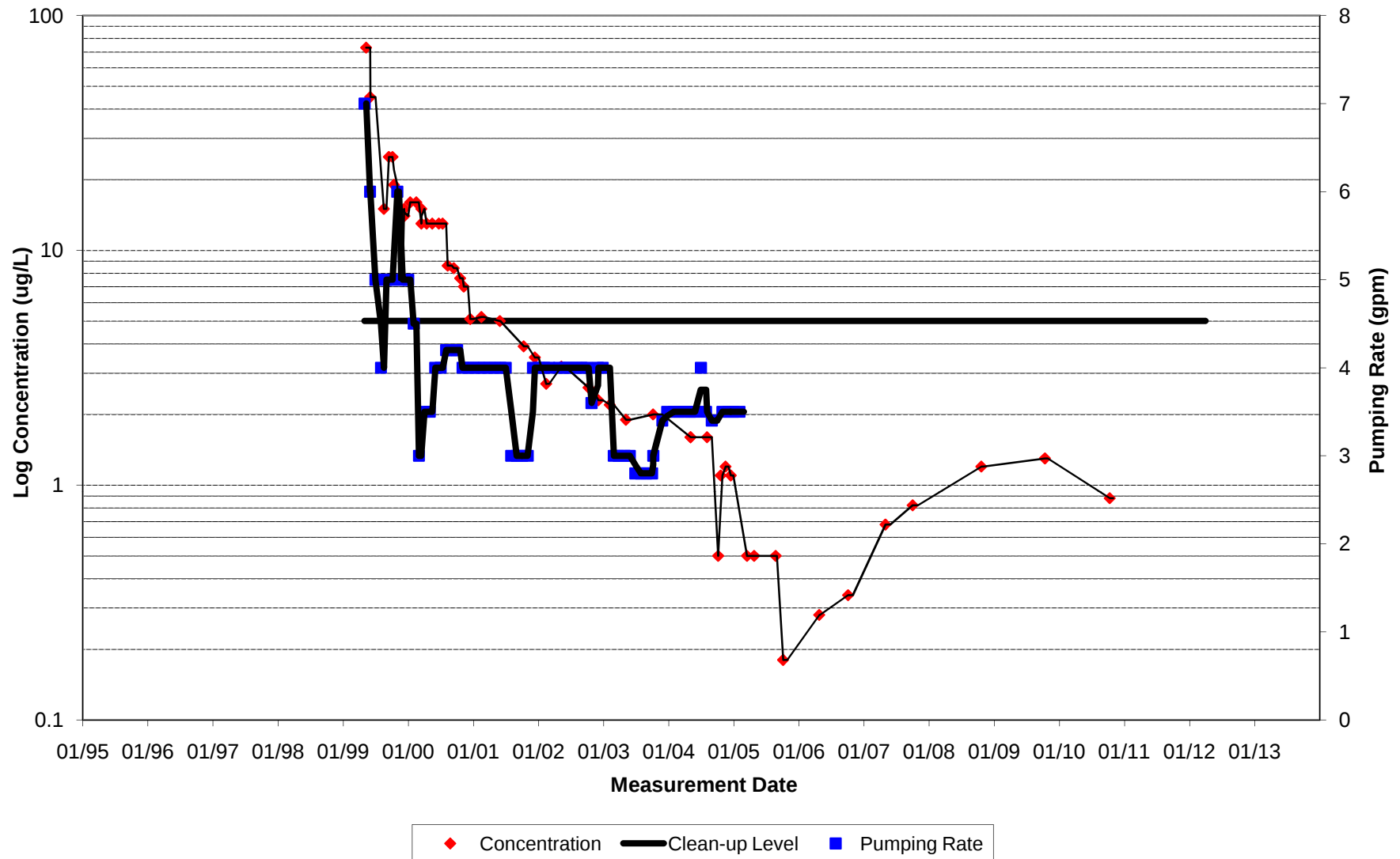
TABLE 1. TRICHLOROETHENE MONITORING DATA
(1999 through Present)

