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REGION 5 RAC2

REMEDIAL ACTION CONTRACT FOR

Remedial, Enforcement Oversight, and
Non-Time Critical Removal Activities at Sites of Release
or Threatened Release of Hazardous Substances in Region 5

BASIS OF DESIGN REPORT

Final Design for Remediation of Groundwater and TCE DNAPL

OMC Plant 2 Site
Waukegan, Illinois
WA No. 053-RDRD-0528/Contract No. EP-S5-06-01

December 2009

PREPARED FOR

U.S. Environmental Protection Agency

PREPARED BY

CH2M HILL

FOR OFFICIAL USE ONLY

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Acronyms and Abbreviations

ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
BODR	Basis of Design Report
CAMU	corrective action management unit
CCI	CH2M HILL Constructors Inc.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	contract laboratory program
cm/sec	centimeters per second
COC	chemical of concern
CQAP	construction quality assurance plan
CSU	Colorado State University
DNAPL	dense nonaqueous phase liquid
DO	dissolved oxygen
EISB	enhanced in situ bioremediation
ELCR	excess lifetime cancer risk
EOS	emulsified oil substrate
FS	feasibility study
FSP	field sampling plan
ft^2	square feet
gpm	gallons per minute
GPS	global positioning system
HASP	health and safety plan
HDD	horizontal directional drilling
HDPE	high density polyethylene
HI	hazard index
HZE	hub zone enterprise

IAC	Illinois Administrative Code
IEC	International Electrical Commission
ISSM	in situ soil mixing
IWQS	Illinois Water Quality Standards
kVA	kilovolt amperes
kW	kilowatt
lb	pound
LNAPL	light nonaqueous phase liquid
MCL	maximum contaminant level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter
MNA	monitored natural attenuation
NAAQS	National Ambient Air Quality Standards
NSSD	North Shore Sanitary District
O&M	operations and maintenance
OMC	Outboard Marine Corporation, Inc.
ORP	oxidation reduction potential
OSHA	Occupational Safety and Health Administration
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PPE	personal protective equipment
PRG	preliminary remediation goals
psi	pounds per square inch
PVC	polyvinyl chloride
QAPP	quality assurance project plan
RA	remedial action
RAO	remedial action objectives
RCRA	Resource Conservation and Recovery Act

RDW	remediation-derived waste
RI	remedial investigation
ROD	record of decision
SBE	small business enterprise
scfm	standard cubic feet per minute
SDBE	small disadvantaged business enterprise
SDWA	Safe Drinking Water Act
SMP	site management plan
SOW	statement of work
SVOC	semivolatile organic compound
TCE	trichloroethene
TCLP	toxicity characteristic leaching procedure
TOC	total organic carbon
USC	U.S. Code
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
UST	underground storage tank
V	volt
VE	value engineering
VFA	volatile fatty acids
VOC	volatile organic compound
WCP	Waukegan Coke Plant
WOB	women-owned business
yd^3	cubic yards
ZVI	zero-valent iron

SECTION 1

Introduction

This Basis of Design Report (BODR) for the Outboard Marine Corporation, Inc. (OMC) Plant 2 site has been prepared for the United States Environmental Protection Agency (USEPA) under Contract No. EP-S5-06-01. This BODR includes the elements specified in the Statement of Work (SOW; dated January 27, 2009) for Work Assignment No. 053-RDRD-0528.

The BODR establishes the design parameters for the remediation of the trichloroethene (TCE) dense nonaqueous phase liquid (DNAPL) and contaminated groundwater beneath the OMC Plant 2 site in Waukegan, Illinois. Based on evaluations of the site conditions, potential alternatives and costs, and input from state, local, and federal stakeholders, USEPA selected a remedy for these media that includes the following components as presented in the Record of Decision (ROD) (USEPA, 2009):

- In situ chemical treatment of the TCE DNAPL by soil mixing with zero-valent iron (ZVI) and bentonite clay
- Enhanced in situ bioremediation (EISB) of the five groundwater "source zones" by performing periodic injection of a soluble substrate (such as sodium lactate or equivalent)
- Air sparging to prevent offsite migration of the dissolved-phase volatile organic compound (VOC) plume
- Monitored natural attenuation (MNA) of VOC-contaminated groundwater upon completion of active treatment activities

This BODR is divided into the following sections:

- Section 1. Introduction
- Section 2. Project Delivery Strategy
- Section 3. Design
- Section 4. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)
- Section 5. Construction Schedule
- Section 6. Cost Estimate
- Section 7. Biddability, Constructability, and Operability Review
- Section 8. References
- Figures
- Appendixes

The following appendixes included in this BODR provide supplemental information integral to the design and implementation of the selected remedy:

- Appendix A: Cost Estimate—The cost estimates of the different remedial components with an accuracy of plus 15 percent to minus 5 percent

- Appendix B: Site-Specific Plans (bound separately)—The plans required to implement the remedial action (RA) including the Site Management Plan (SMP), Health and Safety Plan (HASP), the Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) which includes field sampling plans, Construction Quality Assurance Plan (CQAP), and the Operation and Maintenance (O&M) Manual outline (the final plan will be provided following the completion of construction and system startup).
- Appendix C: Design Specifications and Drawings (bound separately)
- Appendix D: Construction Schedule

1.1 Site Description

The OMC Plant 2 site is a 60-acre industrial property on the lakefront in Waukegan, Illinois (Figure 1-1). The site is bordered by the North Shore Sanitary District (NSSD) to the north, Lake Michigan to the east, Sea Horse Drive and Waukegan Harbor to the south, and E.J. & E Railroad tracks to the west (Figure 1-2). The North Ditch drains upland (offsite) areas and runs along the NSSD border towards Lake Michigan until it turns to the south close to the lake. The lakefront part of the site is emergent dune land and beachfront. Except for the North Ditch, there are no existing wetlands on the site.

1.2 Site Background

1.2.1 Site History

OMC manufactured outboard motors from about 1948 until 2000 in the 1,000,000-square-foot (ft^2) OMC Plant 2 facility. OMC used hydraulic and lubricating oils containing polychlorinated biphenyls (PCBs) in its production line machinery beginning in 1961 until 1972 and allowed the oils to empty into floor drains that led to either an outfall into former Slip 3 or into the former Crescent Ditch and Oval Lagoon, which fed into the North Ditch. OMC Plant 2 was the source of contamination in Waukegan Harbor (Operable Unit [OU] 1) sediment (through the Slip 3 outfall) and likely a source of PCB contamination in Lake Michigan (through the Oval Lagoon, Crescent Ditch, and North Ditch drainage systems). The Oval Lagoon and Crescent Ditch were covered or filled in as a result of the harbor cleanup action conducted from 1990 to 1992 and no longer exist. The West Containment Cell was constructed over the former Oval Lagoon and Crescent Ditch area.

OMC operated several vapor degreasers at the facility to clean newly made parts with TCE. Leaking degreasers and/or TCE storage tanks have created a widespread TCE groundwater contaminant plume and an isolated DNAPL TCE pool beneath the site.

OMC declared bankruptcy in 2000 and ceased manufacturing operations in August 2001. The OMC Plant 2 properties were abandoned and put up for sale by the Trustee during the bankruptcy proceedings. The City of Waukegan assumed the title to the OMC Plant 2 property in December 30, 2005 and is responsible for maintaining the building, property, and O&M of the containment cells.

1.2.2 Recent Actions at the Site

USEPA began a remedial investigation (RI) at the OMC Plant 2 site in 2004 to determine the nature and extent of contamination in site groundwater, sediment, and soil and within the OMC Plant 2 building. The *Remedial Investigation Report*, including the investigation results and human health and ecological risk assessments, was issued in April 2006 (CH2M HILL, 2006a). A feasibility study (FS) was conducted in 2005 to examine site cleanup alternatives designed to protect human health and the environment, and the *Feasibility Study Report* was issued in December 2006 (CH2M HILL, 2006b).

In January 2006, USEPA's Emergency Response Branch began a removal action in the dune area near the East Containment Cell because high levels of PCBs were found in the sands outside the cell. The removal activities included soil excavation and offsite disposal of more than 6,000 cubic yards (yd^3) of PCB-contaminated soil from two areas adjacent to the East Containment Cell and a 150-foot stretch of the South Ditch to a depth of about 2 feet. USEPA also cleaned out several storm sewers leading from the OMC Plant 2 facility to prevent recontamination of the beachfront by residual PCBs discovered in the sewer lines.

Based on the results of the RI, the City of Waukegan hired a subcontractor to demolish nearly 400,000 ft^2 of uncontaminated structures down to the concrete slabs beginning in August 2006. In 2008, most of the concrete slabs were demolished and stockpiled on the northern part of the site.

In January 2007, the City of Waukegan and USEPA also removed PCB-containing transformers, except for one that remains on the roof of the building (due to inaccessibility), and an extensive amount of copper wire and electrical connectors from the plant.

1.3 Remedial Action Plans

In January 2007, USEPA issued a proposed plan for the cleanup of the soil, sediment, and the abandoned building. The proposed plan presented the recommended remedy for the PCB- and polynuclear aromatic hydrocarbon (PAH)-impacted soil and sediment and PCB-impacted building media. Upon review of public comments on the proposed plan, USEPA issued an ROD for these media in August 2007 and noted the initiation of pilot tests of in situ remedial technologies for the groundwater and DNAPL. The remedial design for the cleanup of the soil, sediment, and building materials was completed in June 2008 under a separate work assignment.

The remedial action (RA) for the soil, sediment, and building media will be initiated under the American Recovery and Reinvestment Act by USEPA's small business remedial action contract (RAC) contractor. It is anticipated that the RA will be implemented in the following construction phases.

- Asbestos Abatement.
- Building Demolition—Decontamination, lead removal, demolition of the building down to the concrete floor slab, and disposal of the building materials.
- Soil and Sediment Excavation and Disposal—Demolition and disposal of the concrete slab, and excavation and disposal of the contaminated sediment and contaminated

unsaturated zone soils inside and outside of the building footprint. This phase of work also includes the investigation and characterization of unsaturated soil beneath the concrete floor slab.

In 2008, USEPA completed the pilot test of in situ groundwater technologies and a bench-scale test of ZVI for remediation of the TCE DNAPL. The findings of the pilot test and bench-scale study are presented in the *Enhanced In Situ Bioremediation Pilot Study Report* (CH2M HILL, 2008a). Based on the results of the pilot test and bench-scale study, the potential alternatives presented in the FS report were re-examined and the evaluation is summarized in the *Supplemental Feasibility Study Report* (CH2M HILL, 2008b). USEPA issued a proposed plan for the cleanup of the TCE DNAPL and groundwater in August 2008 and an ROD in February 2009. The results of the testing, technical parameters, and design elements of the DNAPL/groundwater remedy are discussed in this BODR.

1.4 Remedial Action Objectives and Goals

The remedial action objectives (RAOs) for the groundwater were developed to actively reduce the concentrations of the chemicals of concern (COCs) to levels that would allow the groundwater to be used for residential purposes without restrictions. The RAOs for the TCE DNAPL were developed to actively reduce the concentration of TCE to the maximum extent practicable. The specific RAOs are as follows:

- Remediation of DNAPL and groundwater within the DNAPL area to the extent practicable and minimization of the migration of contaminants in groundwater.
- Prevention of residential indoor inhalation of VOCs that causes a calculated hazard index (HI) greater than 1 or an excess lifetime cancer risk (ELCR) greater than an estimated risk range of 1×10^{-4} to 1×10^{-6}.
- Prevention of construction worker exposure to groundwater, through direct contact, ingestion, or inhalation that causes a calculated HI greater than 1 or an ELCR greater than 1×10^{-4} to 1×10^{-6}.
- Remediation of contamination in groundwater to concentrations below a calculated HI of 1 or an ELCR of 1×10^{-4} to 1×10^{-6} within a reasonable timeframe.

These RAOs are consistent with the reasonably anticipated future land use for the OMC Plant 2 site. The City of Waukegan has stated its desire to redevelop its lakefront into a high-density residential area. It is anticipated that these RAOs will be achieved through implementation of the remedial actions presented in the ROD, which include a combination of in situ treatment technologies and institutional controls. The performance and effectiveness of the remedy will be evaluated as part of USEPA's statutory five-year review for the OMC site. Site cleanup levels for the groundwater and TCE DNAPL, as specified in the ROD, are shown in Table 1-1.

TABLE 1-1
Site Cleanup Levels for Groundwater

Compound	Media	Cleanup Level (source)	Residual Risk
TCE	Groundwater	5 µg/L (MCL)[a]	ELCR = 3×10^{-6}
Cis-1,2-DCE	Groundwater	70 µg/L (MCL)	HI = 0.20
Vinyl chloride	Groundwater	2 µg/L (MCL)	ELCR = 4.7×10^{-5}
Arsenic	Groundwater	10 µg/L (MCL)	ELCR = 2×10^{-4}
TCE	DNAPL	Maximum Reduction Practicable	----------

Notes:

[a]Maximum contaminant level (MCL) under the Safe Drinking Water Act.

TCE = Trichloroethene, DCE = Dichloroethene, ELCR = Excess lifetime cancer risk, HI = Hazard index, µg/L = Micrograms per liter, DNAPL = Dense nonaqueous phase liquid

1.5 Description of the DNAPL and Groundwater Remedy

Based on the results of the human health risk assessment, USEPA determined that the TCE DNAPL and VOCs in the groundwater beneath the OMC Plant 2 site may cause unacceptable potential risks to humans under the current and reasonably anticipated future land use exposure scenarios. Thus, response actions are necessary to protect public health and welfare from actual and future potential exposures to pollutants or contaminants in the DNAPL and groundwater media.

The attainment of the RAOs for groundwater requires remediation or containment of the sources of VOCs to the groundwater. Shallow VOC sources in the unsaturated soils that may be contributing to the groundwater plume will be addressed as part of the soil RA after the building slab is removed. The groundwater "source zones" and TCE DNAPL source will be addressed as part of the groundwater RA. It should be noted that the presence of the building has not allowed full delineation of the TCE DNAPL below the concrete slab. Further delineation of the TCE DNAPL will be conducted upon removal of the slab prior to initiation of the DNAPL remedy. The delineation activities will be conducted in two areas, the southwest corner of the in situ soil mixing area to define the extent of the TCE DNAPL and the southwest corner of the property to delineate the extent of the PCB DNAPL. The results of the delineation will be used to refine the estimated DNAPL treatment area to be addressed in the groundwater RA.

Based on discussions with USEPA, it is anticipated that the groundwater remedy will be implemented in three separate construction phases. These construction phases include the following:

- In situ soil mixing
- Enhanced in situ bioremediation
- Downgradient air sparging

The fourth remedy component, monitored natural attenuation (MNA), will be implemented upon completion of the active remedy phases. The activities conducted for the MNA

component have been incorporated into the long-term performance monitoring. Potential cost savings may be realized if the remedy components are conducted simultaneously.

Five-year reviews will be conducted to evaluate the effectiveness and performance of the remedy and to determine if the remedy is protecting human health and the environment. The five-year reviews will be conducted in accordance with USEPA's *Comprehensive Five-Year Review Guidance* (EPA 540-R-01-007).

1.5.1 Downgradient Air Sparge Curtain

VOC concentrations downgradient of the source zone areas may remain elevated for several years after the initiation of in situ soil mixing (ISSM) and EISB. In addition, the removal of the building will increase the amount of recharge to the groundwater. Accordingly, there is a potential for dissolved-phase VOCs in groundwater to migrate offsite. An air sparge curtain, consisting of a horizontal, directionally drilled well, will be installed near the base of the aquifer along a part of the southern property boundary.

The air sparge curtain creates an aerated zone that will reduce dissolved-phase chlorinated VOC concentrations in the groundwater flowing through the sparge zone by aerobic biodegradation and volatilization (stripping). The air sparge curtain reduces the potential for chlorinated VOCs to migrate offsite to the Larsen Marine Services property and Waukegan Harbor. Although the air sparge curtain is designed to address dissolved-phase chlorinated VOC concentrations in the groundwater, there will be an impact on arsenic present within the area of influence of the air sparge curtain. Arsenic mobilized under strongly reducing conditions hydraulically upgradient of the proposed air sparge curtain will become less mobile under the aerobic conditions created by the curtain.

Based on the objective and the proposed location near the southern property boundary, the installation of the air sparge curtain is not dependent on the completion of the building demolition or the soil remedy. The installation and operation of the air sparge curtain can be safely implemented before or concurrently with building demolition and soil cleanup activities.

1.5.2 In Situ Soil Mixing (ISSM)

A bench-scale study was performed by Colorado State University (CSU) in 2006 through 2007 using site soil, groundwater, and TCE DNAPL. The results of the bench-scale study indicate that the technology effectively reduced the TCE concentrations within the mixed volume and the permeability of the mixing zone (CH2M HILL, 2008b).

Based on the bench-scale study results, ISSM will be implemented to treat the TCE DNAPL source zone northwest of the former Trim building. The treatment area may be expanded to include addition DNAPL areas identified during the delineation activities of the soil beneath the building slab. In addition to the subslab investigation, additional characterization activities will be conducted to complete the delineation of two DNAPL areas that include:

- The southwestern corner of the proposed ISSM treatment area. The presence of TCE DNAPL has been verified in this area, however the southwestern extent of the DNAPL was not defined because of limited access to this area within the building.
- The southwest corner of the site, in the area surrounding the MW-517 well nest. DNAPL consisting of PCBs was found in this well during groundwater sampling.