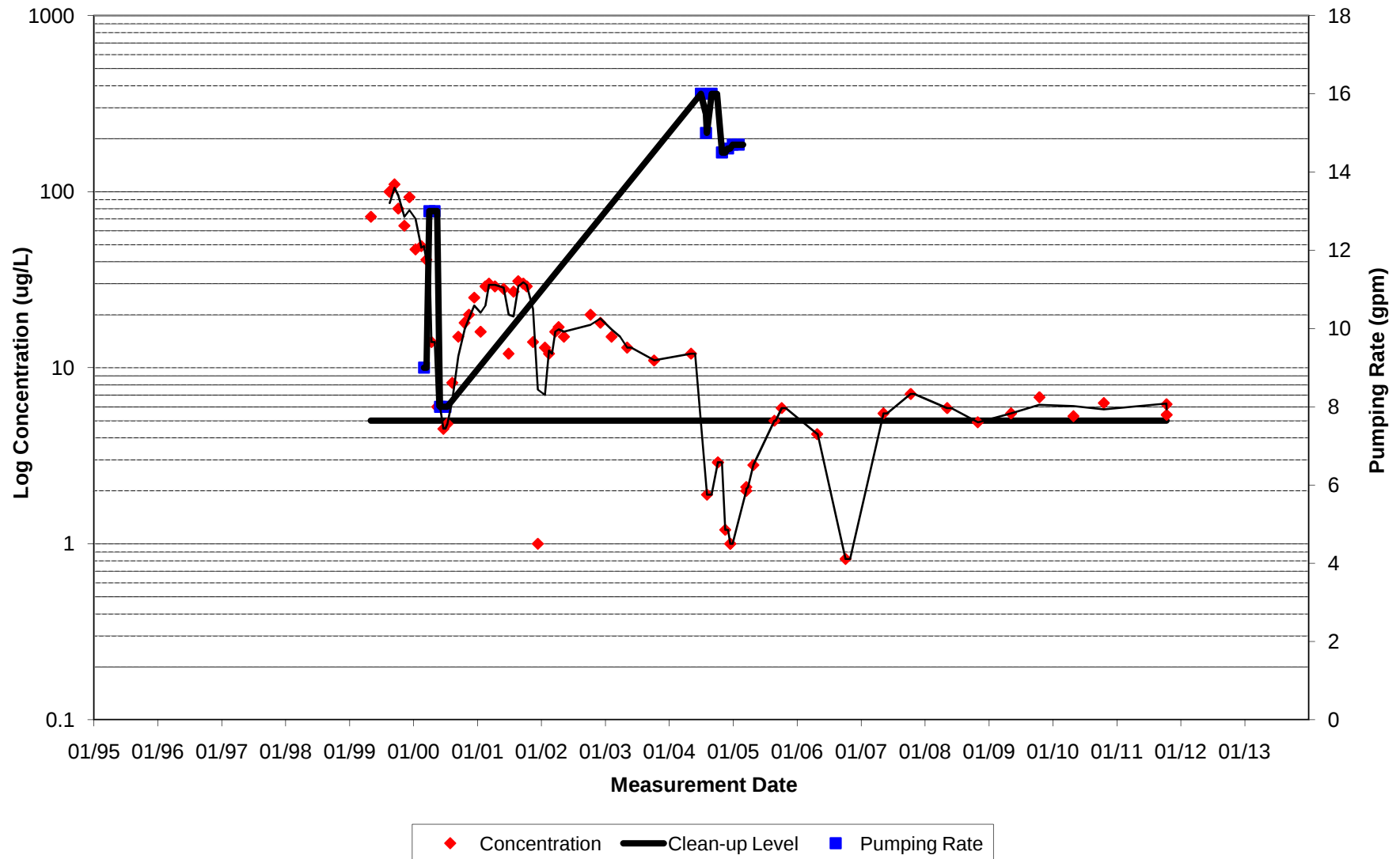
Sample Date	Toe- of-Plume Area			Church-of-God Area				
	AMW-42	MW-35	MW-48	AMW-27	AMW-61	MW-25D	MW-26D	MW-49
Jul-05								
Aug-05	0.50 U	5.0	0.50 U					
Oct-05	0.18 J	5.9	0.50 U	57			1.6	9.0
Apr-06	0.28 J	4.2	0.50 U	55			1.6	8.0
Oct-06	0.34 J	0.82	0.50 U	39	43	9.9	1.3	9.1
Feb-07						9.0		
May-07	0.68 J	5.5		52		2.6	1.7 J	8.4
Jul-07								
Oct-07	0.82	7.1	0.50 U	33		2.0	1.7	6.3
May-08		5.9		29		1.9	1.8	5.0
Oct-08	1.2	4.9	0.50 U	23	6.5	1.9	1.9	4.9
May-09		5.5		23		1.9	1.5	3.4
Oct-09	1.3	6.8	0.50 U	19		1.4	1.3	2.9
Apr-10		5.3		16		1.2	0.85	2.4
Oct-10	0.88	6.3		16	6.0	1.3	0.78	
Apr-11				15		1.3	0.79	1.7
Oct-11		6.2		14		1.5	0.72	1.4
Apr-12				12		1.3	0.76	1.4