Further investigation and delineation efforts have been implemented, however the presence of the building limited the ability to identify the source zone and delineate the lateral extent of the PCB DNAPL.

Once the extent of the TCE DNAPL has been delineated, ISSM will be conducted to mix ZVI and bentonite throughout the soil column to stabilize and treat the TCE DNAPL area(s). The inclusion of the bentonite with the ZVI will create a low-permeability zone that will also reduce the volume of groundwater flowing through the area. Once the extent of the PCB DNAPL has been delineated, treatment technologies will be evaluated.

Soil and groundwater monitoring will be conducted for a 1-year period following completion of mixing. The first event will be completed at 1 month and subsequent events at 6 and 12 months after completion of ISSM activities. Long-term groundwater monitoring will be conducted annually thereafter as part of the EISB and MNA monitoring events.

1.5.3 Enhanced In Situ Bioremediation (EISB)

The objective of the groundwater remedy is to treat the VOC source zones and the VOC-contaminated groundwater plume (greater than 1 milligram/liter [mg/L]) to concentrations less than 1 mg/L total VOCs. The RI identified five VOC groundwater source zones with high dissolved-phase concentrations of TCE that can continue to contribute to and sustain dissolved-phase plumes. In 2007, CH2M HILL conducted an EISB pilot study on two of these source zones and the results indicated that periodic injections of a soluble substrate was effective in enhancing the naturally occurring bioremediation to reduce the VOC concentrations in the groundwater (CH2M HILL, 2008a).

Based on the pilot test results, the five source zone areas will be treated by periodic injections of a soluble substrate. Upon demolition and removal of the concrete building slab, injection wells screened in the shallow and deep parts of the aquifer will be installed within the identified source zones and a soluble substrate will be injected quarterly for a period of 1 year and then periodically thereafter with a frequency no greater than quarterly for up to 4 years. Injection frequency after the first year will be based on the quarterly performance monitoring analytical results from select source zone monitoring wells.

1.5.4 Monitored Natural Attenuation

Monitored natural attenuation (MNA) will remediate groundwater VOC and arsenic concentrations outside of the TCE DNAPL and TCE source zones to meet RAOs. MNA includes a variety of physical, chemical, and biological processes that reduce the toxicity, mobility, volume, and concentration of contaminants in the groundwater. The processes include biodegradation, dispersion, dilution, sorption, volatilization, transformation, or destruction. Analytical results from the groundwater sampling events performed as part of the RI and the pilot study indicate that natural attenuation is occurring and the conditions present are favorable for continued biodegradation at the site.

In addition to the quarterly EISB performance monitoring, a larger subset of wells will be sampled annually to provide analytical data for evaluating MNA site-wide. An estimated 68 monitoring wells, including 34 EISB performance monitoring wells, will be sampled annually for select parameters to provide the evidence necessary to verify MNA is ongoing.

SECTION 2

Project Delivery Strategy

This section presents the project delivery strategy for the remediation of TCE DNAPL and VOC-contaminated groundwater at OMC Plant 2. As discussed in Section 1, it is anticipated that this RA will be designed and implemented as three independent components with multiple subcontracts. The initiation of the RA for the TCE DNAPL and groundwater, with the exception of the air sparge system, is dependent on the completion of the RA for the soil, sediment, and building materials. The installation and operation of the air sparge system can be implemented independent of the building and soil RA, as well as the other groundwater remedy components.

The following activity will be completed before the building demolition and soil RA:

- Groundwater samples will be collected from the monitoring wells slated for abandonment (within the building footprint, the 20-foot buffer zone around the building and the ISSM area) and other selected monitoring wells and analyzed for VOCs, natural attenuation parameters, and PCBs in a limited number of wells.

The following activities will be initiated after the completion of the building demolition and soil remediation RA:

- Delineation of the TCE DNAPL and PCB DNAPL
- Evaluation of PCB DNAPL treatment technologies
- Implementation of ISSM of the TCE DNAPL
- Installation of EISB injection wells and monitoring wells and injection of soluble substrates
- Implementation of post-construction monitoring that incorporates MNA

This design and the remedy implementation strategy are based on the following assumptions:

- The design of the different remedy components will accommodate the City's plans for developing the site provided that there are no negative effects to the remedy effectiveness and the costs.

- The building and soil RA will be completed by USEPA's small business RAC contractor. Their activities that specifically relate to this groundwater design include the following:

  - **Well Abandonment.** Monitoring and injection wells within the building footprint, within 20 feet of the building perimeter, and within the footprint of the ISSM areas (MW-523S, MW-523D, MW-524S, MW-526S, MW-526D, MW-525S, and MW-525D) will be abandoned. Wells outside of the 20-foot buffer zone will not be abandoned.

  - **Building Floor Slab Demolition and Removal.** Demolition of the concrete floor slab will also include the removal of the footings and concrete in soil mixing areas. A part of the slab of the former Trim building will also be removed to grade to accommodate installation of injection wells. The post-remediation surface will be comprised of uncontaminated material.

- **Sub-slab Soil Investigation.** As the building slab is demolished and removed, the exposed unsaturated soil within the building footprint will be characterized and the highly affected soils will be excavated and managed as outlined in the soil and building media management plan. The sub-slab soil investigation will also include delineation of other source areas (soil and/or DNAPL) encountered as the building slab is removed.

The contracting strategy and primary components of the implementation strategy are summarized below. Key project delivery strategies, relative to a specific component, are noted below in their respective sections. Section 3 describes the design, assumptions, and technical parameters associated with the work.

2.1 Contracting Strategy

CH2M HILL intends to competitively solicit proposals for fabrication and installation of the air sparge system, delineation of the DNAPL areas and the implementation of ISSM, installation of the monitoring and injection wells, and injection of the soluble substrate for EISB and allow bidders to propose means and methods, given a set of performance standards (described in Section 3—Design). CH2M HILL proposes a subcontracting approach to maximize the use of small business enterprises (SBE), small disadvantaged business enterprises (SDBE), women-owned businesses (WOB), hub-zone enterprises (HZE), and veteran-owned businesses to the greatest extent possible. The subcontract documents will be prepared based on the understanding that USEPA is the owner of the project and CH2M HILL is the construction contractor. CH2M HILL will prepare the project specifications and drawings and provide the solicitation process instructions and subcontract terms. A total of seven subcontracts are proposed as described below.

2.1.1 Air Sparging

2.1.1.1 Equipment Fabrication Subcontract

The main components of the air sparge equipment fabrication work are presented below:

1. Purchase of fabricated structure to house air sparging equipment
2. Installation of interior, plumbing, heating and venting, electrical, and fire protection to meet applicable local, state, and federal building codes
3. Installation of air sparge system in the fabricated structure
4. Factory and field testing of the air sparge system
5. Shipping (Freight On Board [FOB] Destination) of the fully functional air sparge system to the site
6. Performance of onsite training of CH2M HILL staff

2.1.1.2 Directional Drilling Subcontract

The main components of the air sparge directional drilling work are presented below:

1. Mobilization

2. Utility locate (public and private) activities
3. Horizontal drilling of air sparge well
4. Construction of horizontal air sparge well including well casing, screen, and surface completions
5. Performance of air sparge well development
6. Containerization of drilling mud and solids, liquids from dewatering boxes and well development activities, personal protective equipment (PPE), and other disposable materials that contacted potentially contaminated media in containers provided by others (air sparge curtain – site works subcontractor)
7. Demobilization

2.1.1.3 Site Work Subcontract

The main components of the air sparge site work are presented below:

1. Mobilization
2. Abandonment of injection well
3. Construction of concrete pad for building and transformer
4. Offloading and anchoring of air sparge system and building
5. Pre-construction survey of ground surface along the projection of the air sparge well, and location of other air sparge features.
6. Post-construction survey of building and as-built survey of final air sparge well location
7. Supply of containers for drilling mud and solids, liquids from dewatering boxes and well development activities, PPE, and other disposable materials generated by the air sparge curtain – directional drilling subcontractor
8. Characterization and disposal of drilling mud and solids, liquids from dewatering boxes and well development activities, and PPE, and other disposable materials
9. Pretreatment of wastewater, if needed, based on waste characterization
10. Attachment of final field piping connecting air sparge well to air sparge system
11. Connection of power supply to the air sparge system
12. Construction of a chain-link fence and gravel placement around air sparge system building
13. Site restoration
14. Demobilization

2.1.2 In Situ Soil Mixing

2.1.2.1 ISSM Subcontract

The main components of the ISSM work are presented below:

1. Mobilization
2. Construction of containment berm
3. Performance of soil mixing with offgas treatment
4. Performance of quality assurance/quality control sampling
5. Management of waste including containerizing, characterizing, and disposing waste offsite
6. Pretreatment of wastewater, if needed, based on waste characterization
7. Placement of geotextile, granular fill, backfill, and topsoil over treated area
8. Demarcation of treatment area
9. Installation of a post-treatment security fence
10. Site restoration
11. Demobilization

2.1.3 EISB

2.1.3.1 EISB Drilling Subcontract

The main components of the EISB drilling work are presented below:

1. Mobilization of drilling equipment, personnel, and well materials
2. Performance of borehole drilling and borehole water sampling for DNAPL delineation
3. Performance of borehole drilling for injection and monitoring wells
4. Completion of injection and monitoring well installation
5. Well development
6. Management of drilling-related waste (solids and liquids) including containerizing, characterizing, and disposing offsite
7. Pretreatment of wastewater, if needed, based on waste characterization
8. Survey of monitoring wells, injection wells, the extents of TCE and PCB DNAPL delineation areas and metal stakes demarcating soil mix treatment area
9. Demobilization of drilling equipment, personnel, and well materials

2.1.3.2 EISB Injection Subcontract

The main components of the EISB drilling work are presented below:

1. Mobilization
2. Supply of injection system and substrate
3. Preparation and injection of substrate solution into injection wells for each target zone quarterly for 4 years
4. Demobilization

2.1.4 Facilities

2.1.4.1 Facility Subcontract

The main components of the facilities work are presented below:

1. Construction of gravel area for office trailers and parking
2. Installation of field office trailers for CH2M HILL in a gravel area, securing and connecting them to utilities
3. Coordination and setup of electrical service for subcontractor-supplied office trailer for CH2M HILL, up to two additional field trailers supplied by others, and a batch plant for soil mixing activities
4. Maintenance of existing site perimeter chain-link fencing and gates
5. Provision of copier and other office equipment
6. Set up and payment of monthly usage or service costs for the following:

   a. Office trailer rental
   b. High speed internet service
   c. Hardwired telephone service
   d. Sanitary facilities
   e. Electric service
   f. Bottled water service
   g. Copier maintenance
   h. Dumpster

7. Provision of security in evening and weekends during ISSM and EISB work
8. Installation of hydrant
9. Removal of field office trailers, sanitary facilities, copier and other office equipment, and dumpster
10. Restoration of office trailer and gravel parking area

2.2 Air Sparge Curtain Implementation Strategy

The implementation strategy for the main components of the air sparge curtain is presented below in the expected sequence. The design details and construction methods for each of these components are presented in Section 3. The implementation of the air sparge curtain has been broken into three separate subcontracts described above.

- **Utility Location**—Before horizontal well drilling activities, a field assessment of the underground utilities in the construction area will be conducted. Parties participating in this assessment will include CH2M HILL, the horizontal well drilling subcontractor with a third-party private utility locating firm, the public utility locating firm, and utility owners, as available. Past discussions with the City of Waukegan and local utilities have indicated a high degree of uncertainty regarding the location of underground utilities in the construction corridor. Locating utilities and preventing damage to utilities in the construction corridor will remain the sole responsibility of the drilling subcontractor.

- **Mobilization**—This task will be completed at the outset of each definable construction feature and include mobilization of equipment, personnel, and materials. Before mobilization to the site, each subcontractor will verify that it has obtained, or is in compliance with, the requirements of applicable permits. In addition, each subcontractor will deliver applicable preconstruction submittals to CH2M HILL for approval before mobilization. In addition, the subcontractors will deliver applicable preconstruction submittals to CH2M HILL for approval before mobilization. Mobilization will be accomplished by each of the subcontractors or their lower-tier subcontractors and self-performed by CH2M HILL.

- **Pre-Construction Survey**—Before drilling, a pre-construction survey will be performed by an Illinois-licensed land surveyor to determine vertical coordinates along the ground surface trace of the proposed horizontal well and mark the horizontal location on ground surface for reference during drilling.

- **Site Security**—Site security will entail coordination among CH2M HILL, subcontractors, and the City of Waukegan. Subcontractors will maintain control over their specific work areas. Although the property is owned by the City of Waukegan, USEPA will request that the City of Waukegan restrict access to the site by their employees and subcontractors. CH2M HILL will be responsible for documentation and control of persons entering the work area. However, CH2M HILL and its subcontractors will not be responsible for City employees or subcontractors.

- **Potable Water**—Potable water will be required to perform drilling and installation of the air sparge curtain. It is assumed that potable water required for drilling will be obtained by the directional drilling subcontractor from an offsite source.

- **Injection Well Abandonment**—Because of the air sparge curtain location and radius of influence, 10 existing injection wells in Area 4 will be abandoned by the site work subcontractor before the installation of the horizontal well.

- **Directional Drilling**—The directional drilling subcontractor will advance a horizontal pilot borehole approximately 1,000 feet using directional drilling methods to a depth of

23 feet below ground surface (bgs). The boring will be a "continuous" (double-ended) design. After drilling the pilot borehole, approximately 700 feet of slotted pipe and 300 feet of riser will be pulled into the borehole. Drilling mud, cuttings, and other remediation-derived waste (RDW) will be containerized onsite for characterization and subsequent disposal.

- **Well Development**—The horizontal well will be developed to remove fine sediments and drilling fluids from around the well screen. Development water will be containerized onsite for characterization and subsequent disposal by the site works subcontractor.

- **Air Sparge System**—The air sparge system will include two rotary claw blowers, one heat exchanger, instrumentation, and controls contained in a pre-fabricated treatment enclosure (8 foot by 20 foot land/sea container or equivalent). The enclosure will be sized to add an optional third blower and second heat exchanger, if required, in the future. The equipment fabrication subcontractor will fabricate the system and enclosure at their assembly facility, conduct factory tests of the equipment and controls, and transport the system to the site. The site work subcontractor will place the enclosure on a concrete slab constructed in a grassy plot to the west of the former die cast area and make the connection of the mechanical field piping. Prior to slab construction and placement, a field assessment of the underground utilities in the construction area will be conducted. Parties participating in this assessment will include CH2M HILL, the site work subcontractor with a third-party private utility locating firm, the public utility locating firm, and utility owners, as available. The concrete slab will be constructed by the site work subcontractor before delivery of the enclosure. The equipment fabrication subcontractor will provide onsite field testing and startup of the system.

- **Electrical**—After delivery of the air sparge system enclosure and final connection of mechanical field piping, the electric service meter base will be installed and the electrical feeder connections made between the system main distribution panel and utility service transformer. The local utility company will install required power poles and a pad-mounted transformer from the overhead electrical distribution system, make final service connections to the transformer, and install the electric meter. Expected minimum required power is 480 volts (V), 3-phase, 200 amp service. A mini power center with a step-down transformer (to power 110 V lights, controls, and outlets) and service-rated circuit breaker distribution panel will be installed by the equipment fabrication subcontractor.

- **Fence Construction**—A gated chain-link fence enclosure will be constructed around the equipment enclosure. Geotextile fabric and gravel will be placed within the fenced enclosure to minimize future grounds maintenance.

- **System Startup and Performance Monitoring**—Performance monitoring will be conducted by CH2M HILL in the weeks following system startup to confirm that air is being distributed along the entire length of the well screen and saturated thickness of the aquifer. The actual air sparge curtain zone of influence will also be assessed through performance monitoring. Performance monitoring is described in the QAPP (see Appendix B).

- **Site Restoration**—The site work and drilling subcontractors will be responsible for restoration of disturbed areas after construction activities are completed. Restoration

will include replacement of damaged topsoil, asphalt, and concrete; grading; and reseeding grass in disturbed unpaved areas.

- **Post-Construction Survey**—A post-construction survey performed by a licensed surveyor contracted under the site works subcontract will be conducted by the site work subcontractor to determine the horizontal and vertical coordinates of the horizontal well and equipment enclosure.
- **Demobilization**—This task will include demobilization of subcontractor equipment, personnel, and materials following completion of each definable construction feature.
- **Post-Treatment Performance Monitoring**—Long-term groundwater monitoring will be conducted annually thereafter as part of the EISB and MNA groundwater monitoring events. Five-year reviews will be performed to evaluate performance of the remedy.

2.3 In Situ Soil Mixing (ISSM) Implementation Strategy

The implementation strategy and main components of the TCE DNAPL ISSM are presented below in their expected construction sequence. The design details and construction methods for each of these components are presented in Section 3.

- **Delineation**—The delineation of the southwestern extent of the DNAPL area will be completed after the removal of the building slab and soil RA. The delineation effort will provide the coordinates and boundaries of the treatment area. CH2M HILL will mark the area using a global positioning system (GPS) before mobilization of the ISSM subcontractor.

  Based on the results of the subsurface investigation conducted in November and December 2006, the DNAPL target area, as shown on ISSM Drawing C-201 in Appendix C, may extend further beneath the building in the southern and western direction. For design purposes, an approximate additional area has been assumed; however, an investigation to delineate the DNAPL will be performed by the investigative borehole/well installation subcontractor using direct-push technology (DPT) upon completion of the building demolition and soil removal activities and before implementation of the soil mixing activities. The final delineated area will be surveyed as part of the building demolition activities and coordinates will be provided before mobilization for soil mixing activities.

  Additional DNAPL areas and volumes will be incorporated into the extent and volumes to be treated in the final specifications. Currently, an estimated area of 1,700 ft^2 is provided for planning purposes. Costs for DNAPL treatment outside of the current 9,230-yd^3 DNAPL area are not included in this design.

- **Mobilization**—The ISSM subcontractor will mobilize equipment, personnel, and materials to the site. Before mobilization to the site, the ISSM subcontractor will verify that it has obtained, or is in compliance with, the requirements of applicable permits. In addition, the ISSM subcontractor will deliver applicable preconstruction submittals to CH2M HILL for approval before mobilization. Mobilization by the ISSM subcontractor will include construction of temporary facilities such as material storage facilities,

staging area, and equipment decontamination facilities; mobilization of necessary construction equipment; and placement of required erosion control measures.

- **Utility Location**—Before ISSM activities, a field assessment of the underground utilities in the construction area will be conducted. Parties participating in this assessment will include CH2M HILL, the soil mixing subcontractor with a third-party private utility locating firm, the public utility locating firm, and utility owners, as available.

- **Site Security**—Site security will entail coordination among CH2M HILL, the ISSM subcontractor, the facilities subcontractor, and the City of Waukegan. Although the property is owned by the City of Waukegan, USEPA will request that the City of Waukegan restrict access to the site by their employees and subcontractors. The existing site perimeter fence will be maintained by the facilities subcontractor. The ISSM work area will be delineated by high visibility fencing installed by the ISSM subcontractor during construction activities. CH2M HILL will be responsible for documentation and control of persons entering the ISSM work area. However, CH2M HILL and its subcontractors will not be responsible for City employees and subcontractors. Site security will be provided as part of the facilities subcontract in the evenings and weekends during construction. After completion of the construction activities, a post-treatment security fence will be installed around the mixed area by the ISSM subcontractor.

- **Containment Berm Construction**—The ISSM subcontractor will be responsible for implementing measures to manage and handle soil volume expansion during mixing activities. This will include, but is not limited to, construction of containment berms around the perimeter of the treatment area before mixing.

- **Soil Mixing**—The ISSM subcontractor will advance a large diameter auger from the ground surface to the base of the aquifer at approximately 28 feet bgs while adding 1 percent bentonite and 2 percent ZVI, by mass, based on the pilot test results presented in Section 3.2.1. Mixing will be performed in a series of overlapping vertical columns. Due to the high concentrations of TCE expected in the target treatment area, a vapor collection hood will be placed on the top of the mixing auger. The hood will be connected to a blower to provide negative pressure and collect vapors from the mixing zone. The vapors will be connected to an off-gas treatment system before discharge to the atmosphere.

- **Quality Assurance/Quality Control Sampling**—Soil samples from the treated area will be collected by the ISSM subcontractor and provided to CH2M HILL for field analysis of the iron content during and immediately following mixing to ensure the design specification has been met. Post-mixing samples will be collected by the ISSM subcontractor and submitted to a laboratory in the USEPA's Contract Laboratory Program (CLP) for VOC analysis. The subcontractor will be required to implement quality assurance/quality control measures to ensure the design mix is achieved, thoroughly mixed within each column, and the specified depth is achieved. If the design mix is not achieved based on the field analysis of the iron, the subcontractor will be required to re-mix the applicable area.

- **Backfill**—After soil mixing is completed, the containment berms will be integrated into the treatment area by dozing or blading the material onto the adjacent edges of the treated

soil. The surface material, which at this point will be a combination of treated soil and berm material, will be graded in preparation for placement of the geotextile and fill material. The ISSM subcontractor will lay out and seam together the geotextile fabric that will be placed over the top and extend 5 feet beyond the mixed area. Approximately 3 feet of imported clean material will be placed on top of the geotextile and remaining berm material, and graded to allow for settling and drainage. Backfill material will provide a surcharge to the mixed volume and accelerate settling and compaction of the area. The surface of the imported clean material will be seeded after final grading is completed. Silt fencing will remain in place for erosion control until vegetation is established.

- **Post-Treatment Security**—Due to the physical characteristics and potential settlement of the mixed TCE DNAPL area soils, a post-treatment security fence will be installed around the perimeter of the mixed area to prevent personnel from entering the area. .
- **Demobilization**—Demobilization will include removal of temporary facilities such as field trailers, utilities, material storage facilities, equipment decontamination facilities, and construction equipment. Silt fences will be removed once the vegetation has been established and provides long-term erosion control for the backfill material. General long-term maintenance of the area will be the responsibility of the USEPA and Illinois EPA until transfer of the property to the City of Waukegan or another party.
- **Surveying**—The x, y, and z coordinates of the final soil mixing area extents will be surveyed by the licensed surveyor contracted under the EISB well installation subcontract.
- **Post-Treatment Performance Monitoring**—The post-treatment performance monitoring will include collection of soil and groundwater samples collected from soil borings and two temporary performance wells, respectively, located within the mixed area. The first sampling event will occur 1 month following completion of ISSM activities and subsequent events at 6 and 12 months.

2.4 Enhanced In Situ Bioremediation

The implementation strategy and main components of the EISB are presented below in the expected construction sequence. The design details and construction methods for each of these components are presented in Section 3.

- **Utility Locate**—Before drilling activities, a field assessment of the underground utilities in the construction and DNAPL delineation areas will be conducted. Parties participating in this assessment will include CH2M HILL, the drilling subcontractor with a third-party private utility locating firm, the public utility locating firm, and utility owners, as available. Locating utilities and preventing damage to utilities in the construction corridor will remain the sole responsibility of the drilling subcontractor.
- **Investigative Borehole/Well Installation Mobilization**—This activity will include mobilization of the investigative borehole/well installation subcontractor. Before mobilization to the site, the subcontractor will verify that it has obtained, or is in compliance with, the requirements of applicable permits. In addition, the subcontractor will deliver applicable preconstruction submittals to CH2M HILL for approval before mobilization. Mobilization will include construction of temporary facilities, such as material storage

facilities and equipment decontamination facilities, and mobilization of necessary drilling equipment and well materials.

- **Site Security**—Site security will entail coordination among CH2M HILL, the investigative borehole/well installation subcontractor, facility subcontractor, and the City of Waukegan. Although the property is owned by the City of Waukegan, USEPA will request that the City of Waukegan restrict access to the site by their employees and subcontractors. CH2M HILL will be responsible for documentation and control of persons entering the site. However, CH2M HILL and its subcontractors will not be responsible for City employees and subcontractors. Site security will be provided as part of the facilities subcontract in the evenings and weekends during well installation activities.

- **DNAPL Delineation**— The investigative borehole/well installation subcontractor will advance a borehole to the target depth of sufficient diameter to allow for DNAPL delineation. The subcontractor will also collect a groundwater grab sample from each of the boreholes. Visual inspection of both the soil and the groundwater grab samples will be conducted to determine the presence of DNAPL in each area.

- **Well Installation**—The investigative borehole/well installation subcontractor will advance a borehole to the target depth of sufficient diameter to allow construction of a 2-inch-diameter injection and/or monitoring wells in compliance with applicable regulations. Wells will then be constructed and surface completions installed. After well construction is completed, the EISB drilling subcontractor will perform well development.

- **Surveying**—Injection and monitoring well locations will be surveyed by a licensed surveyor contracted under the EISB well installation subcontract. Top of casing elevations along with x and y coordinates will be measured.

- **Mobilization of Injection Subcontractor**—After well installation and development activities are complete, the EISB injection subcontractor will mobilize to the site. Before mobilization to the site, the EISB injection subcontractor will verify that it has obtained, or is in compliance with, the requirements of applicable permits. In addition, the EISB injection subcontractor will deliver applicable preconstruction submittals to CH2M HILL for approval before mobilization. Mobilization will include construction of temporary facilities such as material storage facilities and equipment decontamination facilities, and mobilization of necessary equipment. The EISB injection subcontractor will mobilize the labor, equipment, and appurtenances required to complete the injection as detailed in the specifications.

- **Injection**—The EISB injection subcontractor will inject the substrate solution per the detailed specifications provided by CH2M HILL quarterly for a period of 1 year and then periodically thereafter with a frequency no greater than quarterly for up to 4 years. CH2M HILL personnel will provide oversight of these activities. The injection subcontractor will be responsible for providing the equipment necessary to accomplish injection including pumps, tanks, substrate, piping, and related appurtenances. No materials or equipment will be stored onsite between injection events.

- **Demobilization**—Demobilization will include removal of temporary facilities, material storage facilities, equipment decontamination facilities, and equipment.

- **Performance Monitoring**—Injection frequency after the first year will be based on the quarterly performance monitoring analytical results from select source zone monitoring wells. The quarterly groundwater monitoring provides the data necessary to verify EISB conditions are present.

2.5 Monitored Natural Attenuation

The implementation strategy and main components of MNA are presented below. The design details and construction methods for each of these components are presented in Section 3.

- **Mobilization**— The field team will mobilize to the site with all necessary equipment and sample collection containers.
- **Groundwater Sampling**—Personnel will measure water levels and collect groundwater samples from an estimated 68 monitoring wells located throughout the site. A low-flow groundwater sampling technique will be used to recovery representative samples of the water in the formation. The samples collected for VOCs will be submitted to the CLP for analysis and the samples collected for MNA parameters will be submitted to the analytical laboratories for analysis.
- **Demobilization**—The field team will demobilize from the site.
- **Date Analysis and Reporting**—Analytical results provided by the laboratories will be validated and evaluated to verify MNA is ongoing. A technical memorandum summarizing the analytical data, field parameters, and documenting the MNA evaluation will be submitted annually.

SECTION 3

Design

The major components of the selected remedy as presented in USEPA's ROD (USEPA, 2009) included chemical reduction to treat the TCE DNAPL, EISB (injection of a soluble substrate) coupled with a downgradient air sparge curtain to address COCs in the groundwater contaminant plume, and MNA to address the residual VOCs in groundwater after completion of active treatment.

Design details for the three construction remedy components are presented below. The fourth remedy component, MNA, will be implemented upon completion of the construction phases. The activities conducted for the MNA component have been incorporated as part of the long-term performance monitoring. To allow greater flexibility in response to uncertainties related to USEPA's schedule and funding stream, it has been assumed that the three construction remedy components will be implemented independently. Cost and schedule efficiencies may be recognized if multiple alternatives are implemented concurrently.

3.1 Air Sparge Curtain

The air sparge curtain is designed to reduce dissolved-phase chlorinated VOC concentrations in groundwater through a combination of aerobic biodegradation and volatilization. The sparge curtain is not intended to function as a source zone treatment, but rather to reduce low-level VOC concentrations in groundwater that is migrating offsite. Arsenic mobilized under strongly reducing conditions hydraulically upgradient of the proposed air sparge curtain will become less mobile under aerobic conditions created by the curtain.

A soil vapor recovery system is not proposed as part of the air sparge curtain design because the estimated daily discharge levels do not exceed daily or yearly discharge limits under Illinois Administrative Code (IAC) Title 35, Environmental Protection, Subtitle B: Air Pollution. It has also been assumed that new buildings constructed on the property would be subject to institutional controls in the form of requirements for foundations to be designed and constructed with engineering controls (such as vapor barriers) to prevent indoor air inhalation risks from VOCs in the groundwater.

As discussed previously, installation of the air sparge curtain is not dependent on the completion of the building and soil RA. Site specific parameters used in calculations for design of the air sparge curtain are summarized in Table 3-1.

TABLE 3-1
Air Sparge Design Parameters

Design Parameter	Unit	Value
Estimated Temperature in Well Piping	deg F	70
Estimated Pressure in Well Piping	psig	9
Estimated Temperature in Manifold Piping	deg F	340
Estimated Pressure in Manifold Piping	psi	16
Design Blower Pressure	psi	20
Factor of Safety for Air Sparge Blower		1
Soil type		Silty sand (80–90% passing No. 40 sieve)

3.1.1 Distance of Influence

It is assumed that the radius of influence will range from 80 to 100 feet around the air sparge curtain (40 to 50 feet on each side of the well) based on the grain size of the soils, design air flow rate, and the submergence depth of the well. Air flow patterns in homogeneous coarse-grained soil are somewhat random and cannot be reliably predicted. The option to operate the sparge curtain on an intermittent or "pulsed" basis has been included in the design, since the technique has been demonstrated to enhance the lateral propagation of air/oxygen at other sites. The zone of influence of the well will be assessed during the post-startup performance monitoring period using a combination of dissolved oxygen measurements and visual observations of bubbling in nearby monitoring wells.

3.1.2 Well Location and Alignment

The air sparge curtain will be located to intercept the 1,000 micrograms per liter (μg/L) dissolved-phase chlorinated VOC plume (Air Sparge System Drawing C-200 in Appendix C). The Larsen Marine Service property, including the boat storage area, located south of Seahorse Drive, prevents installation of the air sparge curtain hydraulically downgradient of the leading edge of the plume. Consequently, the air sparge curtain has been located as far south as possible onsite to intercept the most hydraulically downgradient part of the plume. To the extent feasible and practical, the proximal end of the directional boring (entry point) will be located as close as possible to the planned location of the system enclosure to reduce or eliminate the need for underground conveyance pipe/trenching (refer to Air Sparge System Drawing C-200 in Appendix C). Connection between the air sparge system and horizontal well will be made using a 3-inch-diameter pressure-rated air hose.

3.1.3 Well Construction Details

To maximize air contact with the plume, minimize disruption of surface and near-surface infrastructure, and simplify distribution manifolds and piping, the air sparge curtain will be constructed as a single well using horizontal directional drilling (HDD) techniques. The well will consist of 1,000 feet of 4-inch-diameter fiberglass pipe, which includes approximately

175 feet of entry riser pipe, a 700-foot-long slotted section ("screen"), and 125 feet of exit casing. The well will be double ended, and the well screen will be installed at a depth of approximately 23 feet bgs, which is slightly above the base of the aquifer. Orifice flow modeling will be conducted to develop an appropriate well slotting design, which results in flow across the entire well, with less than 10 percent skew. The slotting pattern will be provided to the drilling subcontractor following contract award. The well will be developed by the drilling subcontractor following installation to remove fines and drilling fluids from around the well screen. Air Sparge System Drawing C-201 in Appendix C presents a cross section of the HDD sparge well.

3.1.4 Process Equipment

At a minimum, process equipment required for operation of the air sparge curtain will include the following:

- Two rotary claw blowers with a minimum total flow capacity of 400 standard cubic feet per minute (scfm) (200 scfm per blower) and a minimum discharge pressure of 20 pounds per square inch (psi). Based on experience and published data from other HDD air sparge wells, the total flow rate was calculated assuming that a flow rate of 0.5 to 0.7 scfm per foot of well screen can be achieved. The optimum flow rate will be confirmed during the post-startup performance monitoring period. Space will be allowed to accommodate a third blower, if necessary. A third blower will be required if the designed radius of influence is not being achieved with two blowers.
- One heat exchanger capable of reducing the blower outlet air temperature to a maximum temperature of 140 degrees Fahrenheit.
- Instrumentation and controls to allow the local and remote monitoring of the air flow rate, pressure, and temperature.

Air Sparge System Drawing N-001 in Appendix C presents the equipment process flow diagram with associated instrumentation and control. Process equipment, including piping, instrumentation, controls, and enclosure will be pre-assembled and tested by the equipment fabrication subcontractor before delivery to the site. The subcontractor will also assist with onsite start-up activities.

3.1.4.1 Equipment Enclosure

Process equipment required to operate the HDD sparge well will be housed in a ventilated and insulated pre-fabricated 8 foot by 20 foot enclosure that meets project specifications and local building codes (Air Sparge System Drawing SM-200 in Appendix C). The enclosure will be placed on and anchored to a concrete pad constructed before delivery. After delivery of the enclosure and anchoring to the concrete pad, a gated chain-link fence will be constructed around the enclosure to prevent unauthorized persons from accessing or damaging the equipment. Geotextile fabric and gravel will be placed within the fenced enclosure to minimize future grounds maintenance. Air Sparge System Drawing SM-200 in Appendix C presents a conceptual layout of the equipment enclosure.

CH2M HILL will work with the City of Waukegan to site the enclosure in a location that will minimize interference with future development activities, to the extent practicable. The

enclosure can be relocated if the location interferes with future development activities; however, a new concrete pad, fenced enclosure, and utility/field piping connections would be required and are not included as part of this effort.

3.1.5 Operation and Maintenance

The air sparge curtain will be operated continuously with the option of pulsing to enhance VOC degradation or to prevent diversion of groundwater around the air curtain area. It is assumed that the curtain will be operated for approximately 30 years. At a minimum, monitoring and maintenance activities associated with the air sparge system will consist of the following:

- Weekly monitoring of system operations by CH2M HILL personnel using a telemetry system.
- Monthly site visits by CH2M HILL personnel to assess system operations and perform minor maintenance tasks.

An outline of the O&M Manual will be provided with the Final Design and will be completed following system startup. This manual will serve as the O&M guide for staff working on the system.