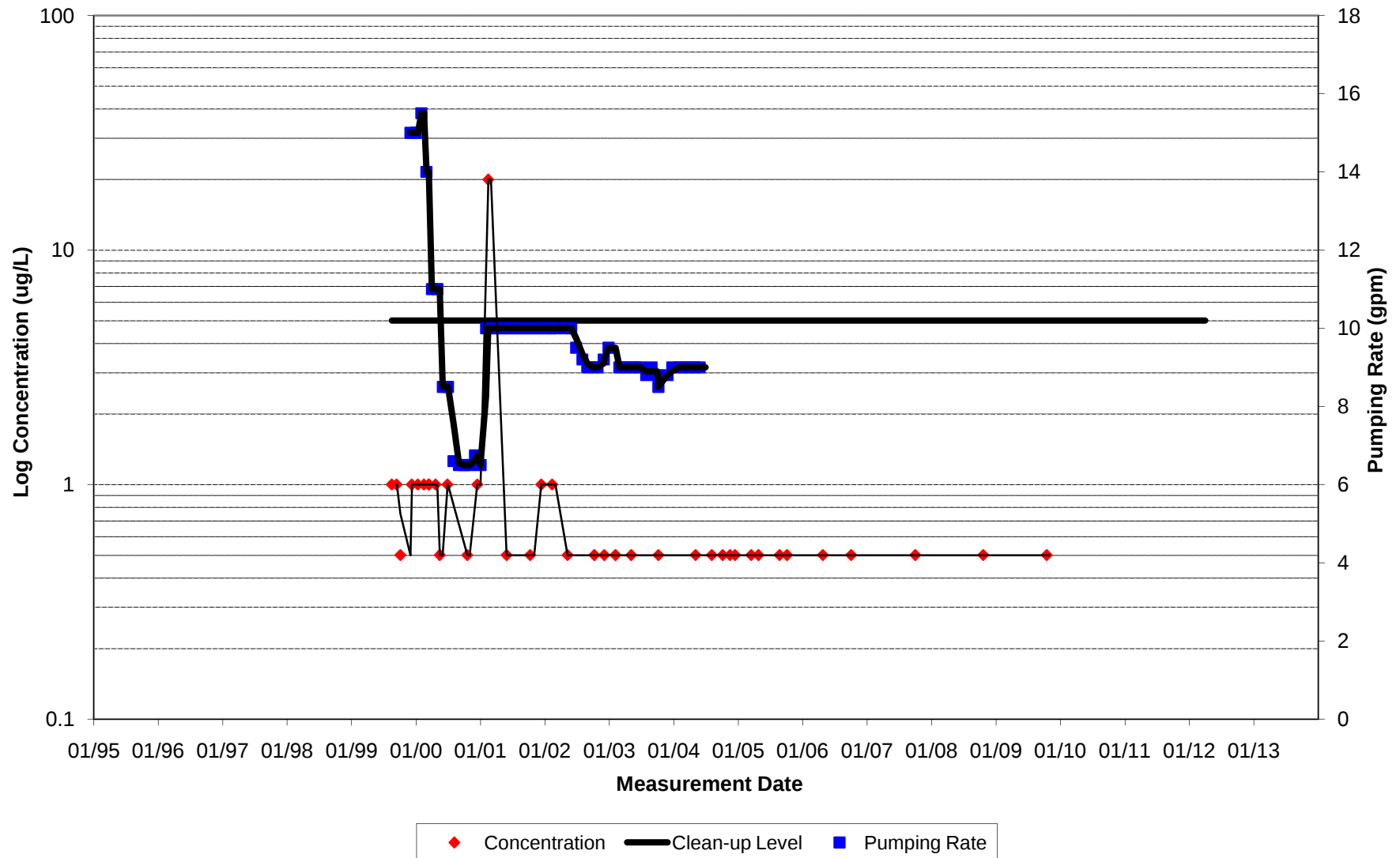
Notes:
J = The result is an estimated concentration that
U = Analyte not detected above the specified reporting limit.
Results are in micrograms per liter (µg/L).
Results shown in **bold** equal or exceed the Site TCE cleanup level of 5 µg/L.
Pre-1999 data is not shown; only MW-25D and MW-26D were sampled during that time.

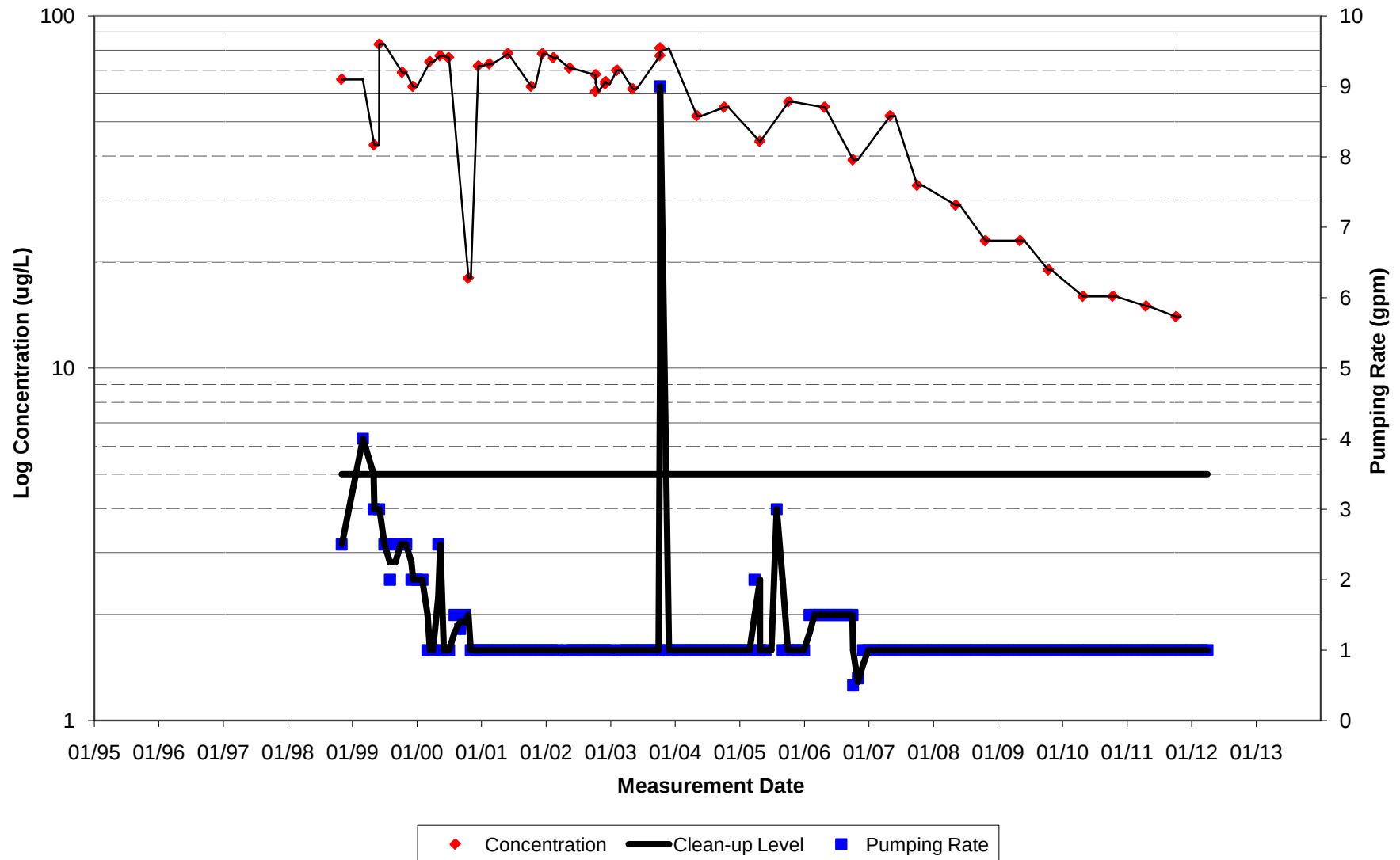
Appendix A

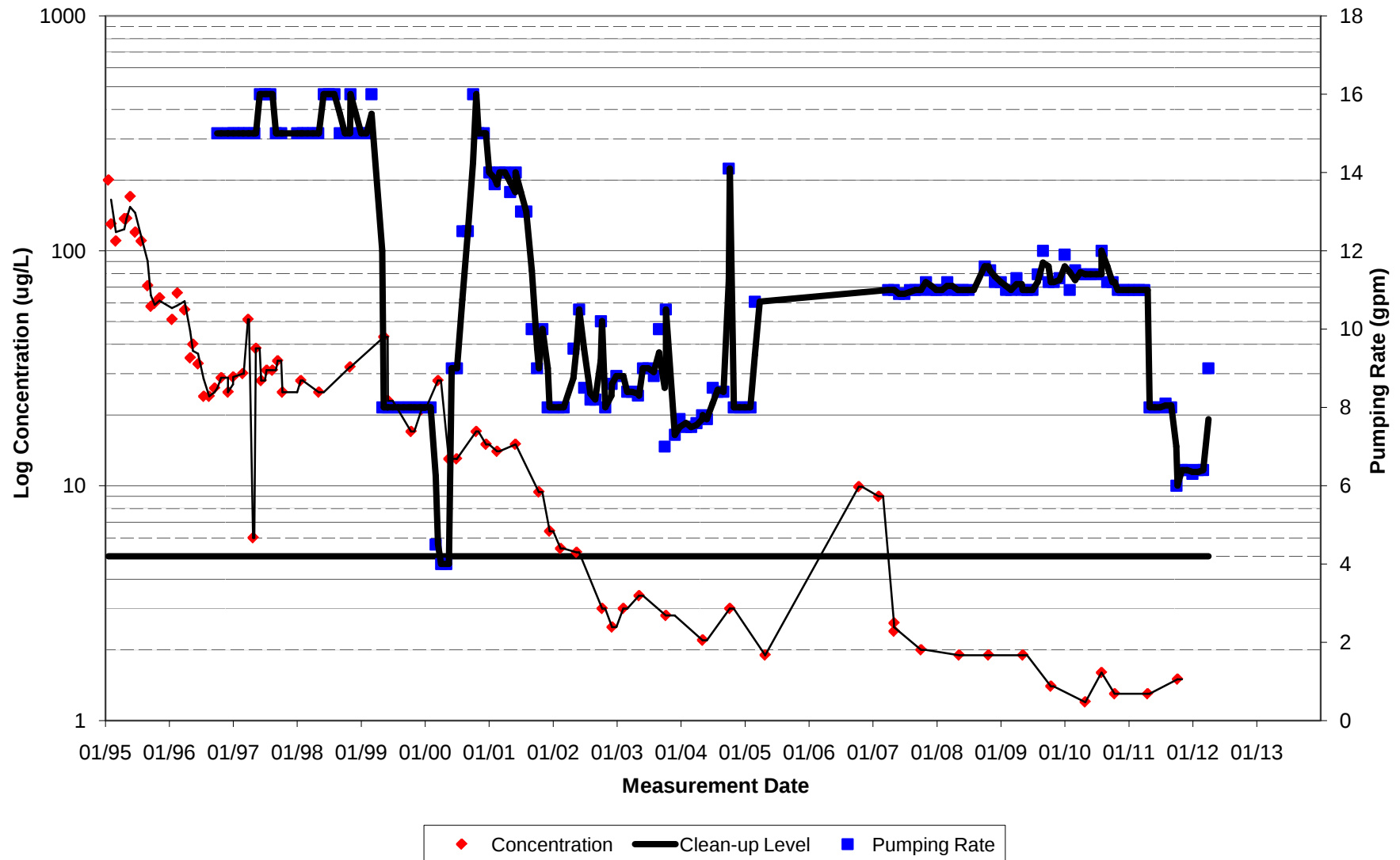
TCE Concentrations and Pumping Rates in Extraction Wells