3.1.6 Performance Monitoring

Performance monitoring will be conducted in the weeks following startup of the sparge system to confirm that air is being distributed along the entire length of the well screen and saturated thickness of the aquifer. Performance monitoring will include measurement of wellhead pressures, contaminant concentrations, dissolved oxygen (DO), and oxidation-reduction potential (ORP) in existing monitoring wells located immediately upgradient and downgradient of the air sparge curtain. Proposed performance monitoring wells include the shallow and deep well pairs at MW-513, MW-514, MW-515, MW-527, MW-528, and MW-529. The performance monitoring sampling strategy will be presented in the O&M Manual. Performance monitoring data will be used to optimize system operations.

The installation of additional monitoring points upgradient or downgradient of the air sparge curtain or along utility corridors will be evaluated based on performance monitoring data.

3.1.7 Waste Management

Waste generated during construction includes solid and aqueous materials associated with the drilling and installation of the HDD sparge well. Solid material including drilling mud and cuttings will be containerized in 30-yd^3 roll-off boxes lined with filter fabric to retain solids and equipped with an under drain system to collect liquids. Aqueous waste transferred from the roll-off boxes or generated during decontamination or well development activities will be containerized in a portable frac tank (Baker tank or similar). Waste characterization samples of the solid and aqueous media will be collected to properly characterize and profile the material for disposal at a licensed offsite facility.

It is anticipated that wastes generated during O&M of the air sparge curtain will be minimal.

3.1.8 Permitting

The substantial requirements for local and state permits will be met before construction activities begin. It is assumed that the following permits or registrations will be required:

- Electrical permit
- Well registration
- Underground injection control permit

To minimize permitting delays, city offices will be contacted before approval of the RA work plan to verify the building and electrical requirements and lead times.

3.1.9 Site Restoration

Areas disturbed during construction activities will be restored to pre-construction conditions. Paved surfaces will be restored to pre-construction conditions using like materials. Unpaved grassy surfaces will be restored with topsoil, graded, and seeded.

3.1.10 Public Utility Locations

Underground utilities can affect the configuration, depth, and constructability of the air sparge curtain. Therefore, the presence of public utilities was assessed relative to the proposed air sparge curtain location using several utility maps of the OMC Plant 2 site. Known underground utilities transecting the proposed alignment of the air sparge curtain include the following:

- One electric line
- One sanitary sewer line
- One gas line
- Two water lines
- Three storm sewer lines

There is also an underground pressurized sanitary sewer line and a storm sewer line running parallel to the south side of the air sparge curtain location. The depths of the underground utilities transecting the proposed alignment are not known at this time, but it is assumed that the utilities will not interfere with the well installation based on the drilling method (HDD) and installation depth. The air sparge curtain has been designed such that the deepest part of the horizontal well will transect the areas with the highest known density of underground utilities. A utility survey will be conducted before implementing the remedy to confirm the utility locations and depths and provide markings in the field. The utility locations are shown on Figure 1-2.

Soil vapor intrusion into surface and subsurface structures is not anticipated to pose unnecessary risk during air sparge curtain operation because of VOC concentrations in groundwater. Some of the utilities crossing the air sparge curtain footprint are backfilled to ground surface with native soil and/or gravel. Therefore, any vapor accumulation within the backfill material of unpaved utilities will likely migrate upwards and discharge to ambient air. To confirm that vapors are not accumulating or migrating along utility corridors, a photoionization detector (PID) will be utilized to measure VOC headspace readings in utility access vaults, man ways, and nearby monitoring wells. PID readings will be measured before system startup to establish a baseline range of values. Following system startup, PID headspace

monitoring will be conducted to assess changes in concentration. If elevated PID readings remain sustained above baseline conditions, changes to the air sparge curtain monitoring program and operation will be evaluated. If changes in operation do not facilitate a decrease in PID headspace readings, an evaluation of soil vapor control devices will be evaluated.

3.2 In Situ Soil Mixing

In situ soil mixing using ZVI and bentonite was selected to target the TCE DNAPL area outside the building in the eastern part of Area 2 (Appendix C, ISSM Drawing C-200). The selected remedy includes the following major components:

- Additional investigations to delineate the southwestern extent of the DNAPL will be performed prior to the soil mixing activities. The delineation will be conducted using DPT methods and contracted separately from the ISSM subcontract.
- Use of soil mixing equipment to inject and mix ZVI and bentonite into the DNAPL zone.
- Installation and groundwater sampling of two temporary performance wells located inside the soil mixing treatment area. These locations will be installed using DPT methods and contracted separately from the soil mixing subcontract.

Conventional soil-mixing equipment will be used to incorporate reactive media (ZVI) and stabilizing agents (bentonite clay) to treat and stabilize the TCE DNAPL. The ZVI corrodes in situ releasing hydrogen, which then results in chemical and/or biological reductive dechlorination of the VOCs. The mixing of DNAPL and soil increases the surface area of the TCE DNAPL available for dissolution and the subsequent chemical reduction, and to a lesser degree, anaerobic biological reductive dechlorination. The stabilizing agent (bentonite clay) provides the following benefits in the ZVI soil mixing stage:

1. Reduces the torque (through lubrication) needed to rotate the augers during the soil mixing.
2. Provides high viscosity delivery fluid necessary for suspension of the reactive media.
3. Reduces the permeability of the mixed soil so that the mass flux from any untreated residuals is greatly reduced.
4. Reduces inflow of competing electron acceptors (for example, dissolved oxygen and nitrate).
5. Increases residence time for the reaction to proceed.

The approach, assumptions, and parameters used to develop the design for the soil mixing are based on the bench-scale study performed by CSU. Additional parameters used in design calculations for the soil mixing are provided in Table 3-2.

TABLE 3-2
Soil Mixing Parameter

Design Parameter	Unit	General
In Situ Soil Dry Density	tons/yd^3	1.4
Estimated Swell	percent	20

Notes: yd^3 = cubic yards

3.2.1 Pilot/Treatability Test Activities

To demonstrate the effectiveness of the ZVI-bentonite to degrade site-specific COCs, a bench-scale study (that is, column testing) was conducted by CSU, the patent holder for this technology, in 2006 and 2007. The bench-scale study also included evaluating the effectiveness of iron from three different sources of iron (Peerless, GMA, Inc., and QMP) and the effect on treatment performance with the addition of sodium bicarbonate and cement.

The effectiveness of Peerless, GMA, Inc., and QMP iron at application rates of 1 percent and 3 percent by dry weight of soil were tested with 1 percent bentonite by dry weight of soil. The addition of sodium bicarbonate (0.5 percent) did not significantly affect treatment whereas the addition of cement (1 percent, local source) significantly inhibited the reaction rate. Complete bench-scale study results are presented in the *Supplemental Feasibility Study Report* (CH2M HILL, 2008b).

During bench-scale testing, the initial post-mixing TCE concentration in soil was approximately 350 milligrams per kilogram (mg/kg). Table 3-3 shows the results of the bench-scale study showed the following TCE concentrations (and percent reductions) after 2 months and approximately 6 months of reaction time.

TABLE 3-3
Summary of Bench-Scale Study Results

	After 2 Months Using 1% Iron	After 6 Months Using 1% Iron	After 2 Months Using 3% Iron	After 6 Months Using 3% Iron
GMA Iron	48 mg/kg (86.3)	0.58 mg/kg (99.8)	0.11 mg/kg (99.9)	0.04 mg/kg (99.9)
Peerless Iron	190 mg/kg (45.7)	16 mg/kg (95.4)	12 mg/kg (96.6)	0.10 mg/kg (99.9)
QMP Iron	216 mg/kg (38.3)	154 mg/kg (56)	89 mg/kg (74.6)	0.7 mg/kg (99.8)

ZVI from GMA achieved the fastest degradation of TCE, followed by Peerless, then QMP. Faster reaction kinetics was achieved by using 3 percent versus 1 percent iron. Although the test using 3 percent iron provided nearly 99 percent reduction in 6 months, the same contaminant mass reduction can be achieved with a 1 percent by weight iron concentration level over a longer duration. Because the time differential for degradation of TCE between 3 percent and 1 percent iron is not significant relative to the overall site remediation, 1 percent iron by weight could be used in full scale; however, the initial TCE concentration of 350 mg/kg in the bench-scale study is less than the anticipated post-mixing TCE concentration in the target area of 2,500 mg/kg. Based on the results of the bench-scale

study and the estimated TCE concentration in the target area, it was decided that 2 percent ZVI from GMA and 1 percent bentonite mixture will be used to treat the DNAPL areas.

3.2.2 TCE DNAPL Target Treatment Area

ISSM will be implemented over an approximate area of 7,200 ft^2 (Appendix C, ISSM Drawing C-200). The area is based on the current delineation of DNAPL. An additional estimated area of 1,700 ft^2 for the southwestern extent has been assumed for cost estimating purposes based on available site investigation data. However, the final mixing area will be determined based on DNAPL delineations performed after the building and soil RA by the investigative borehole/well installation contractor. The results of the delineation effort will be used to finalize the extent and volume of soil to be treated and the subcontract documents (drawings, specification, bid forms, and cost estimates) will be updated with the revised mixing area before submittal to potential subcontractors for bidding.

Large-diameter augers will be advanced 6 to 12 inches into the clay till confining layer and DNAPL at the base of the aquifer at approximately 28 feet bgs. The actual depth to the till will be determined by the ISSM subcontractor by cross referencing existing top of till surface contour data with physical indications such as auger refusal encountered during soil mixing activities. For cost estimating purposes, it is assumed that the soil mixing will treat approximately 9,230 yd^3 of material (a minimum volume of 7,470 yd^3 for the 7,200 ft^2 with an additional of 1,760 $yd^3$for the 1,700 ft^2).

3.2.3 General Site Preparation

Site preparation will include site clearing and preparing the staging area that extends around the target area as described above (Appendix C, ISSM Drawing C-200). Treatment activities and operations will be limited to this area. No known utilities are located in the treatment area. The nearest utility is located approximately 60 feet east from the most easterly section of the soil mixing treatment area. A third-party utility locator will be used by the ISSM subcontractor to confirm this before any subsurface work is conducted.

It is assumed that the building footings will be removed and existing monitoring wells in the soil mixing treatment area will be abandoned during the building demolition and soil RA before the start of soil mixing activities.

3.2.4 Soil Mixing Preparation

Soil mixing preparation consists of those activities required to prepare for treatment. Soil mixing preparation activities will include silt fence installation, construction of containment berms, construction of the off-gas treatment system, and installation of high visibility fencing.

Based on shallow groundwater levels of approximately 2 feet bgs in the treatment area, it is assumed that no overburden excavation will occur before soil mixing. Excavating overburden material too close to the water table may potentially create an unstable platform for soil mixing equipment to operate and potentially compromise safety, increase complexity, and other construction-related issues. However, while no overburden excavation is assumed, it will be the responsibility of the soil mixing subcontractor to determine and describe the planned approach for safely implementing the soil mixing. The subcontractor's approach will be reviewed and approved by CH2M HILL. If a proposed

method includes some overburden excavation, the material excavated is assumed to have been verified as clean material that was placed as backfill during the building and soil RA.

3.2.4.1 Containment Berms

Containment berms will be constructed by the ISSM subcontractor with maximum 2 horizontal to 1 vertical side slopes to contain soil volume expansion and prevent the uncontrolled discharge of treated material from the treatment area. The actual amount of expansion will vary depending on soil and groundwater conditions, as well as the approach used by the subcontractor (for example, the amount of water added to the slurry), but is assumed to be approximately 15 to 20 percent of the total volume. The soil mixing subcontractor will be required to manage and handle soil volume expansion and contain treated material within the treatment area. Although dewatered material from air sparging implementation may be available for use in containment berms or final cover, its use will be based on the implementation schedule and the geotechnical and chemical conditions of the material. Because it is not certain that the materials will be available for use, the subcontractor specifications assume all imported material for use in these areas.

Upon completion of the soil mixing, the containment berms will be integrated into the mixed area as described in Section 3.2.8.

3.2.4.2 Silt Fence Installation

Prior to soil mixing, silt fencing will be installed around the treatment area and containment berms. An approximate layout of silt fence installation is provided on ISSM Drawing C-201 in Appendix C. The actual perimeter will be determined based on the final delineation area and access requirements. During soil mixing, silt fences will be inspected daily to ensure there are no rips, tears, or other issues that require repair. Silt fencing will remain in place following completion of soil mixing and post-mixing grading activities; however, daily inspections will not be performed. The silt fences will be removed by CH2M HILL once vegetation has been established on the backfilled material.

3.2.4.3 High Visibility Fence Installation

Although overall site access will be limited by a chain-link fence around the site, temporary high visibility fencing will be installed around the construction area to control access to the work exclusion zone as shown on ISSM Drawing C-200 in Appendix C. This area is approximated and will be determined based on the final delineation area. Bilingual (English and Spanish) warning signs will be posted on the fence indicating that entry is restricted.

3.2.5 Soil Mixing Implementation

3.2.5.1 Equipment

The soil mixing equipment consists of a drill that turns a hollow-stemmed mixing shaft (generally known as a Kelly Bar). The top of the Kelly Bar is attached to a grout swivel to permit the injection of grout through the bar, with the bottom attached to the mixing auger/tool with a diameter of 6 feet or greater and capable of effectively reaching the target depth of 28 feet. The total depth of penetration, accounting for soil expansion height, will be measured and recorded for each column. The subcontractor will be responsible for verifying that the required mixing depth (6 to 12 inches into the top of the till layer) has been

achieved. The grout plant will generally consist of a slurry mixer, transfer hoses and pumps, storage tanks, metering, proportioning (or weighing) equipment, and other equipment, as needed. The plant will be equipped to accept dry or liquid additives in measured amounts and capable of storing grout for an adequate supply of batches or continuously mixed grout to the soil mixing machine.

The amendments will be injected as the large-diameter augers are advanced to the target depth and retracted several times to ensure complete mixing. The subcontractor will be required to ensure adequate mixing, include distribution of amendments vertically, which will be verified by field quality assurance/quality control testing as described in Section 3.2.8. The mixed columns will be overlapped, approximately 15 to 20 percent, to treat as much of the DNAPL treatment area as possible. Grout will consist of a stable colloidal suspension of ZVI, bentonite, and water to assist in loosening soils for mixing.

Additional equipment will be provided for collecting discrete soil samples during mixing as described in Section 3.2.8.

The actual auger size, layout of mix columns, and grout mixing plant design will be determined by the subcontractor; however, the subcontractor will be required to develop a quality control plan to establish how complete mixing of the target area at the specified mix design will be achieved.

3.2.5.2 Power

Approximately 200 to 300 amp, 3-phase power service will be available for the subcontractor at the location shown on ISSM Drawing C-200 in Appendix C. It is likely that the current power available will need to be increased to accommodate the overall demand and will be coordinated with the facilities subcontractor by CH2M HILL before ISSM mobilization. This upgrade will be in place before mobilization for soil mixing activities. Setup of the electrical service and payment of the electrical usage will be estimated and included in the quantity provided in the facilities services subcontract.

3.2.5.3 Air Pollution Control

Emissions generated during soil mixing will be managed using a metal shroud, or similar, to tightly seal the surface cross section of the actively treated soil mass that has been disturbed due to the mixing. Organic vapors generated during mixing will be captured inside the shroud and drawn by vacuum to the treatment system through hoses connected to the shroud. Vapors will be contained and treated using necessary filters and an appropriately sized activated carbon unit before discharge to the atmosphere. Due to the nature of soil mixing with a bentonite slurry, fugitive dust emissions are not anticipated in areas where mixing has occurred, but the subcontractor will provide appropriate controls, if deemed necessary.

Additional engineering controls may also be required to manage vapors during soil mixing and areas already mixed.

3.2.5.4 Wastewater Collection and Disposal

Water used or collected during soil mixing activities including, but not limited to, water for decontamination activities and stormwater collected within the treatment area will be stored

in a water tank. Samples of the wastewater will be collected after soil mixing is completed by CH2M HILL and sent for analysis to a CLP laboratory. For estimating purposes, it will be assumed that wastewater will be nonhazardous and disposed of offsite. Depending on the characteristics of the wastewater collected during soil mixing activities, onsite reuse may be possible resulting in potential cost savings. Disposal of wastewater will be conducted by the subcontractor following completion of onsite activities.

3.2.6 Materials

The selection of materials and mix design are based on the results of the bench-scale study. The subcontractor will be responsible for procurement and management of materials discussed herein unless otherwise noted.

3.2.6.1 ZVI

Based on the results of the bench-scale study, the ZVI will be procured from GMA, Inc. (preferred supplier) or Peerless. For calculating the ZVI application rate, the dry unit rate of the soil is assumed to be 1.4 tons per cubic yard with an assumed 25 percent moisture content. An estimated total of approximately 9,230 yd^3 of soil are to be treated requiring 194 tons of ZVI based on a 2 percent addition by dry weight applied to the treatment area.

3.2.6.2 Bentonite

Bentonite is typically added to reduce the soil permeability, reduce the friction for soil mixing, and for other benefits as previously described. Based on the bench-scale study results, the estimated dosage will be 1 percent. An estimated total of approximately 97 tons is required based on a 1 percent addition by dry weight to the overall treatment area.

3.2.6.3 Import Material

It is anticipated that imported material will be required for constructing containment berms and backfilling during site restoration. Uncontaminated stockpiled soil from the soil RA or dewatered material from air sparging implementation may be available for use in containment berms or final cover; however, its use will be based on the implementation schedule, and the material's geotechnical and chemical conditions.

Samples will be collected for analysis by the subcontractor of VOCs, semi-volatile organic compounds (SVOCs), pesticides, herbicides, PCBs, and metals, when identifying borrow sources to be used. One sample will also be collected per 1,000 yd^3 imported and analyzed for the same constituents.

Stockpiling of imported material will occur within the construction area as shown on ISSM Drawing C-200 in Appendix C and will be covered to prevent runoff.

3.2.6.4 Water

Potable water, free of excessive amounts of deleterious substances that adversely affect the properties of the mixing will be used. Additionally, water will be required for decontamination procedures and dust suppression, as needed. It is assumed that a hydrant and meter will be installed on the existing 8-inch water line located in a vault south of the Waukegan Coke Plant (WCP) Treatment Plant (that is, the Triax building, ISSM Drawing C-200 in Appendix C) as part of the facilities subcontract. An approximate flow rate of 250 to

350 gallons per minute (gpm) will be required. Installation of the hydrant will be coordinated with the operators of the WCP treatment plant to limit effects on their operations.

3.2.6.5 Materials Storage and Handling

ZVI and bentonite will be stored on site in super sacks. Each super sack will be delivered with manufacturer's tags specifying unit weights. The super sacks will be staged adjacent to the treatment area and covered with tarps for protection from the weather.

3.2.7 Quality Assurance/Quality Control

During soil mixing, material quantity verification and field testing will be conducted for quality assurance and quality control purposes. The quantity of iron and clay needed for each batch will be calculated, considering the number of columns, mix ratio, and calculated volume of soil to be mixed per column. The soil mixing subcontract will prepare a Soil Mixing Plan that describes the method for calculating a determined quantity of iron and clay needed for each batch, ensuring the design mix will be achieved, and ensuring column layout, depth, and overlap is maintained.

Initially, during field testing, more samples will be collected so that adjustments can be made to the mixing method, as necessary. During the first week of mixing, two locations per day will be sampled. Three samples from varying depths (bottom, middle, and top) of the first column are mixed and two samples from the second column (bottom and middle) will be collected. After the first week, two samples will be collected (bottom and middle) from one column per day for iron content analysis.

Samples will be collected at discrete depths within the mixing columns and provided by the subcontractor. Two analyses will be conducted on these samples. One analysis will be a field test for iron content and the other will be a laboratory analysis for VOC concentration (discussed below). The subcontractor will be required to provide a description of sampling methods to collect the samples, which will be reviewed and approved by CH2M HILL. The iron content of the discrete sample will be analyzed by magnetic separation and water content testing as follows:

3.2.7.1 Water Content Test

1. Weigh out approximately 25 grams of treated soil sample.
2. Dry sample on a hot plate or vented oven.
3. Weigh the dry sample and calculate the water content.

3.2.7.2 Magnetic Separation Test

1. Weigh out approximately 150 grams of treated soil sample.
2. Add 150 to 200 milliliters (mL) of deionized water to the treated soil sample.
3. Mix solution until soil particles are dispersed.
4. Pass a high powered magnet wrapped in cellophane through the slurry until all magnetic iron is removed.
5. Remove the iron from the magnet and dry on a hot plate.

6. Grind dry iron with mortar and pestle to remove any remaining soil adhering to iron.
7. Use a high powered magnet wrapped in cellophane to remove iron from dried soil.
8. Weigh iron and calculate the fraction of iron by dividing the mass of iron by the dry mass of soil.

The iron content analysis will be completed by CH2M HILL to confirm adequate iron concentration (2 percent) and homogenous mixing has been achieved. If the results indicate that thorough mixing throughout the treatment area has not been achieved across the column (greater than 25 percent variation [ZVI range from 1.5 to 2.5 percent] or large visual observations of unmixed material), additional iron will be added and remixed and the number of passes through the mixing column will be increased on subsequent columns.

The field team will use the following methods to verify that the soil mixing meets the design requirements:

- Confirm the subcontractor will use a mixing method to ensure the ZVI and bentonite mass delivered to each treatment column is in accordance with the prescribed mix recipe.
- Confirm the quantities of materials by verifying the manufacturer tags on the ZVI and bentonite super sacks.
- Collect and text mixed soil samples as described above.
- Compare recorded results and quantities in the daily log with the soil mixing subcontractor's records at the end of each day.

3.2.7.3 Baseline Soil Samples

Baseline soil samples will be collected immediately following mixing and analyzed by a laboratory for VOCs by USEPA Method 8260B. These samples will serve as the baseline, or time zero analysis.

One column from every 1,000 yd^3 of mixed soils will be selected for collection of two soil samples. The first sample will be collected within 1 foot of the bottom and the second at mid-depth and analyzed for VOCs by USEPA Method 8260B. These samples will be preserved with methanol in the field to inhibit hydrogen gas generation and analyzed on a rush turnaround time (72 hours) to determine accurate baseline concentrations.

3.2.8 Post-Mixing Grading and Backfilling

Backfilling activities will commence following completion of soil mixing. The containment berms will be integrated into the treatment area by dozing or blading the material onto the adjacent edges of the treated soil. The surface material, which at this point will be a combination of treated soil and berm material, will be graded in preparation for placement of the geotextile and fill material.

The area will first be covered with a woven geotextile fabric. The fabric panels will be overlapped and connected in the field to cover the entire area and to extend 5 feet beyond the

mixed area in all directions. After completion of lining the area, the panel will be secured at the edges with stake pins.

When installation of the geotextile is complete, clean backfill will be placed across the treatment area to cover the mixed material and assist in consolidating the treatment matrix. Initially, 1 foot of granular fill will be placed on top of the geotextile using low ground pressure equipment, followed by 1.5 feet of backfill placed in maximum 6-inch lifts, and finished with 6 inches of topsoil. Dewatered material from air sparging implementation may be available for use in final cover; however, its use will be based on the implementation schedule, and the material's geotechnical and chemical conditions.

The area will be graded to account for settling that will occur over time and for surface water drainage away from the treatment area. Disturbed areas will be seeded. The final mixed area will be surveyed in conjunction with surveying of the EISB injection wells, if possible.

Future redevelopment in the treatment area may require surface soils to be amended to improve the geotechnical properties before building construction. The type of amendment to be used and the depth of the treatment area to be amended are dependent on the geotechnical properties required for use. Evaluating and amending the surface of the treatment area in preparation for future redevelopment is not included as a part of the RA and cannot be performed until monitoring confirms that the remediation goals for the target area have been achieved.

3.2.8.1 Access Control

Although overall site access will be limited by a chain-link fence around the site, a post-treatment security fence will be installed around the completed mix area. A minimum of a 12-foot clearance between the fencing and edge of containment for the treatment area will be maintained to allow for navigation around the perimeter and an access gate of at least a 12-foot width (two 6-foot gates) will be installed. Warning signs in English and Spanish will be posted on the fence indicating that entry is restricted.

3.2.9 Performance Monitoring

Post-mixing sampling and analysis of soil and groundwater will be performed to monitor remediation progress.

3.2.9.1 Post-Mixing Groundwater Monitoring

Groundwater sampling of two temporary performance wells located within the treatment area will be performed to monitor the changes in the groundwater concentrations over time following soil mixing activities. Groundwater sampling will be performed on the same schedule as soil sampling at 1 month, 6 months, and 12 months following mixing activities and samples will be analyzed for VOCs and various MNA parameters. The two wells will be installed during collection of the 1-month post-mixing soil samples using the direct-push method and will be subcontracted separately from the soil mixing activities.

3.2.9.2 Post-Mixing Soil Sampling

As discussed in Section 3.2.7, the baseline, or 0-month, sample will be collected during mixing activities. Subsequent soil samples will be conducted at approximately 1, 6, and

12 months after mixing activities are completed. The soil samples will be analyzed for VOCs by USEPA Method 8260B on a standard turnaround time.

The approximate sampling frequency will be one location per 1,000 yd^3 of mixed soil. Each location will have two samples collected, one within 1 foot of the bottom and one at mid-depth, and analyzed for VOCs by USEPA Method 8260B. It is assumed samples will be collected using a direct-push rig or similar equipment to obtain soil cores from the proper depth. It will be the responsibility of the subcontractor to determine methods and equipment necessary for accessing the mixed area for sample collection.

3.3 Enhanced In Situ Bioremediation

EISB using a soluble substrate is the selected remedy for dissolved-phase source zone groundwater remediation. The five source zones (EISB Drawing C-200) that were identified during previous investigations are targeted for EISB remediation.

An EISB pilot study was conducted during 2006 and 2007 in Source Zones 4 and 5 to evaluate the effectiveness of sodium lactate on the contaminant concentrations, as well as to evaluate the effectiveness of the injection well spacing and the designed injection system for delivering the substrate to the affected area. The results of the pilot study are detailed in the *Enhanced In-Situ Bioremediation Pilot Study Report* (CH2M HILL, 2008a) and are summarized in Table 3-4 below. The design for the full-scale EISB is based on the results of the pilot study.

Results of the pilot study indicated that where the injected amendments reached the monitoring wells, they were effective at enhancing naturally occurring reducing conditions to reduce TCE concentrations. Performance monitoring data clearly shows the arrival of substrate at Area 4 monitoring wells MW-527D, MW-514D, and MW-529D, and Area 5 monitoring wells MW-520D and MW-521D.

TABLE 3-4
Summary of TCE Reductions

Monitoring Well ID	Treatment Area	Injection Substrate	Total Injections	Baseline TCE Concentration (mg/L)	December TCE Concentration (mg/L)	Percent Reduction (%)
MW-527D	4	Sodium Lactate	4	0.63	<0.001	>99
MW-514D	4	Sodium Lactate	4	0.5	<0.001	>99
MW-529D	4	Sodium Lactate	4	0.099	<0.001	>99
MW-520D	5	Emulsified Oil	1	44.0	5.1	88
MW-521D	5	Emulsified Oil	1	1.1	<0.001	>99

Notes: mg/L = Milligrams per liter, TCE = Trichloroethene

3.3.1 Injection Design

Elevated groundwater VOC concentrations were identified during site investigation activities. Data indicated that the chlorinated parent compound TCE was released to the subsurface during manufacturing operations and created "source zones." Source zones are defined as parts of the aquifer that have particularly high dissolved-phase TCE concentrations, and which may have residual TCE DNAPL or high concentrations of adsorbed TCE that can continue to create and sustain dissolved-phase plumes. EISB is

effective for reducing dissolved-phase contamination in the identified source zones; however, EISB has not yet been shown as highly effective for directly remediating mobile DNAPL as present in the eastern portion of Source Zone 2 (described below). Therefore, this portion of Source Zone 2 will be remediated by ISSM.

Based on the investigations, five source zones were identified in the *Feasibility Study Report* (CH2M HILL, 2006b) as shown in EISB Drawing C-200 and discussed below.

3.3.1.1 Source Zone 1

Source Zone 1 is approximately 18,000 ft^2 located near the northern wall of the OMC Plant 2 building near the former chip wringer. During investigation activities, light nonaqueous phase liquid (LNAPL) and high concentrations of TCE daughter products were detected in shallow and deep groundwater in the area. In addition, historical facility records indicate a 5,000-gallon TCE underground storage tank (UST) was present in this area. The depth to groundwater in Source Zone 1 is approximately 3 feet bgs with a total aquifer thickness of approximately 26 feet.

3.3.1.2 Source Zone 2

Source Zone 2 is approximately 44,000 ft^2 and is located at the eastern extent of the former metal working area and immediately west of the TCE DNAPL area. During investigation activities, elevated concentrations of TCE and daughter products were detected in shallow and deep groundwater in this area. Historical facility records indicate at least one solvent degreaser and a paint room were present in this area. The depth to groundwater in Source Zone 2 is approximately 3 feet bgs with a total aquifer thickness of approximately 28 feet.

3.3.1.3 Source Zone 3

Source Zone 3 is approximately 35,000 ft^2 and located at the northwest corner of the former Trim building. Historical records indicate this area housed the self-proclaimed world's largest solvent vapor parts degreaser. Investigation activities indicate the presence of TCE and daughter products in shallow and deep groundwater in this zone. The depth to groundwater in Source Zone 3 is approximately 3 feet bgs with an aquifer.

3.3.1.4 Source Zone 4

Source Zone 4 is approximately 18,000 ft^2 located south of the existing building in an unpaved grassy area east of the former corporate building. Investigation activities indicated the presence of TCE in shallow and deep groundwater in the area. Historical records indicate operations occurred in Source Zone 4 and the source of the TCE is unknown. Depth to water in the area is approximately 3 feet bgs with an aquifer thickness of approximately 25 feet.

3.3.1.5 Source Zone 5

Source Zone 5 is approximately 32,000 ft^2 and is located in the northwest area of the existing OMC plant. Investigation activities indicate the presence of TCE and daughter products primarily in the deep groundwater with lower concentrations in the shallow groundwater. The depth to groundwater in the area is approximately 7 feet below grade due to the elevated building floor with an aquifer thickness of approximately 30 feet.

3.3.2 Investigative Boreholes, Injection Well and Monitoring Well Design

3.3.2.1 Investigative Boreholes

Investigative boreholes will be advanced in the two areas on the site where DNAPL delineation has not yet been completed because of the presence of the building. In the TCE DNAPL area, located southwest of the in-situ soil mixing boundary, an estimated 6 boreholes will be required to delineate the extent of the DNAPL. These boreholes will be placed along the southwestern boundary of the current estimated extent of the soil mixing area, each at a distance of approximately 25 feet from the closest previous investigative borehole. In the case of DNAPL presence, additional boreholes will be pushed every 25 feet until the DNAPL area has been delineated, at which point the in-site soil mixing area will be finalized.

In the PCB DNAPL area, located near the MW-517 well nest, an estimated 10 boreholes will be advanced to find the source and extent of the DNAPL. These investigative boreholes will be completed during the EISB injection well installation. None of the current construction phases will be affected by the delineation of this DNAPL, and are therefore not dependent on the results. Further remedial action in this area will not be implemented until the delineation is complete

For each area boreholes will be advanced to the till layer and visually inspected for the presence of product. In addition, a groundwater grab sample will be collected and also inspected for a sheen or other signs of product.

3.3.2.2 Injection Wells

Injection and monitoring wells will be installed as part of the EISB RA component. Injection and monitoring well construction will be consistent for the multiple source zones.

Both shallow and deep injection wells will be constructed for the implementation of the EISB injection remediation efforts. Shallow and deep wells will be constructed with similar materials and methods, with the depth of completion as the only difference. Well construction materials will consist of 2-inch-diameter, Schedule 40, polyvinyl chloride (PVC) risers with 5-foot-long, 2-inch-diameter, 0.010-inch slot, continuously wire-wrapped stainless-steel screens. Injection wells are to be constructed as flush mounts with Schedule 40 PVC slip by female tread fittings and a male cleanout plug cap. EISB Drawing C-500 shows the details of the injection well design.

Shallow wells will be installed to a depth of 15 feet, with a 5-foot screened interval from 10 and 15 feet bgs. Deep wells will be installed to a depth of 1 foot above the till, which is estimated to be approximately 30 feet bgs, with a 5-foot screen.

3.3.2.3 Monitoring Wells

Both shallow and deep monitoring wells will be constructed with similar materials and methods. Well construction materials consist of 2-inch-diameter, Schedule 40 PVC risers with a 5-foot-long, 2-inch-diameter, 0.010-inch slot, Schedule 40 PVC screen. Monitoring wells are to be constructed as flush mounts with a compressive well cap. EISB Drawing C-500 shows the details of the monitoring well design.

3.3.2.4 Well Spacing

Injection and monitoring well layouts for each area were based on the 2007 groundwater VOC concentrations, gradients, and potentiometric surface configuration. Table 3-5 provides a summary of the injection well locations, deep and shallow well spacing, and size for each source zone. These data may be modified after the OMC Plant 2 building demolition. Revised zone dimensions and changes in groundwater flow will be reevaluated following building demolition and prior to EISB implementation through the existing monitoring wells.

TABLE 3-5
Summary of Injection Well Locations

Source Zone	Size (ft^2)	Length of Area (ft)	Depth	Number of Injection Rows	Spacing between Injection Rows	Spacing between Wells (ft)	Total wells	Hydraulic Gradient (ft/ft)	Hydraulic Conductivity (ft/day)
			Shallow	3	70	20	19	0.002	17.38
1	18,650	210	Deep	8	26	25	38	0.001	13.75
			Shallow	2	148	25	20	0.001	100.6
2	44,500	295	Deep	9	25	25	65	0.0008	10.86
			Shallow	4	94	22.5	22	0.002	53.57
3	34,800	252	Deep	10	24	25	56	0.001	11.1
			Shallow	1	NA	30	5	0.002	1.001
4	15,500	153	Deep	2	28	27.5	11	0.004	12.93
			Shallow	3	83	20	30	0.001	49.61
5	31,200	250	Deep	6	31	22.5	56	0.001	15.99
						Shallow	96		
						Deep	226		
						TOTAL	322		

In each source zone, both shallow and deep parts of the aquifer will be treated through EISB injections. Because the aquifer properties vary across source zones and by depth, each source zone will require rows of both shallow and deep injection wells at varying spacing, based on the aquifer properties in each source zone.

Based on the results of the pilot study as well as an individual analysis of each area, it was determined that well spacings ranging from 20 to 30 feet will be the most effective at delivering substrate for each zone. A varying number of rows of injection wells spaced between 23 feet to 153 feet in the shallow zone and 26 to 31 feet in the deep zone, will be placed in each source zone. Well and row spacings were calculated using the hydraulic gradients and hydraulic conductivities of the groundwater specific to the shallow and deep portions of the aquifer in each source zone as well as the porosity of the soil (0.3 percent). Injection well row design allows for a minimum hydraulic travel time of 9 months to a maximum travel time of 20 months, with the exception of Source Zone 4 where rows had been previously constructed to follow an estimated travel time between lines of injection wells of 2 years for the shallow wells and 3 years for the deep wells. These times are based on the anticipated groundwater flow rates in each zone. Details of the injection wells and

row spacing are presented in Table 3-5. Injection well and row layouts for Source Zones 1 through 5 are shown in EISB Drawings C-201 to C-205, respectively.