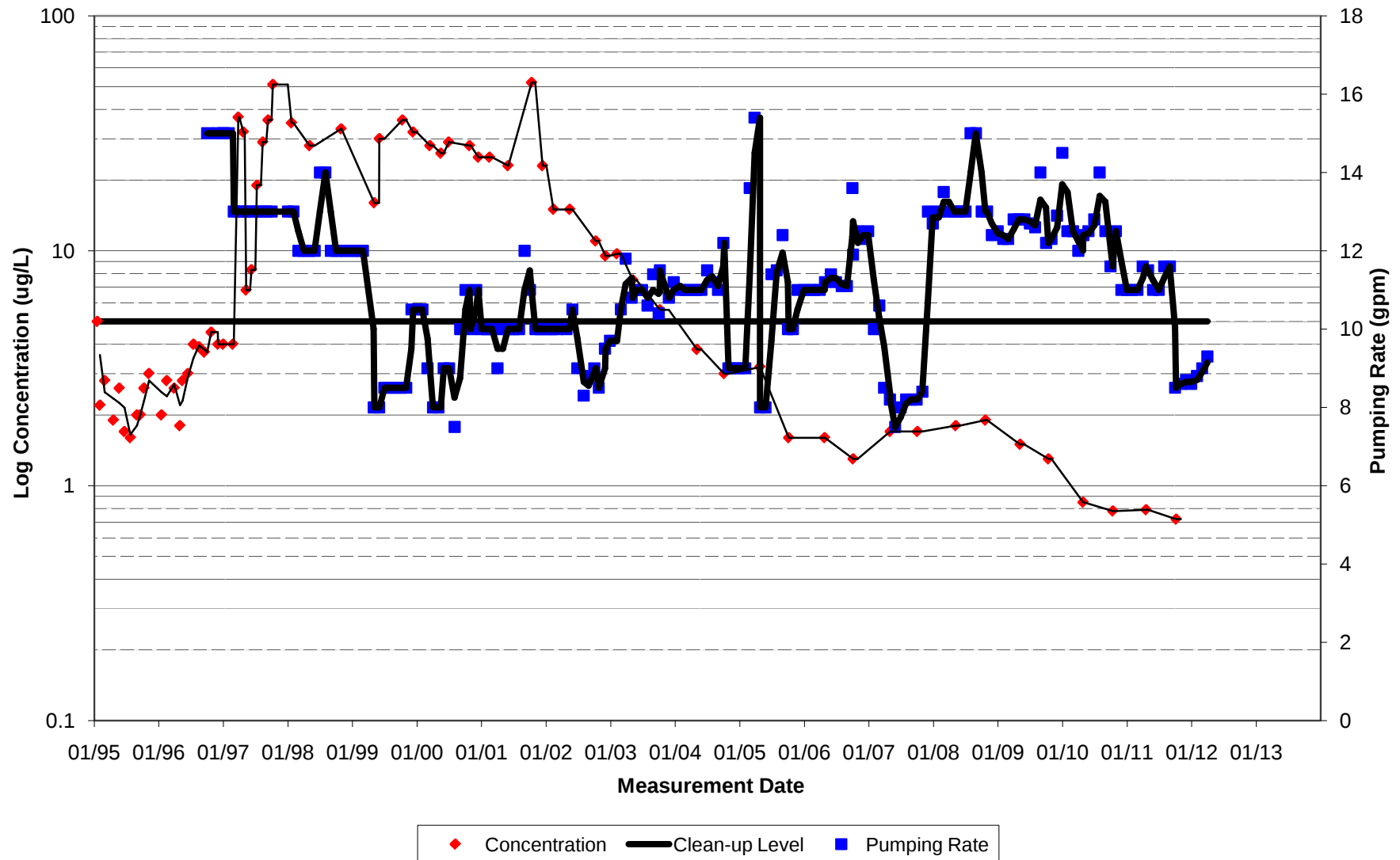
AMW-42 - TCE (ug/L) with Pumping Rates

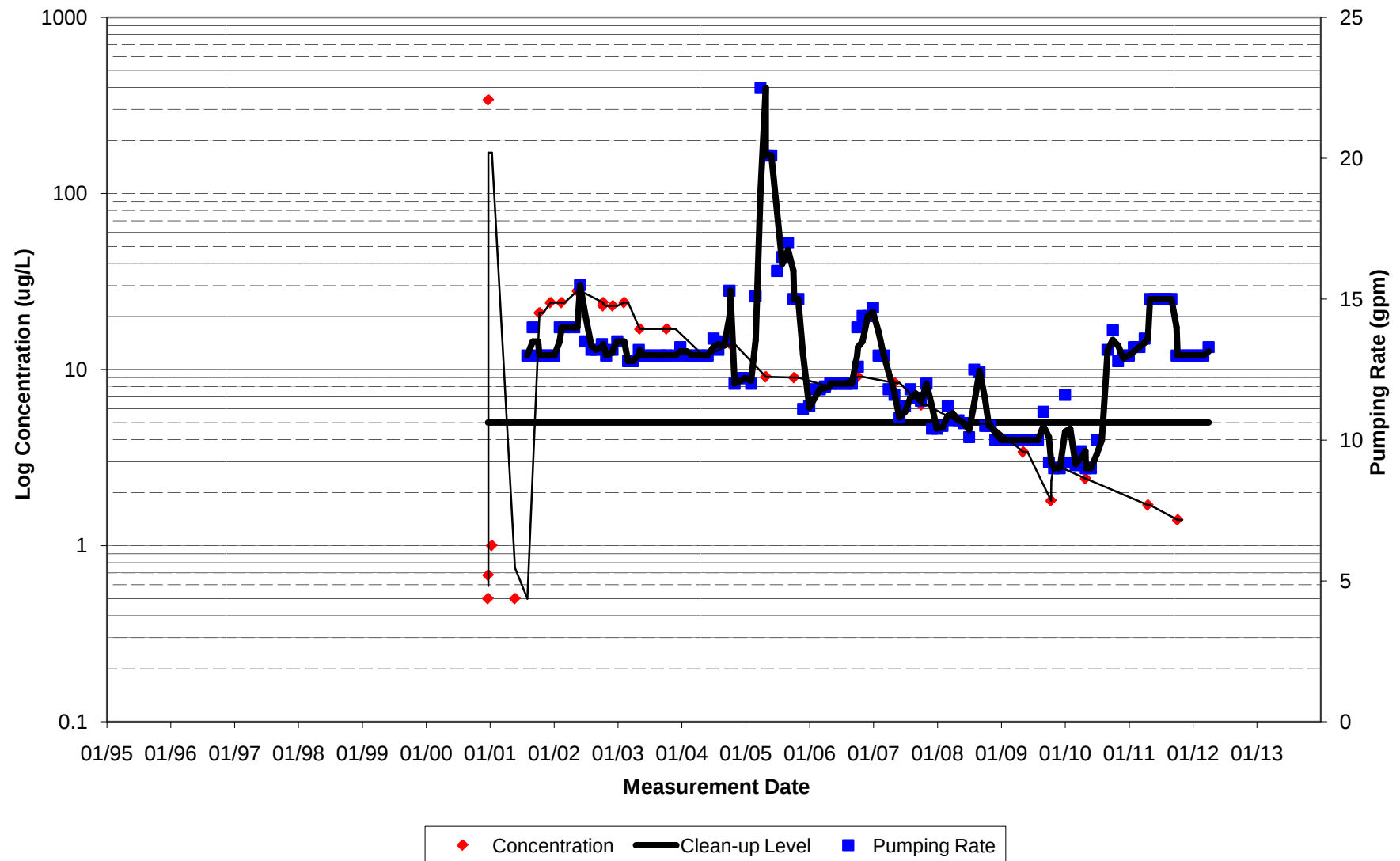
MW-35 - TCE (ug/L) with Pumping Rates

MW-48 - TCE (ug/L) with Pumping Rates

AMW-27 - TCE (ug/L) with Pumping Rates

MW-25D - TCE (ug/L) with Pumping Rates

MW-26D - TCE (ug/L) with Pumping Rates

MW-49 - TCE (ug/L) with Pumping Rates

Appendix B

Material Safety Data Sheet for EHC

Material Safety Data Sheet

EHC®

MSDS #: EHC-C

Revision Date: 2012-04-30

Version 1



This MSDS has been prepared to meet U.S. OSHA Hazard Communication Standard 29 CFR 1910.1200 and Canada's Workplace Hazardous Materials Information System (WHMIS) requirements.

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	EHC®
Recommended use	Bioremediation product for the remediation of contaminated soil and groundwater only. Not for use in potable drinking water.
Manufacturer	Emergency telephone number
FMC CORPORATION FMC Peroxygens 1735 Market Street Philadelphia, PA 19103 Phone: +1 215/ 299-6000 (General Information) E-Mail: msdsinfo@fmc.com	For leak, fire, spill or accident emergencies, call: +1 703-527-3887 (CHEMTREC) +1 303 / 595 9048 (Medical - Call Collect)

2. Hazards identification

Emergency Overview

CONTAINMENT HAZARD:

Any vessel that contains wet EHC must be vented due to potential pressure build up from fermentation gases

Potential health effects

Acute Toxicity

Eyes

No significant health effects anticipated

Skin

Product dust may cause mechanical eye irritation.

Inhalation

None known .

Ingestion

Inhalation of dust in high concentration may cause irritation of respiratory system.

Ingestion may cause gastrointestinal irritation, nausea, vomiting and diarrhea.

Chronic Toxicity

No known chronic effects of components present at greater than 1%.

3. Composition/information on ingredients

Ingredients

Chemical Name	CAS-No	Weight %
Iron	7439-89-6	18-48
Organic Amendment	Proprietary	52-82