It is currently estimated that approximately 7,200 ft^2 of the area in Source Zone 2 (EISB Drawing C-202) has been identified for soil mixing with ZVI for remediation, although the actual southwestern boundary of the area that is targeted for mixing has not been fully delineated, as described in Section 3.2. The area that receives soil mixing, as well as the area directly south of the soil mixing part of Source Zone 2, will not be treated by EISB. The injection well rows and well spacing presented in Table 3-5 has been estimated on the current extent of the TCE DNAPL area. Following further delineation, the locations of rows of injection wells will be changed to accommodate the mixed area. It is assumed that complete delineation of this DNAPL area is expected to occur before installation of EISB injection wells.

The effects of soil mixing will alter the groundwater flow for both the shallow and deep aquifer in Source Zone 2 by changing the current southeastern flow to a southern flow once the groundwater encounters the impermeable mixed area. Because of this, the injection well rows have been oriented in an east to west direction instead of southwest to northeast to be perpendicular to the expected post-soil mixing groundwater flow direction.

Parts of Source Zone 3 (EISB Drawing C-203) are located beneath the existing OMC Plant 2 building, former Trim building, and existing Triax building. Approximately 30 percent of Source Zone 3 falls under the Triax building that is currently in use by the WCP groundwater treatment plant and, therefore, is not accessible. Injection wells slated for installation in the Triax building will be moved to an injection well row south of the Triax building to treat remaining VOCs migrating south of the Triax building. It is assumed that the OMC Plant 2 building and floor along with the former Trim building floor will be removed before installation of injection wells in Source Zone 3.

Source Zone 4 injection wells were installed in 2007 and were used for the pilot study that was completed in 2007. The existing injection well array in Source Zone 4 includes a total of 20 injection wells (5 shallow wells and 15 deep wells) arranged in 4 parallel rows (3 rows of deep wells and 1 row of shallow wells) (EISB Drawing C-204). The air sparge curtain is currently designed to be built through Source Zone 4 and will intersect the two southernmost rows of existing deep wells. Because it is assumed that the air sparge curtain will be installed before initiation of the EISB activities, the abandonment of the 10 wells in these bottom 2 rows is part of air curtain installation activities. These abandoned rows will be replaced by an additional row of deep wells along the northern boundary of Source Zone 4, following the same spacing as the already installed deep wells. It is estimated that the air sparging curtain will have a radius of influence of approximately 40 feet. Injection wells will be installed at a minimum of 40 feet north of the air sparging curtain and out of the expected radius of influence of the curtain.

3.3.2.5 Substrate Selection

A soluble substrate (for example, sodium lactate) was selected for EISB injection. This substrate was selected based on the results of the pilot study, where both sodium lactate and food-grade oil (Emulsified Oil Substrate [EOS®]) were compared for effectiveness in reducing contaminant levels. Although both were effective, sodium lactate, despite its higher injection frequency, was a more cost-effective option for long-term remediation.

Details of the selection process and results of the pilot study can be found in the document *Enhanced In-Situ Bioremediation Pilot Study Report* (CH2M HILL, 2008a). Sodium lactate substrate was used for estimating purposes. If needed, a supplemental nutrient and buffer reagent will be added to the injection solution to enhance the reductive dechlorination process and aid in maintaining the pH of the groundwater.

The total volume of substrate solution to be injected in both the shallow and deep wells in each source zone was calculated based on the volume of aquifer to be treated, injection well spacing, target organic carbon concentrations, and desired overlap. The substrate mass required was based on the greater of two factors:

1. Providing enough substrate to meet the equivalent demand set by the contaminant concentrations and by the biochemical factors in the groundwater for the shallow and deep zone in each area based on the composition of the substrate; or
2. Providing enough total organic carbon (TOC) in the injected solution to maintain a target TOC concentration of 50 mg/L in the groundwater.

Table 3-6 provides a summary of the volumes and weights of water, sodium lactate, and solution required for both shallow and deep wells in each source zone. Volumes and weights were based on contaminant concentrations, well spacing, and maintaining a target TOC.

3.3.3 Injection Implementation

3.3.3.1 Injection Frequency

During the pilot test, injections of sodium lactate every 90 days proved to be effective in maintaining elevated TOC concentrations in the treated source zones. Based on the results of the pilot test, injections in each source zone area will occur every 90 days for the first year. Injection frequency for the following 3 years will be based on analytical results of the quarterly EISB performance monitoring. Injections will be scheduled to maintain a groundwater TOC concentration of greater than 50 mg/L and maintain production of volatile fatty acids. It is estimated that after the 4 years of periodic injections, VOC concentrations in the groundwater will be below 1 mg/L, the concentration at which MNA will be capable of reducing VOC concentrations to final cleanup standards in a reasonable timeframe. If VOC concentrations in a zone decrease below 1 mg/L in less than 4 years, discontinuing injections in that zone will be evaluated. Should VOC concentrations in a source zone not meet preliminary remediation goals (PRGs) (set at 1 mg/L) within 4 years, the well spacing, substrate volumes, and site investigation data will be reviewed to evaluate options. Supplements such as trace nutrients or pH adjustments, could be added to the substrate if the effectiveness of substrate addition alone is not effective at reducing VOC concentrations. Addition of trace nutrients and/or pH adjustments has not been included in the specifications or cost estimate. For cost estimating purposes, it has been assumed that 16 injections will be performed over the 4-year design life.

3.3.3.2 Equipment

During the pilot study, injections had been implemented through the use of pumps and a mixing tank on a mobile trailer with an onsite potable water source. Water was continuously pumped from the potable source into a poly mix tank, which was located on the mobile trailer.

Substrate was manually added directly to the mix tank, and then the mixed water/substrate solution was discharged from the pipe outlet into an eight outlet manifold with individual flow meters, which were all piped to the well heads and into the injection wells. Valves were placed before each flow meter (as well as at other locations throughout the system) to cut off flow to a specific well when it had reached a specific volume without restricting flow to other wells.

During full-scale implementation, the process and equipment by which the substrate solution will be injected will not be specified, but will instead be decided by the chosen subcontractor. The subcontractor will be responsible for providing equipment that will deliver a specified volume of sodium lactate and a specified volume of water into each injection well, and will be capable of monitoring these volumes for each well. EISB Drawing G-400 shows the process flow diagram for the injection system.

3.3.3.3 Power

Limited power will be required for injection activities. In addition, the distance between injection areas makes supplying power to each area impractical. The injection subcontractor will instead be required to provide generators for their power needs. The only injection-specific equipment that will require power will be pumps for transferring water from the water source to the injection wells. Based on flow rates, it is assumed these pumps will be gasoline powered. There is a risk of the water and solution freezing prior to injection during cold weather injections. If this is a concern, the subcontractor will be responsible for providing a portable heat source for the mixing tank and sodium lactate and power required to operate the equipment.

3.3.3.4 Wastewater Collection and Disposal

It is not anticipated that wastewater will be generated during injection activities. Potable water will be used for mixing the substrate, and excess substrate and water solution can be injected into the injection wells. During injection activities, it is possible that groundwater may be collected following injection to examine the color or turbidity of the water. If groundwater is removed from a well, this water will be collected in a 55-gallon drum and labeled. For estimating purposes, it is assumed that the wastewater is nonhazardous and will be disposed of offsite. Disposal of the wastewater will be conducted following completion of the activities by the subcontractor.

3.3.3.5 RDW Disposal

It is anticipated that the wells will be installed using large diameter direct-push equipment. With the implementation of this drilling technology, it is assumed there will be no significant RDW production. Decontamination and well development water will be collected in either 55-gallon drums or a poly tank for handling as wastewater. Collected water will be sampled and disposed of offsite, with possible onsite treatment and reuse depending on sampling results.

TABLE 3-6
Substrate and Water Volume

	Area 1S	Area 1D	Area 2S	Area 2D	Area 3S	Area 3D	Area 4S	Area 4D	Area 5S	Area 5D
Number of wells installed	19	38	20	65	22	56	5	11	30	56
Spacing	20	25	22.5	22.5	22.5	25	30	27.5	20	22.5
Years of injection	4	4	4	4	4	4	4	4	4	4
Injections per year[a]	4	4	4	4	4	4	4	4	4	4
Total injections	16	16	16	16	16	16	16	16	16	16
Substrate (gal) total	5,776	20,672	6,080	35,360	6,688	30,464	1,520	5,984	9,120	30,464
Substrate (gal) per event	361	1,292	380	2,210	418	1,904	95	374	570	1,904
Substrate (gal) per well	19	34	19	34	19	34	19	34	19	34
Solution (gal) total[b]	367,080	1,059,136	713,760	2,104,960	647,680	1,505,280	224,440	404,712	1,083,600	999,488
Solution (gal/event)	22,943	66,196	44,610	131,560	40,480	94,080	14,028	25,295	67,725	62,468
Solution (gal) per well	1,208	1,742	2,231	2,024	1,840	1,680	2,806	2,300	2,258	1,116

Notes:
[a]Assumes injections every 90 days
[b]Assumes volume of water and substrate
gal = gallons

3.3.3.6 Materials

Sodium Lactate. Approximately 9,108 gallons of sodium lactate will be required for each injection event. The sodium lactate will be containerized in 55-gallon poly drums, with 4 drums per pallet. The subcontractor will be responsible for purchasing the sodium lactate and moving the sodium lactate from its delivery location to the injection locations. The sodium lactate will not be able to be stored onsite between injection events, and therefore, must be ordered prior to each event or stored by the subcontractor.

Water. Water will be obtained from a private hydrant located as shown on Figure 1-2. The hydrant will be installed as part of the RA by the facilities subcontractor. Potable water must be used for injection activities. Water will also be required for decontamination activities and final cleaning of the equipment. The water line installed will be capable of providing a flow of up to 350 gpm.

3.3.4 Performance Monitoring

3.3.4.1 Baseline Monitoring

Before injection in the five source zones, baseline groundwater conditions will be established to evaluate the progression of the effects of the EISB injections. Baseline samples will be collected by CH2M HILL from site-wide monitoring wells no greater than 90 days before injection. The wells will be sampled for the MNA monitoring parameters listed in Table 3-7 and two additional parameters:

- Volatile fatty acids (VFAs) by ion chromatography method
- Total organic carbon (TOC) by either method SW 9060 or EPA 400 Series

3.3.4.2 Post-Injection EISB Performance Monitoring

Groundwater samples will be collected quarterly for 4 years to monitor the performance of the EISB remedy. EISB will include an estimated 34 monitoring wells associated with the 5 source zones. Analytical parameters included as part of the quarterly EISB performance monitoring will be VFAs, VOCs, TOC, and field parameters.

After the first year of EISB injections and performance monitoring, the analytical results will be used to determine when additional injections are required. If TOC concentrations in source zone monitoring wells are below 50 mg/L and/or VFA concentrations have decreased, indicating the substrate has been exhausted, an additional injection will be performed.

Monitoring wells will be purged and sampled using low flow sampling techniques to remain consistent with the previous sampling techniques used at the site.

3.4 Performance Monitoring and MNA

Each component of the remedy has specific short-term performance monitoring requirements as summarized in Sections 3.1, 3.2, and 3.3 and the QAPP (Appendix B). After the initial short-term performance of each component is verified, a total of 68 monitoring wells on and offsite will be sampled annually to collect data on performance of the MNA remedy component. The 68 wells include the 34 wells that are part of the EISB performance

monitoring. Groundwater samples will be collected using low-flow methods and will be analyzed for the parameters presented in Table 3-7. Each year, one of the quarterly EISB performance monitoring events will overlap with the annual MNA monitoring event. During the overlap event, the EISB wells will also be sampled VFAs and TOC.

TABLE 3-7
List of Annual Groundwater MNA Monitoring Parameters

Parameter	Method
Water Level	Field measurement, taken using a water level indicator
Turbidity	Field measurement
Temperature	Field measurement.
Specific Conductance	Field measurement
Oxygen Reduction Potential (ORP)	Field measurement
Dissolved Oxygen (DO)	Field measurement
pH	Field measurement
Alkalinity	SM 2320-B or EPA 300 Series
Nitrate/Nitrite	SW 9056 or EPA 300 Series
VOCs	AOM01.1
Chloride	SW 846-9056 or EPA 300 Series
Arsenic	SW 846-6010B or ILM05.3
Ferrous Iron	SW 846-6010B or ILM05.3
Dissolved Manganese	SW 846 6010B or ILM05.3
Sulfate	EPA 300 Series
Sulfide	EPA 300 Series
Methane/Ethane/Ethene	RSK 175

Annual MNA monitoring data will be evaluated using the *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water* (USEPA, 1998). This annual groundwater monitoring identifies the data necessary to verify ongoing MNA of VOCs in groundwater, the fourth groundwater remedy component. The results of the MNA trend analysis will be presented as part of the five-year review process as described in Section 3.8.

3.5 Sustainability Evaluation

The use of sustainable remediation (that is, "green remediation") was considered for the implementation of the remedy without compromising the cleanup objectives of the site. Green remediation focuses on techniques that can be used to enhance the sustainability, or mitigate negative aspects of remedial alternatives that have been selected for further evaluation or that are already in operation.

For the air sparge system, a trailer-mounted mobile solar panel system was evaluated for meeting the power requirements of the air sparge equipment. Designed to operate with a combination of International Electrical Commission (IEC)-certified solar panels and dry cell batteries, one solar power system can continuously output approximately 14 kilowatts

(kWs) of power, even under minimal sunlight conditions. Sustainable advantages of using this system include the following:

- No waste generated; there are no air emissions or effluents produced.
- Solar energy provides a renewable energy source.
- Renewable materials are used in the manufacture of solar panels.

Use of a trailer-mounted solar panel system for application with a continuous demand air compressor is not considered feasible because of the following:

- Power requirements for a 40 to 50 horsepower air compressor range from 30 to 37 kWs. This does not account for power demand from the control panel and other ancillary equipment. A minimum of three solar power systems would be required to power the system.
- A large operational footprint would be required for the equipment building and solar power systems, which is not feasible for future development plans.
- The effectiveness of the solar power panels would be limited in the winter when covered by snow. A backup power source would be required to operate the air sparge equipment.

A rotary screw air compressor was originally proposed in the preliminary basis of design document. Follow-on discussions with an equipment vendor indicated that targeted air flow rates could be achieved using two lower horsepower rotary claw air blowers. Therefore, electric consumption will be reduced using the lower horsepower blowers. When operating, heat from the blowers will be used to minimize the need to operate a heater inside the equipment building during the winter.

For the soil mixing, the power needed to operate the slurry plant could be supplied by multiple generators; however, the use of onsite power results in lower carbon emissions. As a result, electricity will be installed near the TCE soil mixing area for use during soil mixing activities.

For EISB, the primary concern is the volume of RDW soil generated during well installation. If each monitoring well and injection well were to be installed using conventional hollow-stem auger drilling techniques, hundreds of cubic yards of RDW would be produced that would require offsite disposal in a landfill. By targeting well installation using large diameter direct-push equipment, little to no RDW soil is produced from well drilling. The availability of this equipment is limited to a few contractors across the country, so additional project costs and potential schedule delays will be weighed against the sustainability effect of RDW production.

Depending on the characteristics of the wastewater collected during construction of the air sparge curtain, and implementation of the soil mixing and installation of the EISB injection wells, onsite reuse may be possible. Also, dewatered material from air sparging implementation may be available for use during implementation of the soil mixing for construction of the containment berms or final cover. Its use will be based on the implementation schedule and the material's geotechnical and chemical conditions.

3.6 Health and Safety

A site-specific Health and Safety Plan (HASP) for construction activities that is in accordance with the Occupational Safety and Health Administration (OSHA) requirements listed in the 20 Code of Federal Regulations (CFR) 1910 and 1926 will be required. The selected subcontractors will also have site-specific HASPs that cover the specific activities that will be performed. In addition, the subcontractors will be required to conform with CH2M HILL's Behavior Based Loss Prevention Program. As part of this program, the subcontractors will be required to develop pre-task safety plans and activity hazard analyses and conduct safe work observations. It is assumed that work specified in this report will be conducted in Level D PPE. Although the soil mixing is anticipated to be performed in Level D PPE, inhalation is the mostly likely exposure pathway. Engineering controls will be use to mitigate the exposure; however, the subcontractor will be required to be trained and capable of performing in Level B PPE, if needed. Additional details specific to each component of the remedy are presented in Sections 2.1, 2.2, and 2.3.

3.7 Institutional Controls

The following institutional controls will be required for development on the OMC Plant 2 site:

- Maintenance of the groundwater use restrictions have been put in place by the City of Waukegan.
- Required sub-slab vapor controls for new foundations to prevent the migration of VOCs into structures.
- Required limits on future redevelopments to prevent construction of basements.

3.8 Five-Year Reviews

Data collected as part of the long-term monitoring program will be reviewed at five-year intervals to determine if human health and the environment continue to be protected or if additional remedial action is warranted.