4. First aid measures

Eye contact	In case of contact, immediately flush skin with plenty of water. Get medical attention if irritation develops and persists.
Skin contact	Wash off with soap and water.
Inhalation	Remove person to fresh air. If signs/symptoms continue, get medical attention.
Ingestion	Rinse mouth with water and afterwards drink plenty of water or milk. Call a poison control center or doctor immediately for treatment advice.

5. Fire-fighting measures

Flammable properties	Combustible material.
Suitable extinguishing media	Dry chemical, CO ₂ , sand, earth, water spray or regular foam.
Explosion Data	
Sensitivity to Mechanical Impact	not applicable
Sensitivity to Static Discharge	not applicable
Specific hazards arising from the chemical	Dry or powdered ingredients are combustible. Dispersal of finely divided dust from products into air may form mixtures that are ignitable and explosive. Minimize airborne dust generation and eliminate sources of ignition.

NFPA	Health Hazard 1	Flammability 1	Stability 0	Special Hazards -
-------------	------------------------	-----------------------	--------------------	--------------------------

NFPA/HMIS Ratings Legend Severe = 4; Serious = 3; Moderate = 2; Slight = 1; Minimal = 0

6. Accidental release measures

Personal precautions	Avoid dust formation. For personal protection see section 8.
Methods for containment	Cover powder spill with plastic sheet or tarp to minimize spreading and keep powder dry.
Methods for cleaning up	Sweep or vacuum up spillage and return to container.

7. Handling and storage

Handling	Minimize dust generation and accumulation. Keep away from open flames, hot surfaces and sources of ignition. Refer to Section 8.
Storage	Keep tightly closed in a dry and cool place. Keep away from open flames, hot surfaces and sources of ignition. Any vessel that contains .? must be vented due to potential pressure build up from fermentation gases.

8. Exposure controls/personal protection

Exposure guidelines	Local nuisance dust standards apply.
----------------------------	--------------------------------------

Occupational exposure controls

Engineering measures

None under normal use conditions. Provide appropriate exhaust ventilation at places where dust is formed.

Personal Protective Equipment**General Information**

If the product is used in mixtures, it is recommended that you contact the appropriate protective equipment suppliers, These recommendations apply to the product as supplied

Respiratory protection

Whenever dust in the worker's breathing zone cannot be controlled with ventilation or other engineering means, workers should wear respirators or dust masks approved by NIOSH/MSHA, EU CEN or comparable organization to protect against airborne dust.

Eye/face protection

Safety glasses with side-shields

Skin and body protection

No special precautions required.

Hand protection

No special precautions required

Hygiene measures

Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and immediately after handling the product.

9. Physical and chemical properties

Appearance	Light-tan powder
Physical state	solid
Odor	odorless
pH	5.6 (as aqueous solution)
Melting Point/Range	No information available.
Freezing point	No information available
Boiling Point/Range	not applicable
Flash Point	not applicable
Evaporation rate	not applicable
Autoignition Temperature	No information available.
Flammable properties	Combustible material
Vapor pressure	No information available
Vapor density	No information available
Density	0.80 g/mL
Water solubility	practically insoluble
Percent volatile	No information available
Partition coefficient:	not applicable
Viscosity	No information available
Oxidizing properties	not applicable

10. Stability and reactivity

Stability	Stable.
Conditions to avoid	Heat, flames and sparks
Materials to avoid	Oxidizing agents Strong acids
Hazardous decomposition products	None known
Hazardous polymerization	Hazardous polymerization does not occur

11. Toxicological information

Acute effects

Remarks The product has not been tested. Data is based on component.

Eye irritation No data available for the formulation. Non-irritating (rabbit) (based on components)
Skin irritation No data available for the formulation. Non-irritating (rabbit) (based on components)

LD50 Oral Iron: 98.6 g/kg (rat)
LD50 Dermal No information available
LC50 Inhalation: Iron: > 100 mg/m³ 6 hr (rat)

Chronic Toxicity

Chronic Toxicity No known chronic effects of components present at greater than 1%.

Carcinogenicity Contains no ingredient listed as a carcinogen.

12. Ecological information

Ecotoxicity

The environmental impact of this product has not been fully investigated

Chemical Name	Toxicity to algae	Toxicity to fish	Toxicity to microorganisms	Toxicity to daphnia and other aquatic invertebrates
Iron		LC50= 13.6 mg/L Morone saxatilis 96 h LC50= 0.56 mg/L Cyprinus carpio 96 h		

13. Disposal considerations

Waste disposal methods

This material, as supplied, is not a hazardous waste according to Federal regulations (40 CFR 261). This material could become a hazardous waste if it is mixed with or otherwise comes in contact with a hazardous waste, if chemical additions are made to this material, or if the material is processed or otherwise altered. Consult 40 CFR 261 to determine whether the altered material is a hazardous waste. Consult the appropriate state, regional, or local regulations for additional requirements

Contaminated packaging

Dispose of in accordance with local regulations

14. Transport information

DOT

not regulated

TDG

not regulated

ICAO/IATA

not regulated

IMDG/IMO

not regulated

15. Regulatory information

International Inventories

TSCA Inventory (United States of America)

-

DSL (Canada)

Complies

NDSL (Canada)

Complies

EINECS/ELINCS (Europe)

Complies

ENCS (Japan)

-

IECSC (China)

Complies

KECL (Korea)

-

PICCS (Philippines)

Complies

AICS (Australia)

Complies

NZIoC (New Zealand)

Complies

U.S. Federal Regulations

SARA 313

Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA). This product does not contain any chemicals which are subject to the reporting requirements of the Act and Title 40 of the Code of Federal Regulations, Part 372.

SARA 311/312 Hazard Categories

Acute Health Hazard

no

Chronic Health Hazard

no

Fire Hazard

no

Sudden Release of Pressure Hazard

no

Reactive Hazard

no

CERCLA

This material, as supplied, does not contain any substances regulated as hazardous substances under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (40 CFR 302) or the Superfund Amendments and Reauthorization Act (SARA) (40 CFR 355). There may be specific reporting requirements at the local, regional, or state level pertaining to releases of this material.

International Regulations**Mexico - Grade**

No information available

Canada

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS Hazard Class

not determined

16. Other information

HMIS	Health Hazard 1	Flammability 1	Stability 0	Special precautions -
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NFPA/HMIS Ratings Legend

Severe = 4; Serious = 3; Moderate = 2; Slight = 1; Minimal = 0

Revision Date:

2012-04-30

Reason for revision:

No information available.

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Prepared By

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End of Material Safety Data Sheet