SECTION 4

Compliance with ARARs

The *Supplemental Feasibility Study Report* identified the potential federal and state ARARs for DNAPL and groundwater remedy compliance. The list of the ARARS was refined based on the review of recent site data and specific components of this design project. The laws and regulations with unique aspects affecting the DNAPL and groundwater remedy are based on the specific components of the project and are discussed below.

4.1 Federal ARARs

4.1.1 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

CERCLA requires that the selected RAs meet the substantive requirements of all environmental rules and regulations that are ARARs unless a specific waiver of the requirement is granted. It is not anticipated that any ARAR waivers under CERCLA will be necessary. ARARs for the groundwater remedy at OMC Plant 2 are included below.

4.1.2 Safe Drinking Water Act (SDWA) – Maximum Contaminant Levels (MCLs)

CERCLA 121(d) states that all RAs are required to attain an MCL under the SDWA. MCLs are enforceable maximum permissible levels of a contaminant, which is delivered to any user of a public water system. The RAs performed at the OMC Plant 2, including the targeted injection and soil mixing actions, involve contaminants within drinking water sources; therefore, the MCLs listed under 40 CFR 141.61 (organic chemicals and arsenic) are considered relevant and appropriate. This is consistent with the RAOs presented in the USEPA ROD (dated February 2009).

4.1.3 Resource Conservation and Recovery Act (RCRA)

RCRA was passed in 1976 and amended the Solid Waste Disposal Act by including provisions for hazardous waste management, under 42 U.S. Code (USC) §321 et seq. RCRA controls the management of hazardous waste from inception to ultimate disposal. RCRA is linked closely with CERCLA, and the CERCLA list of hazardous substances includes all RCRA hazardous wastes. RCRA applies to all RAs that generate hazardous waste. The Illinois EPA has been given authorization to implement RCRA in Illinois. The parts of the IAC that are related to RCRA requirements are listed below.

4.1.3.1 Waste Disposal

IAC Title 35, Parts 720 to 729 addresses the hazardous waste disposal requirements under RCRA. The authority for implementation of RCRA in Illinois was given to the State of Illinois (Illinois EPA). ARARs required by the State of Illinois, which implement the RCRA requirements and standards, are listed below. The standards are applicable to hazardous waste generators, transporters, and operators or hazardous waste treatment storage and

disposal facilities. Although there is no documented evidence of disposal of listed hazardous waste at the OMC Plant 2 site, this ARAR is applicable for soil that will be generated as RDW. The soil cuttings generated during the installation of injection and monitoring wells may be a characteristic hazardous waste and will need to be disposed of offsite as a hazardous waste. This ARAR is not applicable for in situ treatment of the DNAPL soil due to the soil not being generated as RDW.

4.1.3.2 Hazardous Waste Operating Requirements

IAC Title 35, Part 721 is an ARAR for the requirements of identifying, listing, and managing hazardous waste. It states that soils must be managed as hazardous waste if they contain listed hazardous waste or are identified as characteristic hazardous waste. Management of treatment residuals may be subject to RCRA if residuals retain characteristics of hazardous waste. While there is no evidence of disposal of listed hazardous waste at the OMC Plant 2 site, soil excavated during the RAs for onsite ex situ treatment or for offsite disposal may be characteristic hazardous waste. Appropriate and necessary management of hazardous waste will be employed at all times during the RAs.

4.1.3.3 Standards Applicable for Generators of Hazardous Waste

IAC Title 35, Part 722 is an ARAR that establishes regulations in regards to activities of generators of hazardous waste. The RAs may generate RCRA hazardous waste, which would require transportation of the wastes off site and will subsequently adhere to the requirements under this part including, but are not limited to, identification number, record keeping, and use of uniform national manifest. As stated above, the soil will be generated as RDW.

4.1.3.4 Standards Applicable for Transporters of Hazardous Waste

IAC Title 35, Part 723 is an ARAR implementing requirements of the transport of hazardous waste, including the U.S. Department of Transportation (USDOT) regulations, manifests, record keeping, and discharge cleanup. Potential RCRA hazardous wastes will be transported off the OMC Plant 2 site during the RAs.

4.1.3.5 Use and Management of Containers

IAC Title 35, Part 724.270 to 724.279 provides the standards applicable for owners and operators of hazardous waste facilities that store containers of hazardous waste. This is an ARAR for the RAs due to the use of containers for storage of hazardous waste during the remediation activities.

4.1.3.6 Tank Systems

IAC Title 35, Part 724.290 to 724.300 addresses the standards applicable for owners and operators that use tank systems for storing and or treating hazardous waste. This is an ARAR for the RAs because of the potential use of tanks for treatment or storage of hazardous waste, derived from the RA such as liquids (that is, development or decontamination water) that exceed toxicity characteristic leaching procedure (TCLP) limits.

4.1.3.7 Special Provisions for Clean-up

IAC Title 35, Part 724.650 to 724.655 provides the applicable standards for corrective action management units (CAMUs), temporary units, or staging piles. This is an ARAR because

staging piles and or temporary units may be used for soil that is potentially characteristic hazardous waste during the RAs.

4.1.4 Land Disposal Restrictions

Under 40 CFR Part 268, requirements are provided detailing the treatment before land disposal for a wide range of hazardous wastes. This is an ARAR for the disposal of hazardous waste and is applicable to soils that are a characteristic hazardous waste. OMC Plant 2 RAs will involve the potential offsite disposal of characteristic hazardous waste. Contaminated soils must meet the higher of 10 times the universal treatment standard or a 99 percent reduction of the contaminant concentration.

The IAC also includes regulations dealing with land disposal restrictions. IAC Title 35, Part 728 identifies the land disposal restrictions and treatment requirements for materials subject to restrictions on land disposal. Waste-specific treatment standards must be met before disposal of the hazardous waste in a land disposal unit. This is an ARAR for the disposal of hazardous waste and is applicable to the RAs that have the potential to produce soils that are characteristic hazardous waste. The injection RA soil cutting activities will involve soil being generated. The soil during these activities will be generated as RDW. The universal treatment standard (non-wastewater) for TCE and vinyl chloride is 6.0 mg/kg, while the universal treatment standard (wastewater) for TCE is 0.054 mg/L and 0.27 mg/L for vinyl chloride. Contaminated soils must meet the higher of 10 times the universal treatment standard or a 90 percent reduction of the contaminant concentration.

4.1.4.1 Solid Waste and Special Waste Hauling

Under IAC Title 35, Parts 807 to 810, requirements are described for solid waste and special waste hauling. It states that special waste must be treated, stored, or disposed of at a facility permitted to manage special waste. The special waste classes and the method to determine whether the solid waste is a special waste, Class A (all non-Class B special wastes) or Class B (low or moderate hazard special wastes), are presented in these parts of IAC Title 35. RCRA hazardous waste is not included within the special waste classes. This is an ARAR for the disposal of solid waste and special waste resulting from the RAs. Contaminated soil from the RAs, which are not designated as a RCRA hazardous waste, would be required for evaluation to determine whether it is a Class A or B special waste. The potential offsite disposal of special waste must be conducted at a solid waste landfill permitted to receive that special waste class, unless the Illinois EPA specifically allows otherwise.

4.1.5 Coastal Zone Management Act

The Coastal Zone Management Act, under 16 USC §1451 et seq. and 15 CFR 930, states that all federal agency activities affecting any coastal use, resource, or zone will be conducted in a manner that is consistent, to the maximum extent possible, with the enforceable policies of approved management programs. The OMC Plant 2 RAs will be located entirely within the designated Illinois Coastal Zone area. However, although the Illinois Coastal Management Program has been drafted by the Illinois Department of Natural Resources and submitted for review, it has not yet been approved by the National Oceanic and Atmospheric Administration. Therefore, the Coastal Zone Management Act is not applicable to the OMC

Plant 2 RAs due to the fact that the Illinois Coastal Management Program is not, at this present time, an approved management program.

4.1.6 Endangered Species Act of 1973

The Endangered Species Act of 1973, 16 USC §1531 et seq. and 15 CFR 930, requires that federal agencies ensure that any action authorized, funded, or carried out by the agency is not likely to jeopardize the continued existence of any threatened or endangered species or destroy or adversely modify critical habitat. The piping plover is the only threatened or endangered (federal or state) bird species known to have nested in the beach area east of the OMC Plant 2 site. Discussions with the U.S. Fish and Wildlife Service and the City of Waukegan will be conducted relative to possible construction restrictions and minimizing impacts to endangered species (for example, the piping plover) in the vicinity of the site. Based on the location where the DNAPL and groundwater construction will be conducted (away from the dune areas east of the site), it is not anticipated that the critical habitats will be affected.

4.1.7 Clean Air Act

The Clean Air Act is intended to protect the quality of air and promote public health. Title I of the Act directed the USEPA to publish national ambient air quality standards (NAAQS) for "criteria pollutants." The NAAQS Section 109 provides specific requirements for air emission including, but not limited to, particulates, VOCs, and hazardous air pollutants. USEPA also has provided national emission standards for hazardous air pollutants under Title III of the Clean Air Act. Hazardous air pollutants are designated hazardous substances under CERCLA. The Clean Air Act amendments of 1990 greatly expanded the role of National Emission Standards for Hazardous Air Pollutants by designating 179 new hazardous air pollutants and directed the USEPA to attain maximum achievable control technology standards for emission sources. Such emission standards are potential ARARs for RAs producing air emissions or regulated hazardous air pollutants. Requirements for the Clean Air Act are under 40 CFR 50 to 99.

The Act is considered an ARAR for the RAs involving the creation of air emissions, such as excavation activities that have the potential of causing dust or treatment systems that may emit VOCs. IAC Title 35, Subtitle B: Air Pollution, discussed below, contains requirements that pertain to allowable emissions from construction activities. A plan to measure and mitigate air emissions during the RAs will be required as part of the site management plan. It has also been assumed that any new buildings placed on this property would be subject to institutional controls in the form of requirements for foundations to be designed to prevent indoor air inhalation risks from site VOCs (USEPA, 2009).

4.1.8 Hazardous Materials Transportation Act

The Hazardous Materials Transportation Act, under 49 CFR 100 to 109, provides requirements regarding the transportation of hazardous materials, specifically USDOT requirements for labeling, packaging, shipping papers, and transport, by rail, aircraft, vessel, and highway. This is an ARAR for the RAs resulting in offsite shipment of hazardous waste. All appropriate and necessary measures will be employed to adhere to the Act.

4.2 Environmental Regulations for the State of Illinois

4.2.1 Illinois Water Quality Standards (IWQS)

The State of Illinois requires that groundwater must meet the standards appropriate to the specific groundwater class specified in IAC Title 35, Part 620, Subpart D, Sections 620.401 through 620.440.

4.2.1.1 Class I – Potable Resource Groundwater

Most of the groundwater on the OMC Plant 2 site is designated as Class I potable resource groundwater due to its depth below the land surface being greater than 10 feet and its permeability being greater than 1×10^{-4} centimeters per second (cm/sec). This ARAR is required for all Class I potable resource groundwater, and all standards set forth in IAC Title 35, Parts 620.210 and 620.410, must be adhered to.

4.2.1.2 Class II – General Resource Groundwater

The remaining groundwater not designated as Class I on the OMC Plant 2 site, is classified as Class II general resource groundwater. Class II groundwater is applicable to groundwater that is compatible with agricultural, industrial, recreational, or beneficial uses, is not designated as Class I, III, or IV, and is 10 feet or less from the land surface. This ARAR is applicable to all groundwater on the OMC Plant 2 site that is within 10 feet of the surface.

4.2.2 Air Pollution

IAC Title 35, Subtitle B: Air Pollution is an ARAR for RAs that involve the creation of air emissions, such as excavation activities that may create dust or soil mixing activities that might emit VOCs. This ARAR contains all of the State of Illinois regulations of specific requirements that pertain to allowable emissions of criteria pollutants from a range of air contaminant source categories and processes. It also describes the permits and emission standards enacted to protect air quality. The ARARs listed below are provided within Subtitle B: Air Pollution and also apply to the activities during the RAs that result in air emissions. Substantive requirements for air emission control must be followed.

4.2.2.1 Visible and Particulate Matter Emissions

Regulations containing specific requirements that pertain to allowable emissions of fugitive particulate matter are provided in IAC Title 35, Part 212. Dust control will be implemented to control visible particulate emissions during construction activities including, but not limited to, bentonite mixing and excavation for soil mixing RA. A storage pile consisting of approximately 500 yd^3 of backfill from the initial excavation will have uncontrolled emissions of fugitive particulate matter, which will require the implementation of appropriate and necessary dust control mitigation measures.

4.2.2.2 Odors

IAC Title 35, Part 245 contains regulations that specify how nuisance odors are detected. An objectionable odor nuisance exists on or adjacent to industrial premises when odor is detectable in the ambient air after it is diluted with 24 volumes of odor-free air as measured

by the Scentometer. The potential for odors to meet these standards during the RAs is present. Appropriate and necessary odor control will be implemented if it is determined that a nuisance odor exists.

4.2.2.3 Organic Materials Emission Standards and Limitations for the Chicago Area (includes Lake County)

IAC Title 35, Part 218 has established the limit of VOC discharge from any emission unit at 8 pounds (lbs) per hour for the Chicago area, including Lake County where the OMC Plant 2 site is located. A discharge over that limit is prohibited. It would not be necessary to attempt recovery of the VOCs for treatment because the estimated daily discharge levels do not exceed daily or yearly discharge limits under IAC Title 35, Environmental Protection, Subtitle B: Air Pollution. It has also been assumed that any new buildings placed on this property would be subject to institutional controls in the form of requirements for foundations to be designed to prevent indoor air inhalation risks from site VOCs (USEPA, 2009).

4.2.2.4 Noise

IAC Title 35, Parts 900, 901, and 910 provide the regulations containing specific requirements that pertain to nuisance noise levels and the sound emission standards and limitations. The RAs that will occur on the OMC Plant 2 site could potentially create nuisance noise levels, and therefore, will adhere to all appropriate and necessary noise level controls.

4.2.2.5 General Provisions

IAC Title 35, Parts 730 to 738 provides a discussion of the underground injection control and UST programs and regulations of the Pollution Control Board. These regulations are an ARAR for the RAs involving the use of wells for underground injection of materials, in this case, sodium lactate and ZVI, to accelerate groundwater remediation. The injection RA will meet the substantive requirements of this ARAR, unless the requirements are waived by the State.

4.3 Watershed Development Ordinance

The Lake County Stormwater Management Commission implements the Watershed Development Ordinance to regulate specific performance standards for stormwater control. This is an ARAR for the RAs that disturb greater than 5,000 ft^2 of soil. The soil mixing activities will require stormwater controls because this RA will disturb approximately 7,200 total ft^2 with a potential for additional area. The regulations are provided on the official government Web site for Lake County, Illinois, under the Stormwater Management Commission: Floodplain/Stormwater/Wetlands Regulations: Watershed Development Ordinance (http://lakecountyil.gov/Stormwater/Documents/Regulatory/WDO%2011-18-08.pdf).

SECTION 5

Construction Schedule

A proposed construction schedule is presented in Appendix D.

SECTION 6

Cost Estimate

The cost estimates for implementation of the air sparging, ISSM, and EISB components are summarized in Table 6-1 with an accuracy of within plus 15 percent and minus 5 percent. These estimates are construction cost projections and do not include costs for long-term O&M of the air sparge system, annual groundwater monitoring to implement the fourth remedy component, MNA, construction oversight, or program management.

TABLE 6-1
Construction Cost Estimates

Alternative	Total Estimated Construction Cost[a]
Air Sparge Curtain – Equipment Fabrication	$ 98,146
Air Sparge Curtain – Directional Drilling	$ 345,398
Air Sparge Curtain – Site Work	$ 103,106
Enhanced In Situ Bioremediation – Drilling[b]	$ 1,073,834
Enhanced In Situ Bioremediation – Injections	$ 7,416,713
In Situ Soil Mixing[c, d]	$ 1,551,661
Facilities	$ 336,927

Notes:
[a]Cost includes CH2M HILL G&A and fee per contract
[b]Cost includes DNAPL investigative boreholes, and installation of ISSM performance monitoring wells
[c]Cost does not include the cost for DNAPL delineation, installation of performance monitoring wells or collection of performance soil and groundwater samples collected 1, 6, and 12 months following mixing.
[d]Cost includes $7/cy patent fee associated with soil mixing. Fee to be paid by Contractor directly to Colorado State University.

Detailed construction cost estimates for the seven subcontracts associated with air sparging, ISSM, and EISB are presented in Appendix A.

The cost estimates shown, along with resulting conclusions on project financial or economic feasibility or funding requirements, have been prepared for guidance in project evaluation and implementation from the information available at the time that the cost estimate was prepared. The final costs of the project and resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, and other variable factors. As a result, the final project costs will vary from the cost estimates presented herein. Because of these factors, project feasibility and funding needs must be carefully reviewed before specific financial decisions are made or project budgets are established to help ensure project evaluation and adequate funding.

SECTION 7

Biddability, Constructability, and Operability Review

Staff from CH2M HILL's affiliate CH2M HILL Constructors Inc. (CCI) reviewed the BODR and draft drawings and specifications with an emphasis on biddability and constructability. In addition, this BODR and drawings and specifications were reviewed by the project review team, and comments were incorporated, as appropriate. The review did not identify significant concerns.

An independent team of reviewers from CH2M HILL conducted a value engineering (VE) screening to assess health and safety, and environmental and technical elements of the design. Preliminary recommendations and comments resulting from the VE screening were discussed with the design team and the resulting recommendations were then presented to the designer for incorporation within the design or determined not feasible and removed from consideration.

SECTION 8

References

CH2M HILL. 2006a. *Remedial Investigation Report, OMC Plant 2, Waukegan, Illinois.* April.

CH2M HILL. 2006b. *Feasibility Study Report, OMC Plant 2, Waukegan, Illinois.* December.

CH2M HILL. 2008a. *Enhanced In Situ Bioremediation Pilot Study Report, OMC Plant 2, Waukegan, Illinois.* March.

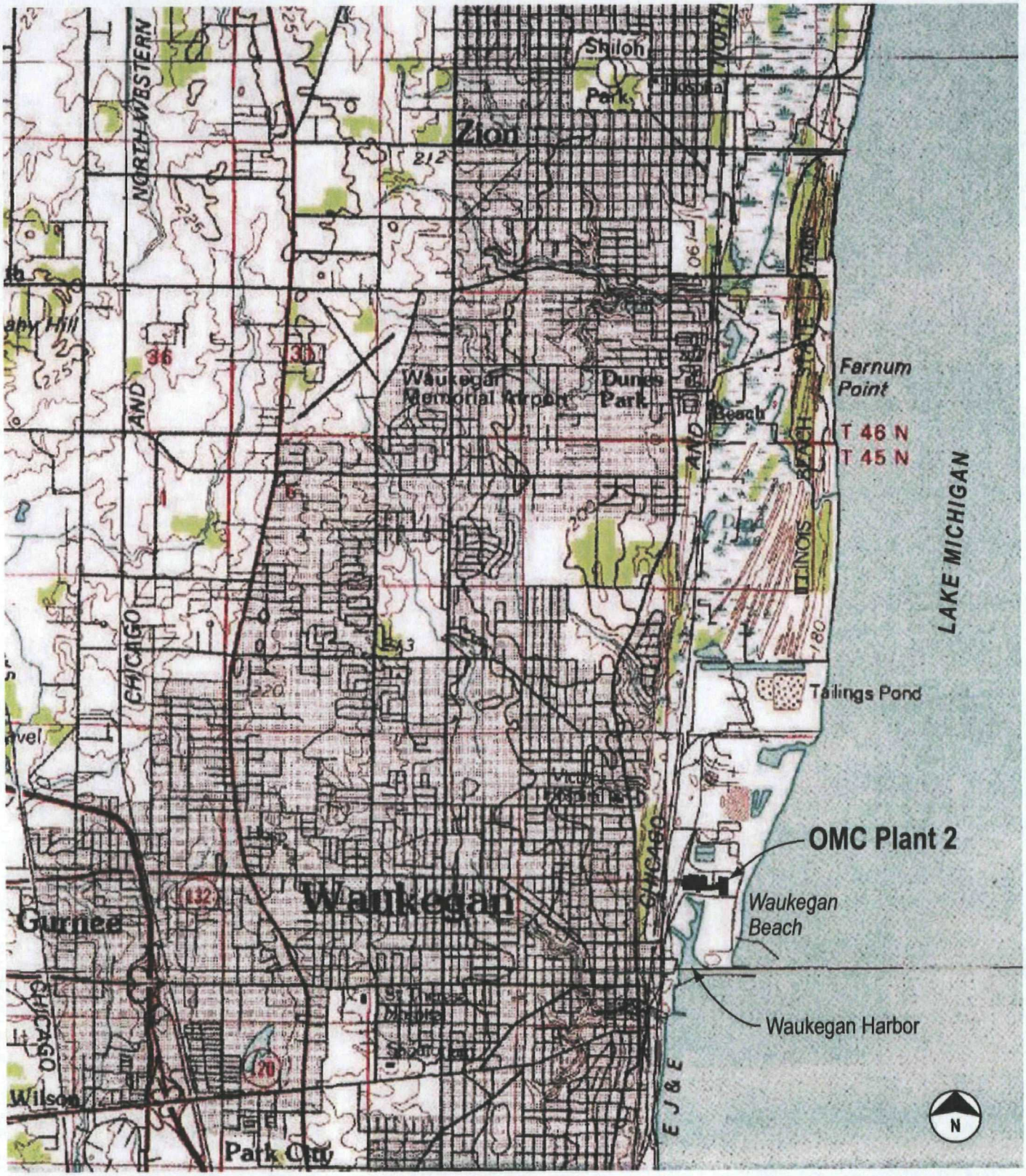
CH2M HILL. 2008b. *Supplemental Feasibility Study Report, OMC Plant 2, Waukegan, Illinois.* July.

U.S. Environmental Protection Agency. 1998. *Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water.*

U.S. Environmental Protection Agency. 2007. *Record of Decision, Selected Remedial Alternatives for the OMC Plant 2 Operable Unit (OU#4) of the Outboard Marine Corporation, Inc. Superfund Site, Waukegan, Lake County, Illinois.* April.

U.S. Environmental Protection Agency. 2009. *Record of Decision, Selected Remedial Alternatives for the OMC Plant 2 Operable Unit (OU#4) of the Outboard Marine Corporation, Inc. Superfund Site, Waukegan, Lake County, Illinois.* February.

Figures



SOURCE: USGS Waukegan Quadrangle Map

0 3,000
SCALE IN FEET

Figure 1-1
Site Location Map
OMC Plant 2

CH2MHILL

E082005021MKE 186305.RS.01 Site Loc Map_Mar06_4 3-29-06tl/jls

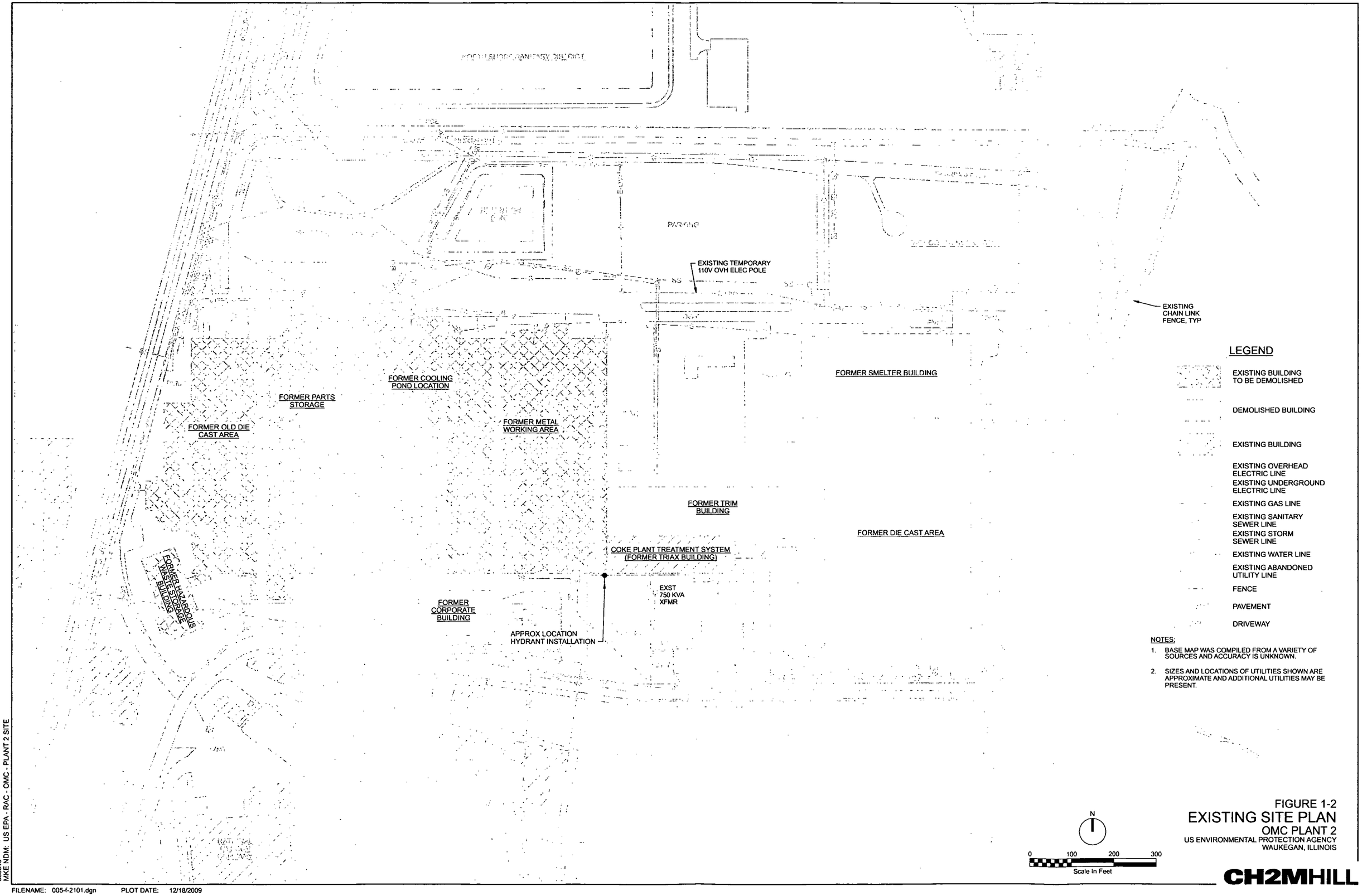


FIGURE 1-2
EXISTING SITE PLAN
OMC PLANT 2
US ENVIRONMENTAL PROTECTION AGENCY
WAUKEGAN, ILLINOIS

CH2MHILL

386543
MKE NDM: US EPA - RAC - OMC - PLANT 2 SITE

FILENAME: 005-f-2101.dgn PLOT DATE: 12/18/2009

Appendix A
Cost Estimate

Appendix B
Site-Specific Plans

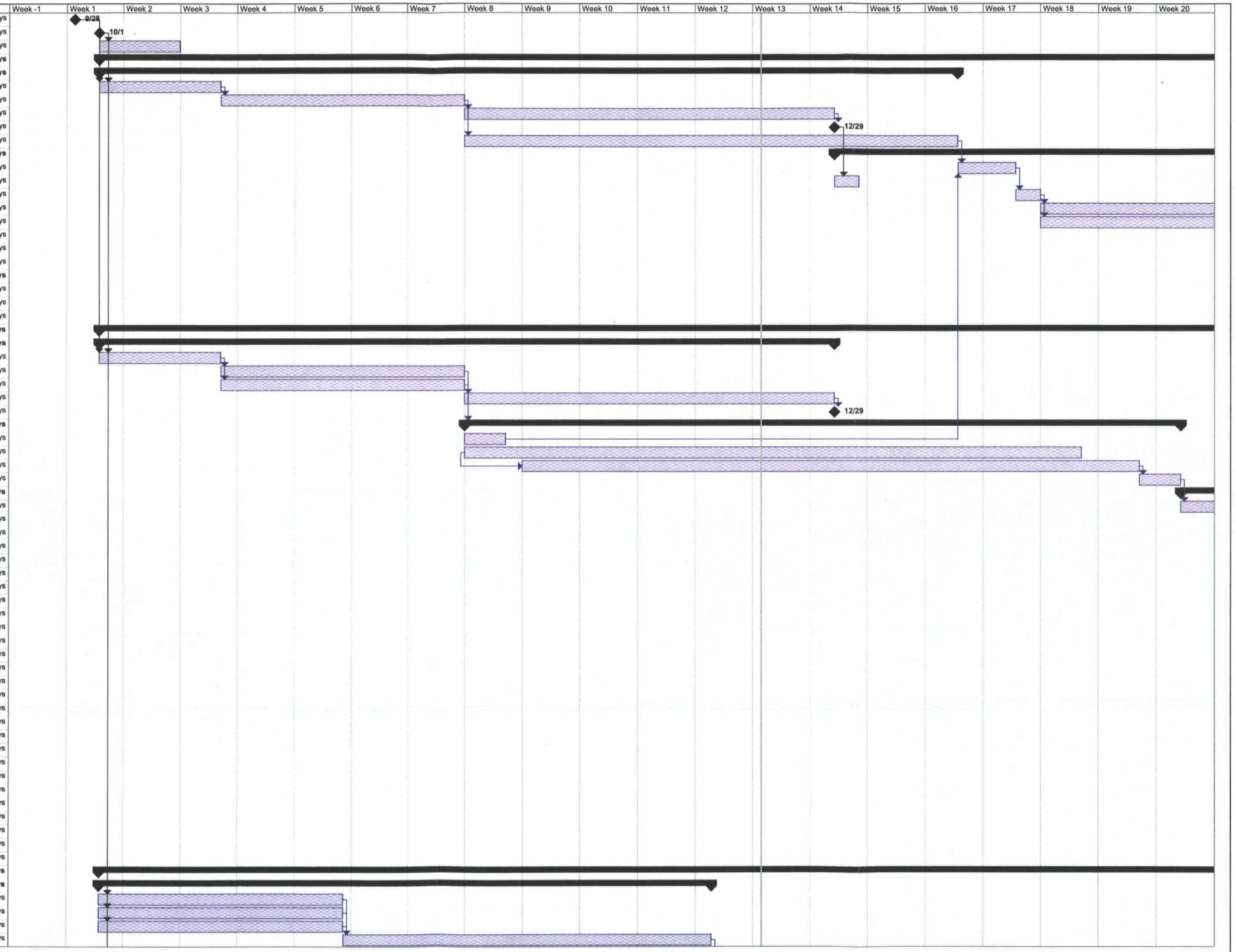
Due to size, Appendix B is provided digitally herein and bound as a separate hard copy submittal.

Appendix C
Design Specifications and Drawings

Due to size, the specifications and drawings are provided digitally herein and bound as a separate hard copy submittal.

Appendix D
Construction Schedule

ID	Task Name	Duration
1	Completion of Building Demolition, Soil Delineation, and Well Abandonment	0 days
2	Remedial Action Work Plan Approval	0 days
3	Finalize Underground Injection (UIC) Permit	10 days
4	**In-Situ Soil Mixing**	**510 days**
5	**Preparation for Work**	**105 days**
6	Update design with DNAPL delineation information	15 days
7	Bid to Potential Subcontractors - Soil Mixing	30 days
8	Finalize Subcontract	45 days
9	Award Bid - Notice Proceed	0 days
10	Coordinated electrical demand to Commonwealth Edison	60 days
11	**Implementation**	**88 days**
12	Soil Mixing Subcontractor Mobilization and Set-Up	7 days
13	Borrow Source Confirmation Sampling	3 days
14	Soil Berm Construction and Establish Erosion Control Measures	3 days
15	In-Situ Soil Mixing	27 days
16	QA/QC Soil Sampling and Baseline Soil Sampling (T=0)	27 days
17	Backfill and Geotextile Placement	17 days
18	Fence Installation	14 days
19	Demobilization	5 days
20	**Post Mixing Sampling Activities**	**338 days**
21	Post- Mixing Soil and Groundwater Sampling (T=1-month)	5 days
22	Post-Mixing Soil and Groundwater Sampling (T=6-month)	3 days
23	Post-Mixing Soil and Groundwater Sampling (T=12-month)	3 days
24	**EISB**	**1566 days**
25	**Preparation for Work**	**90 days**
26	Update design	15 days
27	Bid to Potential Subcontractors - Well installation	30 days
28	Bid to Potential Subcontractors - Injection	30 days
29	Finalize Subcontract	45 days
30	Award Bid - Notice Proceed	0 days
31	**Implementation**	**87 days**
32	TCE/PCB DNAPL plume investigation boreholes	5 days
33	Well Installation (assumes 4 wells per day)	75 days
34	Well Development (assumes 4 wells per day)	75 days
35	Demobilization	5 days
36	**Begin Injection and Sampling**	**1434 days**
37	Baseline Sampling (Round 1)	14 days
38	Year 1 First Injection	40 days
39	Quarterly Post-Injection Sampling (Round 2)	14 days
40	Year 1 Second Injection (2nd Injection)	40 days
41	Quarterly Post-Injection Sampling (Round 3)	414 days
42	Year 1 Third Injection (3rd injection)	40 days
43	Quarterly Post-Injection Sampling (Round 4)	14 days
44	Year 1 Fourth Injection (4th injection)	40 days
45	Year 1 Summary	0 days
46	Year 2 First Injection (5th injection)	40 days
47	Annual Post-Injection Sampling (Round 5)	14 days
48	Year 2 Second Injection (6th injection)	40 days
49	Year 2 Third Injection (7th injection)	40 days
50	Year 2 Fourth Injection (8th injection)	40 days
51	Year 2 Summary	0 days
52	Year 3 First Injection (9th injection)	40 days
53	Annual Post-Injection Sampling (Round 6)	14 days
54	Year 3 Second Injection (10th injection)	40 days
55	Year 3 Third Injection (11th injection)	40 days
56	Year 3 Fourth Injection (12th injection)	40 days
57	Year 3 Summary	0 days
58	Year 4 First Injection (13th injection)	40 days
59	Annual Post-Injection Sampling (Round 7)	14 days
60	Year 4 Second Injection (14th injection)	40 days
61	Year 4 Third Injection (14th injection)	40 days
62	Year 4 Fourth Injection (15 injection)	40 days
63	Year 4 Summary	0 days
64	**Air Sparge Curtain Installation**	**244 days**
65	**Preparation for Work**	**75 days**
66	Bid to Potential Subcontractors - Equipment Fabrication	30 days
67	Bid to Potential Subcontractors - Directional Drilling	30 days
68	Bid to Potential Subcontractors - Site Work	30 days
69	Finalize Subcontracts	45 days



Project: OMC Groundwater Remedial A
Date: Mon 12/21/09

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline