United States Environmental Protection Agency

EPA 540-R-013-017
May 2013
Office of Solid Waste and Emergency Response
Office of Superfund Remediation and
Technology Innovation

Optimization Review
Hastings Ground Water Contamination Site
Second Street Subsite Operable Units #12 and #20

Hastings, Adams County, Nebraska

OPTIMIZATION REVIEW

HASTINGS GROUND WATER CONTAMINATION SITE
SECOND STREET SUBSITE OPERABLE UNITS #12 AND #20
HASTINGS, ADAMS COUNTY, NEBRASKA

Report of the Optimization Review
Site Visit Conducted at the Hastings Ground Water Contamination Site
Second Street Subsite, Operable Units #12 and #20 on March 21, 2012

FINAL REPORT
May 15, 2013

EXECUTIVE SUMMARY

Optimization Background

U.S. Environmental Protection Agency's (EPA) definition of optimization is as follows:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness."* [1]

An optimization review considers the goals of the remedy, available site data, the conceptual site model (CSM), remedy performance, protectiveness, cost-effectiveness, and the closure strategy. A strong interest in sustainability has also developed in the private sector and within federal, state, and municipal governments. Consistent with this interest, optimization now routinely considers green remediation and environmental footprint reduction during optimization reviews. An optimization review includes reviewing site documents, interviewing site stakeholders, potentially visiting the site for 1 day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness
- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed before the recommendation can be implemented. Note that the recommendations are based on an independent review and represent the opinions of the review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

---

[1] U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28, 2012.

Site-Specific Background

The Second Street Subsite is one of the seven subsites that constitute the Hastings Groundwater Contamination Site. The site is located primarily in Adams County, Nebraska, and covers the central industrial area of the City of Hastings and adjacent area outside of the city limits. The Second Street Subsite lies on the eastern edge of the downtown Hastings business area. The current owner of the property is the City of Hastings.

The Second Street Subsite is a former manufactured gas plant (FMGP); benzene, toluene, ethylbenzene, xylenes (collectively referred to as BTEX) and polynuclear aromatic hydrocarbons (PAHs) have been detected in the Second Street Subsite soil and groundwater, indicating that wastes remaining from the FMGP have contaminated the soil and groundwater. The Second Street Subsite has been divided into two operable units (OUs): (1) OU 12 addresses the contaminated soils and source materials at the subsite, and (2) OU 20 addresses the contaminated groundwater that extends from the source area and has migrated beyond the boundaries of the Second Street Subsite.

Summary of Conceptual Site Model

Manufactured gas plant (MGP) residuals released at the surface or in the shallow subsurface from a FMGP located at 109 West Second Street have contaminated soil and groundwater at the site with BTEX and PAH compounds. Based on the dates of operation, some of the releases are more than 100 years old. Primary sources at the FMGP include two gas holders, a retort area and a suspected spill area. Typical MGP residuals would have included coal tar, which is a dense non-aqueous liquid (DNAPL) that sinks in groundwater. Contaminants released from these source areas seeped downward through 120 feet of vadose zone soils and into the upper 20 to 30 feet of the saturated zone, leaving behind adsorbed phase MGP residuals at the source areas and a dissolved phase groundwater plume that extends more than 2,700 feet downgradient to the east-southeast in groundwater. As the plume migrates downgradient, it deepens to around 175 to 200 feet below ground surface (bgs) at the distal end (more than 2,700 feet downgradient). Benzene and naphthalene are highly mobile in groundwater compared with the other contaminants of concern, are present in the full length of the contaminated groundwater plume, and are therefore the primary contaminants of concern.

Immediately downgradient of the FMGP site is another contaminant source at the Foote Oil site. Petroleum contamination from Foote Oil includes BTEX and PAH that comingle with and are indistinguishable from the same constituents in the FMGP site contaminant plume. The Foote Oil contaminants also include 1,2-dichloroethane (1,2-DCA) and ethylene dibromide (EDB) compounds, which are unique to the Foote Oil plume and are not associated with the FMGP plume. An additional contaminant source upgradient and south of the FMGP site is the Colorado Avenue Subsite. Chlorinated solvent contamination from the Colorado Avenue Subsite includes chlorinated volatile organic compounds (CVOCs) that also comingle with but are distinguishable from the FMGP plume.

The geology consists of relatively permeable aeolian fine-grained sediments (primarily silts and sands) that are underlain by coarser, saturated fluvial sediments. Both the aeolian and fluvial deposits coarsen with depth. The linear groundwater flow velocity in the aquifer is estimated to range from 500 feet/year to more than 700 feet/yr. Therefore, the results of remedial activities in the source areas can be apparent in downgradient locations within a few years.

Remediation of the FMGP source area soil includes a soil vapor extraction (SVE) system that has operated since 1997 and excavation and thermal treatment of shallow vadose zone soils (0 to 20 feet bgs) in 2011. Remediation of source area groundwater includes a groundwater pump and treatment (P&T) system that has been operational since 1997. Remediation of downgradient groundwater includes a combination of in-well stripping (since 2001) and in situ bioremediation (since 2005) at locations 700, 1,350 and 1,750 feet downgradient of the source area.

Summary of Findings

- The SVE system has removed a substantial amount of BTEX and naphthalene contamination from the vadose zone since 1997 and may be partially responsible for declining concentrations in the source area groundwater extraction well.

- The P&T system operates with less than 40 percent up time, and as a result the system is likely not effectively controlling the remaining source area.

- The two operating extraction wells (MW-09 and EXW-3) likely do not provide adequate horizontal coverage to control the source area, even if they were operating continuously.

- Formerly operated extraction wells EXW-1 and EXW-2 may be too deep to capture the BTEX and naphthalene concentrations detected in piezometer PZ-1.

- The optimization team has several concerns regarding the proposed In Situ Chemical Oxidation (ISCO) remedy, including the following:
  - An overestimated radius of influence of the injections, which would leave large volumes of the vadose zone untreated
  - An underestimate of the oxidant demand required, which would result in significant residual contamination after implementation
  - Potential to mobilize contamination in a source zone that is not hydraulically controlled

- The multiple source areas, relatively fast transport times, various source area, and downgradient remedies, variation in operation effectiveness of these remedies, and other remedy-specific factors make it difficult to evaluate the performance of each remedy component.

Summary of Recommendations

Recommendations are provided to improve the effectiveness of the remedy, provide technical improvement, and assist with accelerating site closure. The recommendations in these areas are as follows:

Improving effectiveness – Evaluate hydraulic control of the source area, install and operate additional extraction wells as needed to provide hydraulic control, and reduce system downtime.

Reducing cost – None provided.

Technical improvement – Improve reporting of routine monitoring.

Site closure – Pursue hydraulic control of the source area, evaluate monitored natural attenuation (MNA) for the downgradient plume, enhance the SVE system to treat the vadose zone source material, and consider ISCO for addressing saturated zone source material.

NOTICE

Work described in this document was performed by Tetra Tech GEO for the U.S. Environmental Protection Agency (EPA). Work conducted by Tetra Tech GEO, including preparation of this report, was performed under Work Assignment 2-48 of EPA contract EP-W-07-078 with Tetra Tech EM Inc. in Chicago, Illinois. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

PREFACE

This report was prepared as part of a national strategy to expand Superfund optimization from remedial investigation to site completion implemented by the U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI)[2]. The project contacts are as follows:

Organization	Key Contact	Contact Information
EPA Office of Superfund Remediation and Technology Innovation (OSRTI)	Jennifer Edwards	U.S. Environmental Protection Agency Technology Innovation and Field Services Division 1200 Pennsylvania Ave., NW (5204P) Washington, DC 20460 edwards.jennifer@epa.gov phone: 703-603-8762
Tetra Tech EM Inc. (Contractor to the EPA)	Therese Gioia Doug Sutton, PhD, P.E.	Tetra Tech EM Inc. 1881 Campus Commons Drive, Suite 200 Reston, VA 20191 therese.gioia@tetratech.com phone: 815-923-2368 Tetra Tech 2 Paragon Way Freehold, NJ 07728 phone: 732-409-0344 doug.sutton@tetratech.com

[2] U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28, 2012.

LIST OF ACRONYMS AND ABBREVIATIONS

µg/L	Micrograms per liter
ARARs	Applicable or relevant and appropriate requirements
bgs	Below ground surface
BMP	Best management practice
BNRR	Burlington Northern Railroad
BNSF	Burlington Northern Santa Fe Railway
BTEX	Benzene, toluene, ethylbenzene, xylenes
BVSPC	Black & Veach Special Projects Corp.
C	Celsius
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	Cubic feet per minute
COC	Chemical of concern
CLP	Contract Laboratory Program
CSM	Conceptual site model
CVOC	Chlorinated volatile organic compounds
cy	Cubic yards
1,2-DCA	1,2-Dichloroethane
1,1-DCE	1,1-Dichlorothene
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved oxygen
DPE	Dual-phase extraction
EDB	Ethylene dibromide (1,2-Dibromoethane)
EQ	Equalization
EXW	Extraction well
FMGP	Former manufactured gas plant
FS	Feasibility study
GAC	Granular activated carbon
gal	Gallon
gpm	Gallons per minute
HWS	Hoskins-Western-Sonderegger, Inc.
IC	Institutional controls
ICA	Institutional control area
IP	Injection point
ISCO	In situ chemical oxidation
IWA	In-well aeration
IWS	In-well stripping
lbs	pounds
LTM	Long-term monitoring
MCL	Maximum contaminant level

MCLG	Maximum contaminant level goal
mg/kg	Milligrams per kilogram
mg/L	Milligram per liter
MK	Morrison Knudsen Corp
MNA	Monitored natural attenuation
MGP	Manufactured gas plant
MW	Monitoring well
NDEQ	Nebraska Department of Environmental Quality
NDOH	Nebraska Department of Health
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
ORC	Oxygen release compound
ORP	Oxidation reduction potential
OSRTI	Office of Superfund Remediation and Technology Innovation
OSWER	Office of Solid Waste and Emergency Response
OU	Operable unit
OWS	Oil/water separator
O&M	Operations and maintenance
PAHs	Polynuclear aromatic hydrocarbons
P&T	Pump and treat
PCE	Tetrachloroethylene (perchloroethylene)
PID	Photoionization detector
QAPP	Quality Assurance Project Plan
RA	Remedial Action
RAO	Remedial action objective
ROD	Record of Decision
ROI	Radius of influence
RSE	Remedial system evaluation
scfm	Standard cubic feet per minute
SSSA	Second Street Source Area
SVE	Soil vapor extraction
SVOC	Semivolatile organic compound
TCA	1,1,1-Trichloroethane
TCE	Trichloroethylene
TD	Thermal desorber
UPRR	Union Pacific Railroad
EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
UST	Underground storage tank
VOC	Volatile organic compound
VW	Vent well
yr	Year

TABLE OF CONTENTS

List of Tables

Attachments

1.0 INTRODUCTION

1.1 PURPOSE

During fiscal years 2000 and 2001, independent reviews called Remediation System Evaluations (RSEs) were conducted at 20 operating Fund-lead pump and treat (P&T) sites (those sites with P&T systems funded and managed by Superfund and the states). In light of the opportunities for system optimization that arose from those RSEs, the U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI) has incorporated RSEs into a larger post-construction complete strategy for Fund-lead remedies, as documented in *OSWER Directive No. 9283.1-25, Action Plan for Ground Water Remedy Optimization*. Concurrently, the EPA developed and applied the Triad Approach to optimize site characterization and development of a conceptual site model (CSM). The EPA has since expanded the definition of optimization to encompass investigation stage optimization using Triad Approach best management practices (BMP), optimization during design, and RSEs. The EPA's definition of optimizationis as follows:

> *"Efforts at any phase of the removal or remedial response to identify and implement specific actions that improve the effectiveness and cost-efficiency of that phase. Such actions may also improve the remedy's protectiveness and long-term implementation which may facilitate progress towards site completion. To identify these opportunities, regions may use a systematic site review by a team of independent technical experts, apply techniques or principles from Green Remediation or Triad, or apply other approaches to identify opportunities for greater efficiency and effectiveness."*[3]

As stated in the definition, optimization refers to a "systematic site review," indicating that the site as a whole is often considered in the review. Optimization can be applied to a specific aspect of the remedy (for example, focusing on long-term monitoring [LTM] optimization or on one particular operable unit [OU]), but other site or remedy components are still considered to the degree that they affect the focus of the optimization. An optimization review considers the goals of the remedy, available site data, the CSM, remedy performance, protectiveness, cost-effectiveness, and closure strategy. A strong interest in sustainability has also developed in the private sector and within federal, state, and municipal governments. Consistent with this interest, OSRTI has developed a Green Remediation Primer (www.cluin.org/greenremediation) and now routinely considers green remediation and environmental footprint reduction during optimization reviews. The optimization review includes reviewing site documents, potentially visiting the site for 1 day, and compiling a report that includes recommendations in the following categories:

- Protectiveness
- Cost-effectiveness

[1] U.S. Environmental Protection Agency (EPA). 2012. Memorandum: Transmittal of the *National Strategy to Expand Superfund Optimization Practices from Site Assessment to Site Completion*. From: James. E. Woolford, Director Office of Superfund Remediation and Technology Innovation. To: Superfund National Policy Managers (Regions 1 – 10). Office of Solid Waste and Emergency Response (OSWER) 9200.3-75. September 28, 2012.

- Technical improvement
- Site closure
- Environmental footprint reduction

The recommendations are intended to help the site team identify opportunities for improvements in these areas. In many cases, further analysis of a recommendation, beyond that provided in this report, may be needed before the recommendation can be implemented. Note that the recommendations are based on an independent evaluation and represent the opinions of the review team. These recommendations do not constitute requirements for future action, but rather are provided for consideration by the region and other site stakeholders. Also note that while the recommendations may provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and quality assurance project plans (QAPP).

The national optimization strategy includes a system for tracking consideration and implementation of the optimization recommendations and a provision for follow-up technical assistance from the optimization team as mutually agreed on by the site management team and the EPA OSRTI.

The Second Street Subsite is one of the seven subsites that constitute the Hastings Groundwater Contamination Site. The site is located primarily in Adams County, Nebraska, and covers the central industrial area of the City of Hastings and adjacent area outside of the city limits. The Second Street Subsite lies on the eastern edge of the downtown Hastings business area and is bounded by Second Street to the north, the former Union Pacific Railroad (UPRR) to the east, , Burlington Northern Santa Fe Railway (BNSF) right-of-way to the south, and Minnesota Avenue to the west. The current owner of the property is the City of Hastings.

Trichloroethene (TCE) and other chlorinated solvents were detected in the Hastings groundwater in 1983. The EPA began investigating sources of groundwater contamination in the Hastings area in 1984. Because of the high levels of volatile organic compounds (VOCs) found in three municipal wells, the EPA designated the contaminated area as the Hastings Groundwater Contamination Site and placed the site on the National Priorities List (NPL) in May 1986. The Second Street Subsite has been divided into two OUs: (1) OU 12 addresses the contaminated soils and source materials at the subsite, and (2) OU 20 addresses the contaminated groundwater that extends from the source area and has migrated beyond the Second Street Subsite boundaries. The Second Street Subsite is a former manufactured gas plant (FMGP); benzene, toluene, ethyl benzene, xylenes (collectively referred to as BTEX) and other VOCs (for example, styrene) and polynuclear aromatic hydrocarbons (PAHs) have been detected in the Second Street Subsite soil and groundwater, indicating that wastes remaining from the FMGP have contaminated the soil and groundwater.

1.2 TEAM COMPOSITION

The optimization team consisted of the following individuals:

Table 1-1. Optimization Team Members

Name	Affiliation	Phone	Email
Mike Noel*	Tetra Tech	262-792-1282	mike.noel@tetratech.com
Jennifer Abrahams*	Tetra Tech	916-853-4526	jennifer.abrahams@tetratech.com
Douglas Sutton	Tetra Tech	732-409-0344	Doug.sutton@tetratech.com

** Attended the site visit.*

Jennifer Edwards from the EPA OSRTI also attended the site visit.

1.3 DOCUMENTS REVIEWED

The following documents were reviewed. The reader is directed to these documents for additional site information that is not provided in this report.

- *Groundwater Report Hastings Groundwater Contamination Site; Hastings, Nebraska;* prepared by PRC Environmental Management, Inc.; April 1990.
- *Colorado Avenue Subsite Hydrogeology Letter Report*; prepared by PRC Environmental Management, Inc.; July 20, 1990.
- *Detailed Hydrogeologic Investigation of Hydrocarbon Contamination at Foote Oil, Foote Oil Company, Hastings, Nebraska;* prepared by HWS Consulting Group Inc. (HWS) for K&F Realty, May 1994.
- *Remedial Investigation Report for the Second Street Subsite*; prepared by Morrison Knudsen Corp. (MK), 1995.
- *Area Wide Remedial Investigation Report for Hastings Groundwater Contamination Site; Hastings, Nebraska;* prepared by Morrison Knudsen Corp; December 1996.
- *Construction Completion Report for the Second Street Subsite Operable Unit 12, Hastings Groundwater Contamination Site, Hastings, Nebraska*; prepared by (MK) for the EPA Region VII, March 1997.
- *Final Remedial Investigation Supplement, Second Street Subsite, Hastings, Nebraska*; prepared by BVSPC for the EPA Region VII, November 29, 2000.
- *Feasibility Study Report, Second Street Downgradient Plume*, submitted to the EPA by BVSPC, September 25, 2002.
- *Interim Record of Decision (ROD) Hastings Ground Water Contamination Site, Operable Unit 20, Hastings, Nebraska*; prepared by the EPA Region VII; July, 2003.
- *Operations and Maintenance Manual – Soil Gas and Ground Water Extraction and Treatment Systems (Revised); Second Street (Source Area) Subsite; Hastings, Nebraska*; prepared by BVSPC for the EPA Region VII, January 2006.
- *Feasibility Study for Second Street Subsite, Operable Unit 12*, submitted to the EPA by BVSPC, July 2006.
- *Record of Decision (ROD) Hastings Ground Water Contamination Site, Operable Unit 12, Hastings, Nebraska;* prepared by the EPA Region VII; September 21, 2006.
- *Operation & Functional Report, Operable Unit 20, Second Street Subsite, Hastings NPL Site, Hastings, Nebraska*, prepared by the EPA Region VII, dated February 5, 2007.
- *Draft Data Evaluation Report Appendix C, submitted to the EPA by BVSPC, March 2007*
- *Final Interim Remedial Action Report, Second Street Subsite, Operable Unit 20 – Groundwater, Hastings, Nebraska*; prepared by BVSPC for the EPA Region VII, Final dated May 2007.
- *Third Five-Year Review Report for Hastings Groundwater Contamination Site; Hastings, Nebraska*; prepared by the USACE for and signed by the EPA Region VII; July 2007.
- *Final DO Comparison Technical Memorandum, Second Street Subsite, Hastings, Nebraska*, submitted to the EPA by BVSPC, July 26, 2007.
- *Amendment to the Record of Decision; Second Street OU12: Hastings Ground Water Contamination Site; Hastings, Nebraska;* prepared and signed by the EPA Region VII; September 2008.
- *Remedial Action Basis of Design Report; Second Street Subsite Operable Unit 12, Hastings, Nebraska*, prepared by BVSPC for the EPA Region VII, September 2008.
- *Final Second Street Downgradient Plume Spring 2008 Downgradient Plume Data Evaluation Report*, submitted to the EPA by BVSPC, December 22, 2008.

- *Final Treatability Study Report, Second Street Subsite, Operable Unit 12,* submitted to the EPA by BVSPC, July, 2008.
- *City of Hastings Source Area Systems Operations Status Reports 2009 and 2010*; prepared by City of Hastings.
- *Consent Decree with City of Hastings; Second Street Subsite, Hastings Ground Water Contamination Site; Hastings, Nebraska*; prepared by the EPA Region VII; Signed June 29, 2010 (entered into court August 30, 2010).
- *Second Street Downgradient Plume 2010 Groundwater Mass Estimate* completed BVSPC for internal use, November 2, 2010.
- *Draft Second Street Downgradient Plume (OU20) Fall 2010 Groundwater Data Evaluation Report*, submitted to the EPA by BVSPC, July 2011.
- *Draft Second Street Downgradient Plume Spring 2011 Groundwater Data Evaluation Report*, submitted to the EPA by BVSPC, August 2, 2011.
- *Interim Remedial Action Report; Second Street Subsite Operable Unit 12 Excavation; Hastings Groundwater Superfund Site, Hastings, Nebraska;* prepared by the EPA Region VII; September 26, 2011.
- *Interim Remedial Action Report; Second Street Subsite Operable Unit 20 Phase II; Hastings Groundwater Superfund Site, Hastings, Nebraska;* prepared by the EPA Region VII; October 24, 2011.
- *NPDES Permit Number NE0132021 Summer 2011 Compliance Report; 2nd St (Hastings) OU20 LTRA; submitted to NDEQ (via the EPA) by BVSPC*, November 28, 2011.
- *Summary of SVE Operations, Hastings Second Street OU20;* provided to Tetra Tech by BVSPC via email dated June 7, 2012
- *Summary of groundwater Source Area P&T Operations, Hastings Second Street OU20;* provided to Tetra Tech by BVSPC via email dated June 8, 2012
- *2012 ICA Report*, Hastings Utilities, City of Hastings, NE, April 2013.

1.4 QUALITY ASSURANCE

This optimization review utilizes existing environmental data to interpret the CSM, evaluate remedy performance, and make recommendations to improve the remedy. The optimization team evaluates the quality of the existing data before the data are used for these purposes. The evaluation of data quality includes a brief review of how the data were collected and managed (where practical, the site QAPP is considered), the consistency of the data with other site data, and the use of the data in the optimization review. Data that are of suspect quality are either not used as part of the optimization review or are used with the quality concerns noted. Where appropriate, this report provides recommendations made to improve data quality.

1.5 PERSONS CONTACTED

A stakeholders meeting was held on March 21, 2012, at the Second Street Subsite in Hastings, Nebraska. In addition to the optimization team, the following persons were present for the stakeholders meeting:

Table 1-2. Persons Contacted

Name	Affiliation	Email Address
Brad Vann	EPA Region 7	vann.bradley@epa.gov
Tom Buell	NDEQ	thomas.buell@nebraska.gov
Scott Summerside	NDEQ	scott.summerside@nebraska.gov
Mike Felix	NDEQ	mike.felix@nebraska.gov
Marshall Claxton	Black & Veatch Special Projects Corp (BVSPC) (EPA contractor)	claxtonm@bv.com
Jeremy Groves	City of Hastings	jgroves@cityofhastings.org

The stakeholders meeting consisted of a tour of the Second Street Subsite, beginning at the source area and extending downgradient to tour the components of the existing groundwater remediation system. The entire group participated in the Second Street Subsite tour.

2.0 SITE BACKGROUND

2.1 LOCATION AND DESCRIPTION

The Hastings Ground Water Contamination Site is located in Adams and Clay Counties in Nebraska. The City of Hastings began taking public water supply wells out of service after contamination was discovered in wells located in old industrial areas along the Burlington Northern Railroad (BNRR) right-of-way. In 1983 the Nebraska Department of Health (NDOH) sampled the Hastings public water supply system in response to citizen complaints of foul taste and odor in the drinking water. That same year, the NDOH and the Nebraska Department of Environmental Quality (NDEQ) began investigating widespread groundwater contamination in the Hastings area. Eventually, three city-operated water supply wells were taken out of service and others were placed on standby status.

The Second Street Subsite is an FMGP, located immediately east of the Hastings downtown corridor and abuts the BNRR and the former Union Pacific Railroad (UPRR) right of way (Figure 1). The FMGP occupied an area consisting of one-half of a city block at the street address of 109 West Second Street. The local surface topography is relatively flat and the approximate elevation is 1,920 feet above mean sea level. The monitoring network for the Second Street Subsite plume of contaminated groundwater extends approximately 2,700 feet eastward from the FMGP.

2.2 SITE HISTORY

2.2.1 HISTORICAL LAND USE AND OPERATIONS

The Second Street Subsite originated from an FMGP, which operated from before the turn of the century until about 1931 (Figure 2, Attachment A). After natural gas became available, the plant was decommissioned and subsequently demolished. Residues from the gas manufacturing processes, commonly referred to as coal tar, were left on site and resulted in soil and groundwater contamination. The FMGP is considered to be the source area for the Second Street Subsite (Figure 3, Attachment A).

The contaminated groundwater plume at the Second Street Subsite extends east to southeastward from the source area and travels beneath commercial and residential areas for a distance of at least 2,700 feet (Figures 4 and 5, Attachment A). The groundwater plume contains contaminants that are typical of FMGP wastes, including; VOCs, specifically BTEX, and semivolatile organic compounds (SVOCs), specifically PAHs.

The City of Hastings is the current owner of the existing facilities located at the FMGP source area. These facilities include: the former City of Hastings Police Department building (occupied until 2001); the former county animal shelter (occupied until 2004); a power substation; and the facilities for the source area treatment component installed on the former UPRR property (now owned by the city). The city currently uses the buildings at the FMGP intermittently for storage and other purposes.

In addition to the Second Street Subsite, there are two areas of concern located near to FMGP: the Foote Oil Company Underground Storage Tank (UST) Site and the Colorado Avenue Subsite (Figure 3). The Foote Oil Company UST Site, located immediately to the east of the FMGP, contains contamination associated with underground gasoline storage tanks, VOCs, primarily BTEX, 1,2-dichloroethane (1,2-DCA) and 1,2-dibromoethane (EDB). Investigations identified the presence of gasoline contamination in the soil and in the groundwater monitoring wells installed on and near the Foote Oil Company property. Corrective actions implemented at the Foote Oil UST Site include a soil vapor extraction (SVE) system installed in 1999, a dual phase extraction (DPE) system installed in 2005 to address free product, and an air sparging system installed in 2009 to address contaminants in groundwater.

Several of the constituents in FMGP wastes (namely BTEX compounds) are the same contaminants found in refined petroleum products such as gasoline. To a limited degree, it has been possible to use 1,2-DCA and EDB as the indicator chemical for the Foote Oil UST Site contamination, as these compounds are not found in FMGP wastes. However, because of the location of the Foote Oil UST Site (immediately downgradient of the subsite), it is impossible to fully distinguish the Foote Oil UST Site groundwater plume from the Second Street Subsite groundwater plume. Therefore, in addition to the Second Street Subsite source area removal action and Foote Oil corrective actions, the EPA initiated a removal action for the combined downgradient plumes emanating from the two source areas. This removal action includes an in-well stripping and treatment system.

The Colorado Avenue Subsite, itself a subsite of the Hastings Ground Water Contamination Site, is located immediately south and 500 feet west of the Second Street Subsite (see Figure 3 in Attachment A). Soil and groundwater at the Colorado Avenue Subsite is contaminated by chlorinated VOCs, including TCE; 1,1,1-trichloroethane (TCA); tetrachloroethene (PCE); 1,2-DCA; and 1,1-dichloroethene (1,1-DCE). The northern boundary of the Colorado Avenue Subsite is generally considered to be the BNRR tracks. However, minor concentrations of chlorinated VOCs have been observed in some of the Second Street Subsite monitoring wells, including MW04, MW09, and several of the Foote Oil wells. It is likely that one possible source of the chlorinated VOCs in the Second Street wells is the Colorado Avenue Subsite. Remedial actions being implemented at this site include SVE and groundwater remediation by in-well stripping (IWS).

2.2.2 CHRONOLOGY OF ENFORCEMENT AND REMEDIAL ACTIVITIES

In 1988, the EPA installed a groundwater monitoring well (well MW09) in the UPRR right-of-way, which adjoins the eastern boundary of the FMGP property. A strong petroleum odor was noted during construction of this well. Although well MW09 had been intended to define the northern extent of the Colorado Avenue Subsite TCE plume, the presence of high concentrations of BTEX in the groundwater became the basis for initiating a remedial investigation of the FMGP property. In 1988 and 1989, styrene and PAH compounds were detected in the groundwater in addition to the BTEX contaminants. The five PAHs found at greatest concentrations were naphthalene, 2-methylnaphthalene, acenaphthylene, fluorine and phenanthrene. All of these contaminants are commonly associated with manufactured gas plan (MGP) wastes.

In 1993, the EPA installed three monitoring wells downgradient of the FMGP property and also sampled the Foote Oil UST Site monitoring wells. The presence of BTEX and PAHs in the soil and groundwater indicated that wastes from the FMGP operations had contaminated the soil and the groundwater at the Second Street Subsite. This subsite is divided into two OUs; OU12 encompasses the source materials and contaminated soils, and OU 20 encompasses the contaminated groundwater that emanates from the source and has migrated beyond the boundaries of the Second Street Subsite.

The EPA identified source area removal actions for the Second Street Source Area (SSSA) in 1995, which consisted of groundwater extraction and treatment and SVE. Both systems would use a catalytic oxidizer to thermally treat extracted groundwater and vapors. The systems began operation in early 1997.

The EPA and the city entered into an Administrative Order on Consent in 1996 that defined responsibilities for operation of the source area treatment systems (EPA 1996). The City of Hastings took over operation and maintenance (O&M) of the source area systems in mid-1999 and continues their O&M.

From 1997 to 2000, the EPA performed additional investigations and identified that the groundwater plume extended from the FMGP source area at least 2,700 feet east (to approximately Elm Avenue). Contamination from the Foote Oil UST Site commingled with the Second Street Subsite plume, and in 2001 a downgradient groundwater removal action of IWS was implemented approximately 700 feet east of the FMGP Source Area (near Pine Avenue). The IWS system uses a compressor to blow air into two specifically designed wells to separate VOCs from the groundwater. The VOCs are removed from the gaseous phase using granulated activated carbon (GAC).

In November 2000, the City of Hastings, through City Ordinance Number 3754, created the Institutional Control Area (ICA). The controls established by the ICA include requirements for well registration, limited water usage from existing wells, and periodic analysis. The city administers the ICA program and provides results of laboratory testing and related information to property owners. The ICA does nothing to limit the migration of the contaminated groundwater or restore this resource to a beneficial use. Based on the groundwater sampling associated with the ICA, the entire area currently affected by the Second Street groundwater plume is within the ICA. Site-related compounds are not detected above relevant cleanup criteria in the any of the ICA wells downgradient of the FMGP. However, constituents of concern from other OUs (for example, TCE) have been detected in ICA wells downgradient of the FMGP.

The EPA issued the interim Record of Decision (ROD) for OU20 in July 2003 (EPA 2003b), which identified the groundwater remedy to include the following components:

- Continued operation of the 1997 SSSA pump and treat and SVE systems;
- Continued operation of the 2001 Pine Avenue IWS system;
- Extraction of groundwater combined with treatment by GAC;
- In situ bioremediation treatment by adding oxygen into the remnant downgradient plume not addressed by other actions; and
- Long-term groundwater monitoring of the actions defined.

Two injection well "fences" (for a total of 14 injection wells) installed in 2005 are used to inject a slow oxygen release compound and spot treatment with slow oxygen release for remnants in the plume “tail.” The first oxygen release compound (ORC) injection was performed in November 2005. Additional in situ bioremediation treatment of the plume “tail” portion was performed using the passive in situ treatment by installing ORC socks in July 2006. Two additional injection wells were installed in 2011. Since 2005, annual injections and monitoring to assess the remediation progress continue.

The EPA issued the ROD for OU12 in September 2006 (EPA 2006), which included the following components to address VOC and SVOC contamination in the subsurface soils and fill at the FMGP:

- Removal by excavation of the shallow soils and source materials (upper vadose zone), followed by thermal treatment, and
- In situ chemical oxidation (ISCO) to address the contaminated soils and source materials in the lower vadose zone and saturated zone, which are inaccessible to excavation.

The EPA issued an amended ROD for OU12 in September, 2008 (EPA 2008), making a fundamental change to the scope of the remedial action to include groundwater remediation by (1) adding applicable or relevant and appropriate requirements for groundwater (ARARs), (2) adding groundwater remediation goals, (3) modifying the remediation goals for soils, (4) changing the remedial action goal for soils from a residential standard to an industrial standard, and (5) adding an institutional control to the selected remedy.

The major components of the 2008 amended remedy selected by the EPA for OU 12 include the following:

- Excavation of soils and source material in the upper vadose zone followed by thermal treatment as required for disposal;
- In situ chemical oxidation of soils and source material in the lower vadose zone, saturated zone, and groundwater, which are inaccessible to excavation; and
- Land use restrictions in the form of an environmental covenant consistent with the Nebraska Uniform Environmental Covenants Act to limit future use of the property.

In early April 2011, 4,383 cubic yards (cy) of shallow soils and source materials (upper vadose zone) at OU12 were excavated and transported to an off-site thermal desorber (TD) treatment unit.

2.3 EXISTING DATA AND INFORMATION

The information provided in this section is intended to represent data already available from existing site documents. Interpretation included in this section is generally interpretation from the document used to obtain the information. The optimization team's interpretation of these data is discussed in Sections 4.0 and 5.0 of this report.

2.3.1 GEOLOGY AND HYDROGEOLOGY

The Second Street Subsite is underlain by unconsolidated silts, clays, sands, and gravels of Pleistocene and Pliocene/Miocene ages. The Cretaceous Niobrara Formation, consisting of chalky shale, limestone and chalk, is the bedrock in this area. The boring for well OW-04D, located approximately 1,500 feet downgradient of the SSSA, encountered shale at a depth of 230 feet below ground surface (bgs).

The SSSA (FMGP) is underlain by up to 15 feet of fill composed of a silty/clay matrix that contains varying amounts of construction debris (bricks, concrete, asphalt, wood, metal, and wire). The natural unconsolidated material identified under the Second Street Subsite consists of aeolian fine-grained sediments (primarily silts and sands) that are underlain by coarser, saturated fluvial sediments. Both the aeolian and fluvial deposits coarsen with depth. Figure 6 (see Attachment A) provides a cross-section through the SSSA before any removal/remedial actions had been implemented at the SSSA.

The wind-deposited, fine-grained sediments extend to a depth of approximately 50 to 70 feet bgs and can be subdivided into three stratigraphic horizons: (1) an upper silty clay and/or clayey silt; (2) an intermediate clayey and sandy silt; and (3) a lower fine to very fine-grained sand and silty sand. The upper and intermediate horizons are loess; they are indistinguishable from each other in all the boreholes. The cumulative thickness of the upper two loess horizons varies from 20 to 50 feet, although in some boreholes it is as thick as 70 feet. The lower, wind-deposited horizon, consists primarily of very fine to fine-grained sand and silty sand. This deposit varies in thickness from 20 feet to approximately 50 feet thick.

The fluvial deposits underlying the aeolian deposits generally consist of (1) an upper poorly graded (well-sorted) fine to medium grained silty sand (78 percent sand and 22 percent silt) ranging in thickness from 21 to 44 feet, and (2) a lower well-graded (poorly sorted), medium to very coarse-grained, gravelly sand extending from approximately 80 to 90 feet bgs down to 225 feet bgs. These fluvial deposits may be up to 170 feet thick in the Hastings vicinity. These sands and occasional gravels have interbedded, thin clayey silt lenses.

Groundwater in the fluvial deposits constitutes a continuous zone of saturation underlying the entire Hastings Groundwater Contamination Site. The upper surface of the fluvial aquifer is the water table (approximately 120 to 130 feet bgs), and the lower surface of the fluvial aquifer is the top of the Cretaceous bedrock (approximately 230 feet bgs). The aquifer is considered unconfined, based on the location of the potentiometric surface relative to potential confining zones or layers, and the response of the aquifer to pumping. Representative groundwater flow characteristics at the Second Street Subsite consists of the following (MK, 1995): hydraulic conductivity of 250 feet/day; gradient of 0.002 foot/foot; porosity of 0.274; groundwater flow velocity of 1.2 to 1.5 feet/day for the upper saturated zone (120 to 150 feet bgs) and 1.8 to 2.1 feet/day for the lower saturated zone (greater than 150 feet); and a flow direction of east to southeast. Figures 7 and 8 (see Attachment A) present groundwater elevation contours for the upper and lower portions of the aquifer in the fall of 2011.

Recharge to the aquifer comes mainly from precipitation and subsurface inflow from the west. Most of the precipitation that falls in the area evaporates or is extracted by vegetation; however, a small portion percolates through the unconsolidated sediments and reaches the principal zone of saturation. The amount of this infiltration to the zone of saturation differs widely from time to time and place to place. Recharge from precipitation averages slightly less than 1.0 inch per year up to 2.0 inches per year.

Groundwater levels vary seasonally and regionally because of the large-scale agricultural and industrial pumping conducted east of Hastings. Based on water level data collected between 2006 and 2011, water levels at the distal (east) end of the plume vary seasonally by approximately 2 feet. U.S. Geological Survey (USGS) well 403415098202001, located approximately 2 miles east-southeast of the plume near the community college and golf course shows water levels increased approximately 11 feet from 1982 to 2000, decreased by 6 feet between 2000 and 2004, and then remained generally stable between 2004 and 2012. The net increase in the water table between 1982 and 2012 was 5 feet; however, this increase is the result of an increase of 11 feet that was partially offset by a subsequent decrease of 6 feet. It is unclear from the available data the degree that pumping or infiltration of precipitation affects these water level trends.

2.3.2 SOURCE AREA CHARACTERISTICS

The Second Street Subsite source area consists of contaminated soil in the vadose and saturated zones at the FMGP property. Contaminants include the presence of BTEX, other VOCs and PAHs. The maximum concentrations found in the source area soil for some of the Second Street Subsite contaminants are summarized in Table 2-1 (from Interim ROD, 2003).

Table 2-1. Contaminants and Maximum Detected Concentrations

Volatile Contaminants	Maximum Concentration	PAH Contaminants	Maximum Concentration
Benzene	257 mg/kg	Naphthalene	2300 mg/kg
Ethyl benzene	761 mg/kg	2 methylnaphthalene	7800 mg/kg
Toluene	757 mg/kg	Acenaphthalene	1200 mg/kg
Xylene	961 mg/kg	Phenanthrene	1700 mg/kg
Styrene	640 mg/kg	Pyrene	1100 mg/kg

Note: In addition to the PAHs listed above the following PAHs were found in soil samples at levels below 1,000 mg/kg and above 100 mg/kg: anthracene, fluoranthene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthrene, benzo(g h i)perylene, and indeno(l 2 3 cd)pyrene
mg/kg = Milligrams per kilogram

There are five primary source areas at the FMGP:

- Area 1: Potential Spill Area
- Area 2: Retort Area
- Area 3: South Gas Holder
- Area 4: North Gas Holder
- Area 5: Eastern Edge of the FMGP

These areas are shown on pre-2011 excavation Figure 9 (see Attachment A). Average BTEX and PAH concentrations for each of these areas is provided in Table 2-2 below for the upper vadose zone (0 to 20 feet bgs), lower vadose zone (20 to 120 feet bgs) and saturated zone (120 to 140 feet bgs) intervals. Results are from sampling conducted in 2003 to 2007 after SVE start-up in 1997 (BVSPC 2008).

Table 2-2. Average BTEX and PAH Concentrations (mg/kg) in Source Area Soils

	Area 1		Area 2		Area 3		Area 4		Area 5	
	BTEX	PAH	BTEX	PAH	BTEX	PAH	BTEX	PAH	BTEX	PAH
0-20 feet bgs	22	1,911	ND	ND	3.4	1,034	55	356	ND	ND
20-120 feet bgs	ND	ND	23	538	256	3,148	92	2,099	ND	ND
120-140 feet bgs	ND	ND	ND	48	72	1,142	160	1,999	48	1,328

The potential spill area (Area 1) contamination may have resulted from spillage of coal tar or waste materials generated from FMGP operations along the BNSF railroad tracks. The contamination in this area is primarily in the upper vadose zone from a depth of 0 to 20 feet bgs. The retort area (Area 2) has contaminated soils which were identified from about 20 feet bgs to 140 feet bgs (or about 20 feet below the groundwater table). The south gas holder (Area 3) contains source material (coal tar/oil waste). The former gas holder is approximately 43 feet in diameter, and the soil approximately 10 feet outside the walls of the former gas holder appears to be contaminated. Before it was excavated in 2011, the depth of the contents of the former gas holder had been estimated to be 15 feet bgs. Contamination from the former gas holder extends through the vadose zone and into the saturated zone. The north gas holder (Area 4) contains source material. The former gas holder is approximately 50 feet in diameter, and soil approximately 10 feet outside the walls of the former gas holder appears to be contaminated. The eastern edge of the FMGP property (Area 5) contains contaminated soils within the top 20 feet of the saturated zone. No soil contamination was detected in the vadose zone of Area 5, indicating that the contamination present in the saturated zone results from migration from upgradient within the saturated zone.

Based on the average concentrations and the volume of contaminated soil, the BTEX and PAH contaminant mass estimated by the site team before the excavation is provided in Table 2-3, below (BVSPC 2008).

Table 2-3. BTEX and PAH Contaminant Mass (pounds) in Source Area Soils

	Area 1		Area 2		Area 3		Area 4		Area 5	
	BTEX	PAH	BTEX	PAH	BTEX	PAH	BTEX	PAH	BTEX	PAH
0-20 feet bgs	132	11,435	-	-	8	2,560	184	1,192	-	-
20-120 feet bgs	-	-	228	5,326	4,212	51,796	2,047	46,695	-	-
120-140 feet	-	-	-	95	230	3,649	691	8,635	950	26,294
Total	132	11,435	228	5,421	4,450	58,005	2,922	56,522	950	26,294

As part of the OU12 remedial action conducted in May 2011, a total of 4,383 cy of shallow soils and source materials to a depth of 20 feet bgs were removed from the SSSA. During the removal, the Area 1 mass estimates were recalculated by averaging every sample result obtained for each lift from a cell and by multiplying the COC average by the mass of each lift. For Areas 3 and 4, the Table 2-3 estimates were recalculated based only on an increase in the volume of the materials actually removed from these areas in 2011. The amount of contaminant mass removed by this excavation activity was estimated to be 18,606 pounds (9.3 tons) (EPA 2011a). The amount of contaminant mass remaining at the SSSA is estimated to be 110,304 pounds (55.2 tons) in the lower vadose zone (20 to 120 feet bgs) and 40,545 pounds (20.3 tons) in the saturated zone (120 to 140 feet bgs) (BVSPC 2008).

2.3.3 CHARACTERISTICS OF THE GROUNDWATER PLUME

During operation of the FMGP, wastes containing BTEX and PAHs were disposed of or released on site. Additionally, gasoline components including BTEX and 1,2-DCA were released to the vadose zone from the nearby Foote Oil property. These contaminants have since migrated vertically into the deeper vadose zone and have entered the underlying aquifer. Once the contaminants entered the aquifer, they migrated primarily in the direction of groundwater flow, which is toward the east and more recently east-southeast. Figures 4 and 5 (see Attachment A) present the Second Street Subsite contaminated groundwater plume from the fall of 2010 for benzene (Figure 4) and naphthalene (Figure 5). These mobile constituents are representative of the entire length of the groundwater plume. Analytical results from monitoring wells for the Foote Oil LUST site investigation have been used to establish a better definition of the overall contaminant plume. A summary of the highest concentrations of selected contaminants found in groundwater samples before the source area groundwater removal action was initiated in January 1997 is provided in Table 2-4. The maximum contaminant levels (MCLs) pursuant to the Safe Drinking Water Act for public water supplies are provided for comparison purposes The MCLs represent levels that are considered safe for human consumption. ICA groundwater sampling delineates site contaminants to the east and east-southeast.

Table 2-4. Maximum Contaminant Concentrations in Groundwater

Compound	**Maximum concentrations (ug/L)**				**MCL (µg/L)**
	Western Plume	Eastern Plume	Western Well	Eastern Well	
Benzene	25,000	6,700	HWS 5	HWS 14	5
Toluene	28,000	2,500	HWS 2	HWS 14	1,000
Ethyl benzene	19,000	480	HWS 2	HWS 14	700
Xylenes	12,000	1,100	HWS 2	HWS 14	10,000
Naphthalene	24,000	12,000	MW 9	SW 14	1.1 (1)
1,2-DCA	1,700	970	HWS 5	SW 5S	5

Well locations reflect western/eastern plume areas Well HWS 14 is located east
Wells SW 5S and SW 51 are located east of Pine Avenue at California Avenue
The prefix "HWS" denotes wells installed as part of the Foote Oil Company UST site investigations
MCL Maximum Contaminant Levels (EPA Drinking Water Regulations)
(1) – The naphthalene cleanup level is risk based and was set in the 2008 Second Street Subsite ROD Amendment.
µg/L= Micrograms per liter

(Table from Interim ROD, 2003)

3.0 DESCRIPTION OF EXISTING REMEDIES

The information provided in this section is intended to represent information already available from existing site documents. Interpretation included in this section is generally from the document used to obtain the information. The optimization team's interpretation of this information and evaluation of remedy components are discussed in Sections 4.0 and 5.0 of this report.

3.1 RAOs and Standards

The 2003 Interim ROD Remedial Action Objectives (RAOs) for OU 20 downgradient groundwater are:

- To prevent further migration and further worsening of the downgradient plume;
- To remediate or contain the contaminated groundwater to reduce risk; and
- To provide a remedy which, when combined with a suitable remedy for the source area (OU 12), will achieve the long term objectives (1) to reduce the contaminant levels in the groundwater to levels less than the MCLs or maximum contaminant level goals (MCLGs), if they are greater than zero, or to state cleanup levels derived from Nebraska Title 118 regulations, or to levels where the excess cancer risk is computed as being less than one additional cancer per million persons of population (1×10^{6}) or where the hazard index is less than 1.0, so that the aquifer can be restored to its beneficial use, and (2) to prevent further degradation of the groundwater.

The 2008 ROD Amendment RAOs for OU 12 source area are:

- To reduce or prevent the accidental ingestion, inhalation, and direct dermal contact of contaminants of concern (COCs) in excess of risk-based standards for industrial settings through the excavation and treatment of shallow soils from the surface to 20 feet;
- To prevent further contaminant migration and degradation of the downgradient plume through the treatment of soils at depths greater than 20 feet and treatment of groundwater so that MCLs or risk-derived standards are not exceeded; and
- To restore groundwater to its beneficial use as a source of potable water through excavation and treatment of soil and treatment of groundwater so that MCLs or risk-derived standards are not exceeded.

3.2 Remedy and Remedy Components

The Second Street Subsite remedy consists of several remedy components (Figure 10, Attachment A) for each of the two OUs, as specified in the Interim ROD for OU 20 (EPA 2003), the ROD for OU 12 (EPA 2006), and the Amendment to the ROD for OU 12 (EPA 2008). OU 12 is the FMGP source area and OU 20 is the contaminated groundwater plume downgradient from the source area.

The OU 20 downgradient groundwater remedial action consists of the following components:

- Continued operation of the 1997 SSSA pump and treat and SVE systems;
- Continued operation of the 2001 Pine Avenue in-well stripping (IWS) system;

- In situ bioremediation treatment by adding oxygen into the remnant downgradient plume not addressed by other actions;
- Extraction of groundwater combined with treatment by GAC; and
- Long-term groundwater monitoring of the actions defined.

The fourth treatment component listed (extracted groundwater combined with treatment by granular activated carbon) has been postponed and will be implemented in the future only if needed.

The OU 12 source area remedial action consists of the following components:

- Excavation of soils and source material in the upper vadose zone followed by thermal treatment as required for disposal;
- In situ chemical oxidation of soils and source material in the lower vadose zone, saturated zone, and groundwater, which are inaccessible to excavation; and
- Land use restrictions in the form of an environmental covenant consistent with the Nebraska Uniform Environmental Covenants Act to limit future use of the property.

3.2.1 SOURCE AREA TREATMENT SYSTEM DESCRIPTION

In September 1995, the EPA issued a Removal Action Memorandum that formalized the first removal action for the subsite. The removal action selected for the vadose zone contamination was SVE followed by bio-venting. The general response action for groundwater was containment of the source area groundwater contamination at the eastern edge of the subsite. The technologies selected for groundwater were extraction, treatment, and discharge. Continued operation of these systems was incorporated into the 2003 Interim ROD for OU 20.

The layout of the SSSA groundwater extraction and treatment system and an SVE system as it was originally designed for operation is provided in Figure 11. The SSSA groundwater extraction and treatment system was installed in 1997 and is composed of the following major components:

- Groundwater extraction wells:
  - Two wells (EXW-1 and EXW-2) screened from approximately 135 to 155 feet bgs
  - One well (MW-9) screened from 120 to 140 feet bgs
  - One well (EXW-3) screened from 130 to 150 feet bgs was later added in 2007
- Perched water collection sumps in gas holder:
  - Two wells (PEW-1 and PEW-3) screened from approximately 5 to 15 feet bgs
- An oil-water separator (OWS) (later added in 1998 as pre-treatment for extraction well MW-9 as a result of the presence of heavy oil/tar in the pumped groundwater). Note, only well MW-9 is plumbed to the OWS; the other three wells are plumbed directly to the equalization (EQ) tank. The EQ tank components consist of an equalization tank, a transfer pump and a filter bag system. In 2004, the originally installed flat bottom EQ tank, which had a bottom discharge, was replaced with a cone-bottom side-discharge tank in an effort to retain more solids and reduce the frequency of fouling the filter bag system. This change was made to reduce changeouts and downtime. In another effort to reduce filter bag downtime, the single filter bag system was changed to a multi-bag system in 2006.
- An air stripper component (consisting of an air stripping tank/tower, an air stripper blower and a water transfer pump.)

- Liquid phase GAC units (two 1,500-pound units operated in parallel with a third unit in series, and with one spare unit on site)

The treated groundwater (or water effluent) is discharged to a city storm sewer, which ultimately discharges to surface water (the city's Heartwell Lake). The vapor stream generated can be treated thermally (using the catalytic oxidizer) or discharged directly to the atmosphere.

The Source Area SVE extraction and treatment system is composed of the following major components:

- SVE extraction wells:
  - Six shallow wells (SVE-5S to SVE-10S) screened from approximately 20 to 40 feet bgs
  - Two dual deep/intermediate wells (SVE-1D/2I and SVE-3D/4I) screened from approximately 60 to 80 (intermediate) and 90 to 110 (deep) feet bgs
  - Each well is connected to the SVE system by individual pipelines. The individual well pipelines are manifolded into header pipes that feed a single pipeline to the vacuum blower inside the treatment building.
- Vent wells:
  - Six wells (VW-1 to VW-5 and VW-10) screened from approximately 60 to 130 feet bgs
  - Four wells (VW-6 to VW-9) screened from approximately 60 to 110 feet bgs
  - Installed to curtail vacuum influences from adjacent contaminated areas and to provide a source of oxygen to the contaminated vadose zone. Vent wells VW-1 to VW-5 are located along the east to prevent potential contaminant migration from the Foote Oil site. Vent wells VW-6 to VW-10 are located along the southern boundary to prevent potential contaminant migration from the Colorado Avenue Subsite.
- The SVE blower component:
  - Vapor water separator
  - Vapor filter
  - Vacuum blower (500 cubic feet per minute [cfm])
  - Silencer.

The condensate water generated from this system is directed to and treated within the Source Area water treatment system for discharge. The vapor stream generated can be treated thermally (using the catalytic oxidizer) or discharged directly to the atmosphere. When operations began, the catalytic oxidizer provided thermal treatment of vapors generated from both the water and SVE treatment systems. However, after significant reductions in contaminants in the vapor streams generated from the SVE and air stripper, the need for this treatment was re-evaluated, and thermal treatment was found to not be required. As a result, operation of the catalytic oxidizer ceased in 2004 and the vapors generated were rerouted to allow for direct discharge to the atmosphere.

As a result of the 2011 source area soil and source material excavation and treatment, the source area remedial systems — specifically the SVE system — was altered. Two of the six shallow wells (SVE7S and SVE9S), one of the two intermediate/deep SVE dual wells (SVE 3D/4I), and four of the five south vent wells (VW7 throughVW10) had to be abandoned in place. Figure 11 depicts those system components that were abandoned in place.

3.2.2 PINE AVENUE TREATMENT SYSTEM DESCRIPTION

In September 1999, the EPA issued a second Removal Action Memorandum, authorizing the second Removal Action for the subsite. IWS, also called in-well aeration (IWA), was selected for treatment of the downgradient plume. The IWS system was installed at Pine Avenue, approximately 700 feet downgradient (east) from the SSSA (Figure 12, Attachment A). Continued operation of this system was incorporated into the 2003 Interim ROD for OU 20.

The Pine Avenue IWS treatment system was installed in 2001 and is composed of the following major components:

- IWS wells (Figure 13, Attachment A):
  - Two wells (IWS-01 and IWS-02) completed to approximately 171 feet bgs
  - 8-inch educator in 12-inch casing
  - Upper screen approximately 118.5 to 131 feet bgs
  - Lower screen approximately 155 to 165 feet bgs
- A carbon heat exchanger.
- Vapor phase GAC units (four 2,000pound vessels with 1,000 pounds carbon each) operated in two stages of two units in series.
- A blower package (consisting of 40 horsepower blower, filter, silencer, and blower enclosure) to deliver 250 standard cubic feet per minute (scfm) per well.
- The primary heat exchanger (consisting of the exchanger and the exterior cooling air system).
- A carbon dioxide addition (scale prevention) system to deliver 5 scfm per well.

Contaminant removal in this closed-loop system is provided by vapor phase GAC units.

3.2.3 IN SITU BIOREMEDIATION TREATMENT DESCRIPTION

Based on the in situ bioremediation remedy selected by the 2003 OU 20 ROD, in situ treatment wells were installed to inject a chemical into the aquifer that slowly (over approximately a year) releases oxygen into the groundwater. Local microbes use the additional dissolved oxygen (DO) to bio-degrade the COCs in the plume. Direct chemical oxidation of the COCs is believed to be minimal, if it occurs at all.

The in situ bioremediation system (Figures 10 and 14) was installed in two phases (2005 and 2011) and includes the following components:

- Pine Avenue Fence:
  - Six vertical injection points (IP-1, IP-2, IP-3, IP-4, IP-6 and IP-8).
  - Three slanted (approximately 4 to 10 degrees) injection points (IP-5, IP-7 and IP-9).
  - Approximately 5,000 pounds of oxygen release compound (ORC) are added per injection event in this area with 10,000 gallons of potable water. Assuming 17 percent of the ORC is oxygen, this ORC addition translates to addition of 850 pounds of dissolved oxygen.
- East Fence (east of California Avenue):
  - Three vertical injection points (IP-12, IP-13 and IP-14).
  - Two slanted (approximately 4 to 10 degrees) injection points (IP-10 and IP-11).
  - One vertical injection point (IP-15) added in 2011.
  - Approximately 2,425 pounds of ORC are added per injection event in this area with 5,000 gallons of potable water. Assuming 17 percent of the ORC is oxygen, this ORC addition translates to addition of 412 pounds of dissolved oxygen.

- Midpoint well:
  - One vertical injection point (IP-16) added in 2011
  - Approximately 800 pounds of ORC are added per injection event in this area with 1,600 gallons of potable water. Assuming 17 percent of the ORC is oxygen, this ORC addition translates to addition of 136 pounds of dissolved oxygen. In lieu of injections, this well may also be used as a passive treatment well similar to well BW01, for deployment of slow oxygen release compounds by "socks."

- "Tail" portion of downgradient plume:
  - One well (BW01) screened from 120 to 215 feet bgs.
  - Slow oxygen release compound "socks" deployed annually from 165 to 200 feet bgs.
- Each IP well is 4 inches in diameter and has three screen intervals:
  - 156 to 164 feet bgs.
  - 166 to 174 feet bgs.
  - 176 to 184 feet bgs.
- Annual injection of slurry of clean water and slow oxygen release compound (2005 to present) into injection point (IP) wells using packer injection system in the amounts listed above.

The effectiveness and progress of the treatment are monitored through chemical analysis and field measurement of monitoring wells throughout the plume, including upgradient monitoring wells. The levels of contaminants are also monitored to determine how much treatment chemical will be needed for the next injection at each fence. The oxygen levels at the fences and in downgradient monitoring wells are tracked to determine when the next injection of treatment chemical is necessary.

3.2.4 LONG-TERM GROUNDWATER MONITORING

Long-term remediation activities include semi-annual sampling of between 31 and 49 monitoring wells and treatment well piezometers at between 26 and 37 groundwater sampling locations. The sampling locations provide appropriate geographic distribution from upgradient of the Second Street Subsite source area to the perimeter of the downgradient plume. The site team reports that the current monitoring program reflects a scope adjustment by the EPA to analyze for EDB, which was eventually traced to the Foote Oil site.

3.2.5 SOIL EXCAVATION AND THERMAL TREATMENT FOR SHALLOW SOURCE AREA

The OU 12 excavation, thermal treatment, backfilling, and site restoration for Areas 1, 3 and 4 (Figure 9, Attachment A) was completed in May 2011. Area 1 was excavated to a target depth of 20 feet bgs, and Areas 3 and 4 were excavated to the base of the gas holders (17 and 20 feet bgs). The total volume and estimated contaminant mass removed from each area is summarized in Table 3-1.

Table 3-1. Post-RA Estimates of Materials Removed and Treated

Area	Total Volume (cy)	Total Weight (tons)	Contaminant Mass (lbs)
Area 1-BNSF ROW	2,015	2,992	13,632
Area 3- South Holder	914	1,357	2,815
Area 4- North Holder	1,454	2,159	2,159
Estimated Totals	4,383	6,508	18,606

Post-excavation sampling was only performed on Area 1 as deep vadose zone soils (20 to 120 feet bgs) in Areas 3 and 4 are targeted for treatment using ISCO. Post-excavation sampling in Area 1 (Figure 15, Attachment A) indicates excavation remediation goals were not achieved at the base of excavation (20 feet bgs) at eight out of 10 cells in the western part of Area 1.

3.2.6 IN SITU CHEMICAL OXIDATION FOR DEEP SOURCE AREA

The OU-12 treatment of deep vadose zone (20 to 120 feet bgs) and saturated zone (120 to 140 feet bgs) soil using ISCO has not been implemented. The current plan calls for ISCO treatment in Areas 2, 3, 4 and 5, as shown in Figure 16 (see Attachment A) and Table 3-2 below.

Table 3-2. Areas of Proposed ISCO Treatment and Contaminant Mass Estimates

	Length	**Width**	**Vadose Zone**		**Saturated Zone**		**Total**
	Diameter		**Depth**	**Cont. Mass**	**Depth**	**Cont. Mass**	**Cont. Mass**
Area	**ft**	**ft**	**ft (bgs)**	**Lbs**	**ft (bgs)**	**Lbs**	**Lbs**
Area #2 Near Former Retorts	60	15	20-120	5,554	120-140	95	5,649
Area #3 (South Holder)	43		17-120	56,008	120-140	3,879	59,887
Area #4 (North Holder)	50		17-120	48,742	120-140	9,326	58,068
Area #5: Eastern Edge of MGP	180	50	0	0	120-140	27,245	27,245
Total				110,304		40,545	150,849

The ISCO design assumes a stoichiometric ratio of 10 pounds oxidant to 1 pound contaminant. Based on the treatability study the full-scale oxidant dosage rate was established at 15 pounds oxidant/foot (or 30 pounds RegenOx/foot) at a 3.6 percent oxidant injection solution strength. Using the 3.6 percent oxidant solution injection strength the volumetric injection solution rate will be approximately 50 gallons per foot. Table 3-3 summarizes the number of injection wells for each area; the amount of oxidant, RegenOx product, and injection solution per well point and per event; and the number of events based on the contaminant mass present.

Table 3-3. Proposed Injection Wells and Quantities

			Per Well Point			Per Event			
Area	Wells/ Points	Spacing	Total Oxidant	RegenOx Product	Injection Solution	Total Oxidant	RegenOx Product	Injection Solution	Injection Events
		ft	lb	lb	gal	lb	lb	gal	
Area #2	3	20	1800	3600	6000	5400	10800	18000	10
Area #3	5	16	1845	3690	6150	9225	18450	30750	65
Area #4	6	17	1845	3690	6150	11070	22140	36900	53
Area #5	31	20	300	600	1000	9300	18600	31000	30

3.2.7 FOOTE OIL SITE REMEDIATION

Although not installed or operated by the EPA, remediation has been implemented at the Foote Oil site, which is located adjacent to the eastern property boundary of the SSSA. The remedial actions implemented include an SVE system installed in 1999, a DPE system installed in 2005, and an air sparge system installed in 2009.

4.0 CONCEPTUAL SITE MODEL

This section discusses the optimization team's interpretation of existing characterization and remedy operation data and site visit observations to explain how historical events and site characteristics have led to current conditions. This CSM may differ from that described in other site documents. CSM elements discussed are based on data obtained from the EPA Region 7 and discussed in the preceding sections of this report. This section is intended to include interpretation of the CSM only. It is not intended to provide findings related to remedy performance or recommendations for improvement. The findings and recommendations are provided in Sections 5.0 and 6.0.

4.1 CSM OVERVIEW

MGP residuals released from a FMGP located at 109 West Second Street have contaminated soil and groundwater at the site with BTEX and PAH compounds. The FMGP operated for a period of 37 years from 1894 to 1931 using both the coal carbonization and carbureted water gas processes. Based on the dates of operation, some of the releases are more than 100 years old. Primary sources at the FMGP include two gas holders, a retort area and a suspected spill area. Typical MGP residuals would have included coal tar, which is a dense non-aqueous liquid (DNAPL) that sinks in groundwater. Contaminants released from these source areas seeped downward through 120 feet of vadose zone soils and into the upper 20 to 30 feet of the saturated zone, leaving behind adsorbed phase MGP residuals at the source areas and a dissolved phase groundwater plume that extended more than 2,700 feet downgradient to the east-southeast in groundwater. As the plume migrates downgradient, it deepens to around 175 to 200 feet bgs at the distal end of the current monitoring network (2,700 feet downgradient). Benzene and naphthalene are highly mobile in groundwater compared with the other contaminants of concern, are present in the full length of the contaminated groundwater plume, and are therefore the primary contaminants of concern. Certain compounds, such as the PAHs other than naphthalene, are less mobile and have not migrated as far in the groundwater.

Immediately downgradient of the FMGP site is another contaminant source at the Foote Oil site. Petroleum contamination from Foote Oil includes free product and dissolved phase BTEX contamination that comingles with and is indistinguishable from the same constituents in the FMGP site contaminant plume. The Foote Oil contaminants also include 1,2-DCA and EDB compounds, which are unique to the Foote Oil plume and are not associated with the FMGP plume. An additional contaminant source upgradient and south of the FMGP site is the Colorado Avenue Subsite. Chlorinated solvent contamination from the Colorado Avenue Subsite includes chlorinated volatile organic compounds (CVOCs) that also comingle with but are distinguishable from the FMGP plume.

The geology consists of relatively permeable aeolian fine-grained sediments (primarily silts and sands) that are underlain by coarser, saturated fluvial sediments. Both the aeolian and fluvial deposits coarsen with depth. The lower surface of the fluvial aquifer is the top of the Cretaceous bedrock (approximately 230 feet bgs), and the upper surface is the water table (approximately 120 to 130 feet bgs). Generally, groundwater flows east-southeast through the area. The linear groundwater flow velocity in the aquifer is estimated to range from approximately 1.5 feet/day (shallow) to 2.1 feet/day (deep), 550 feet/year (shallow) and 770 feet/year (deep). Therefore, the results of remedial activities in the source areas can be apparent in downgradient locations within a few years.

Groundwater levels vary seasonally, regionally and over longer periods of time as a result of the large-scale agricultural and industrial pumping conducted east of Hastings. Based on water level data collected between 2006 and 2011, water levels at the distal (east) end of the plume vary seasonally by approximately 2 feet. Based on water levels at a USGS observation well 2 miles east-southeast of the plume, water levels increased approximately 11 feet from 1982 to 2000, decreased by 6 feet between 2000 and 2004, and then remained generally stable between 2004 and 2012. The changes in water levels may correspond with changes in regional pumping and therefore slight shifts in groundwater flow directions in the general area of the plume.

Remediation of the FMGP source area soil includes an SVE system that has operated since 1997 and excavation and thermal treatment of shallow vadose zone soils (0 to 20 feet bgs) in 2011. Remediation of source area groundwater includes a groundwater pump and treatment system that has been operational since 1997. Source area remediation activities have reduced contaminant mass but have not eliminated contaminant flux from the site.

Remediation of downgradient groundwater includes a combination of IWS (since 2001) and in situ bioremediation (since 2005) at locations 700, 1,350 and 1,750 feet downgradient of the source area. Downgradient remediation efforts have had partial success in reducing contaminant concentrations, but continued O&M of these systems is needed because of the continuing contaminant flux from the FMGP and Foote Oil source areas.

The multiple source areas, relatively fast transport times, various source area and downgradient remedies, and variation in operation effectiveness of these remedies make it difficult to evaluate the performance of each remedy component.

4.2 DATA GAPS

There are several data gaps in the existing CSM. These gaps are discussed in Section 5.0.

4.3 IMPLICATIONS FOR REMEDIAL STRATEGY

The implications of the CSM and above data gaps are discussed in Sections 5.0 and 6.0.

5.0 FINDINGS

The observations provided below are the interpretations of the optimization team. They are not intended to imply a deficiency in the work of the system designers, system operators or site managers, but are offered as constructive suggestions in the best interest of the EPA and the public. These observations have the benefit in that they were formulated based on operational data unavailable to the original designers. Furthermore, it is likely that site conditions and general knowledge of groundwater remediation have changed over time.

5.1 SOURCE AREA SOIL AND GROUNDWATER (OU 12)

5.1.1 SVE EFFECTIVENESS

SVE is primarily intended for removal of volatile organics from soils, so it is less effective for removal of less volatile organics or semivolatile organics such as PAHs. In general, while some of the lighter PAHs, such as naphthalene, would be removed by SVE on a slower time scale than volatile organics, the heavier PAHs, such as the four and five ring PAHs, would probably not volatize in significant amounts.

Vapor extraction is achieved using a 500 scfm blower on 10 extraction wells, as described in Section 3.2.1. There are six shallow SVE wells, two intermediate SVE wells, and two deep SVE wells at the FMGP site. The shallow wells are spaced approximately 50 to 70 feet apart across the FMGP and the two intermediate/deep well nests are spaced 110 feet apart within or near the two former gas holders. Although vacuum measurements were not included in the reviewed documents, it has been reported that the radius of influence (ROI) for vacuum extraction is 25 feet for shallow SVE wells and 100 feet for intermediate/deep SVE wells.

All SVE wells were operated from 1997 to 1999. SVE-8S was not operated from 2000 to 2003, and SVE-5S and SVE-10S were not operated from 2000 to 2010 because of the low concentrations. As part of excavation, several vent and SVE wells were abandoned in 2011 (VW-8, VW-9, VW-10, SVE-7S, SVE-9S and SVE-3D/4I).

Taking into account dilution air, the applied SVE extraction rate averaged 334 scfm during period of operation from 1997 to 2010. Based on an average up time of 67 percent as a result of maintenance, repairs, and other outages, the average annual normalized SVE extraction rate was 225 scfm. Table 5-1 below provides the normalized (assumed nonstop around the clock operation) flow rate from each well.

Table 5-1. Annual Normalized Vapor Extraction Rates (scfm) from SVE Wells (1997-2010)

1D	2I	3D	4I	5S	6S	7S	8S	9S	10S	Total
6	62	59	29	4	6	5	21	34	1	225

Based on operational summary provided by BVSPC (2012a)

Based on monitoring results measured between 1997 and 2010, soil gas BTEX concentrations have been reduced by an average of more than 97 percent at all SVE well locations. Table 5-2 below provides annual BTEX mass removal rates from each SVE wells based on extraction rates and measured soil vapor concentrations at each well. Based on monitoring results and extraction rates total BTEX removal from extraction is estimated to be in excess of 30,000 pounds. Based on the calculation, more than half of this mass was removed in the first year. In actuality, mass removal was likely highest during the first year, but the calculation likely also overestimates first-year mass removal. Concentrations decreased sharply between the first and second vapor measurements, and given this sharp decrease, the first vapor concentration measurements may not be a representative average of the vapor concentrations during the first year. Nevertheless, mass removal is significant, demonstrating the effectiveness of the remedy. Additional mass removal through aerobic degradation is also likely but cannot be quantified given the available data.

Table 5-2. Annual BTEX Mass Removal Rates (lbs/yr) from SVE Wells (1997-2010)

lbs/yr	SVE1D	SVE2I	SVE3D	SVE4I	SVE5S	SVE6S	SVE7S	SVE8S	SVE9S	SVE10S	Total
1997	1614	5018	3166	3302	123	429	1447	64	1350	0	16510
1998	422	406	429	579	36	138	241	55	681	2	2987
1999	859	216	214	207	6	51	236	110	891	0	2790
2000	256	40	110	596	0	13	590	0	401	0	2006
2001	271	40	153	676	0	8	449	0	353	0	1950
2002	61	10	52	102	0	2	65	0	4	0	294
2003	136	12	80	219	0	16	284	45	8	0	801
2004	154	11	78	239	0	11	152	97	5	0	746
2005	135	8	62	205	0	5	35	113	2	0	565
2006	46	6	51	74	0	7	117	113	2	0	415
2007	43	1	58	125	0	4	76	113	2	0	422
2008	43	0	67	178	0	1	38	117	2	0	446
2009	25	0	40	105	0	1	23	69	1	0	264
2010	44	0	70	185	0	1	40	122	2	0	466
Total	**4109**	**5767**	**4629**	**6790**	**164**	**687**	**3792**	**1019**	**3702**	**3**	**30662**

Naphthalene was not included as a part of analysis for samples collected prior to 2003. Based on samples that included naphthalene analysis, a single ratio of naphthalene to total BTEX of approximately 1.5 to 1 was established by the optimization team. The optimization team then calculated an estimate of naphthalene removal for each well for each year of operation. Table 5-3 below provides annual naphthalene mass removal rates from each SVE wells based on the calculated established ratio and BTEX mass removal rates. Total naphthalene removal by extraction is estimated to be more than 46,000 pounds. The same considerations and conclusions regarding BTEX mass removal apply to this estimated naphthalene removal.

Table 5-3. Annual Naphthalene Mass Removal Rates (lbs/yr) from SVE Wells (1997-2010)

	SVE1D	SVE2I	SVE3D	SVE4I	SVE5S	SVE6S	SVE7S	SVE8S	SVE9S	SVE10S	Total
1997	2451	7621	4808	5014	186	651	2197	97	2050	1	25075
1998	642	616	651	879	54	209	366	83	1034	3	4536
1999	1305	328	325	314	9	77	358	168	1354	1	4238
2000	389	60	167	905	0	20	897	0	609	0	3046
2001	411	60	233	1027	0	13	682	0	536	0	2962
2002	92	14	78	154	0	3	98	0	6	0	447
2003	207	18	122	333	0	25	432	69	11	0	1217
2004	233	17	119	362	0	17	230	148	7	0	1133
2005	206	13	94	311	0	8	53	171	3	0	858
2006	69	9	77	112	0	10	177	171	4	0	630
2007	66	1	88	189	0	6	115	172	3	0	641
2008	65	1	102	270	0	2	58	178	3	0	678
2009	38	0	60	159	0	1	34	105	2	0	400
2010	67	1	106	281	0	2	61	186	3	0	707
Total	6241	8759	7030	10312	250	1044	5759	1547	5623	4	46569

Despite relatively limited coverage, particularly in the intermediate and deep zones, SVE has been an effective means of removing the volatile fraction of contamination in the vadose zone. Additional significant mass could likely be removed with additional, appropriately located SVE wells. Mass removed by the SVE system is probably partially responsible for the decreases in BTEX and naphthalene concentration at MW-09 since 1999.

5.1.2 GROUNDWATER EXTRACTION AND TREATMENT

Subsurface Performance

There are four groundwater extraction wells (EXW-1, EXW-2, EXW-3 and MW-09) located along the eastern boundary of the FMGP site. MW-09 ran at startup in 1997 and was shut down after oil/tar was noted. It was put back on line in 1998 after an oil/water separator was installed and has remained in operation since then. Wells EXW-1 and EXW-2 operated for the first couple of years until concentrations in the influent were consistently below MCLs. EXW-3 was installed and brought on line in 2007. Table 5-4 below provides a summary of average groundwater extraction rates (provided by the site team), percentage of the year the well is operational, (provided by the site team), estimated annual groundwater extraction rates for each well (calculated by the optimization team), and average total extraction rate (calculated by the optimization team). More than 70 percent of the extracted groundwater has come from well MW-09.

Table 5-4. Extraction Well Operation and Annual Groundwater Extraction Rates

	Average Pumping Rate (gpm) & % Operation				Annual Extraction (gal/yr)				Average Extraction Rate (gpm)
	MW-09	EXW-1	EXW-2	EXW-3	MW-09	EXW-1	EXW-2	EXW-3	
	20-25	25-30	25-30	25-30	gal/yr	gal/yr	gal/yr	gal/yr	
1997	0.5%	30.0%	15.0%		59130	4336200	2168100		12.5
1998	35.0%	20.0%	10.0%		4139100	2890800	1445400		16.1
1999	35.0%	20.0%	10.0%		4139100	2890800	1445400		16.1
2000	40.0%	2.5%	0.5%		4730400	361350	72270		9.8
2001	40.0%	2.5%	0.5%		4730400	361350	72270		9.8
2002	40.0%	2.5%	0.5%		4730400	361350	72270		9.8
2003	40.0%	2.5%	0.5%		4730400	361350	72270		9.8
2004	55.0%	2.5%	0.5%		6504300	361350	72270		13.2
2005	35.0%	2.5%	0.5%		4139100	361350	72270		8.7
2006	40.0%	0.5%	0.5%		4730400	72270	72270		9.3
2007	37.5%	0.5%	0.5%	7.5%	4434750	72270	72270	1084050	10.8
2008	37.5%	0.5%	0.5%	7.5%	4434750	72270	72270	1084050	10.8
2009	37.5%	0.5%	0.5%	7.5%	4434750	72270	72270	1084050	10.8
2010	37.5%	0.5%	0.5%	7.5%	4434750	72270	72270	1084050	10.8
2011	37.5%	0.5%	0.5%	7.5%	4434750	72270	72270	1084050	10.8

Based on operational summary provided by BVSPC (2012b)

The treatment system was originally designed for treating water containing dissolved phase BTEX contaminants at a flow rate of 75 gallons per minute (gpm). But even with the addition of the oil/water separator, the oily/coal tar waste extracted by well MW-09 has significantly reduced the flow capacity of the system's GAC units and requires increased operator efforts. As a result, both wells have substantial down time, and the average extraction rate is approximately 10.8 gpm (2007 through 2011).

The 2002 feasibility study report (BVSPC 2002) suggests that one extraction well pumping at 150 gpm would be sufficient based on the modeling effort performed during the original Engineering Evaluation/Cost Analysis report (Appendix C, MK, 1995b which was not included in the review documents). At an average extraction rate of 10.8 gpm, the actual average extraction rate is less than 10 percent of the estimated rate required for capture. Based on this limited information, it would appear that comprehensive source control is not provided. The analysis regarding system downtime below indicates that there are extended periods where well MW-09 operates at less than 15 percent of the time and other periods where it operates more than 90 percent of the time indicating that the degree of source control is inconsistent over time. Typical of most sites, there is insufficient water level information to evaluate plume capture, and evaluation of water quality at downgradient wells is complicated by presence of contamination from the Foote Oil site. Therefore, there are no other converging lines of evidence that would support a significant degree of source control.

Based on average annual influent concentrations and groundwater extraction rates from all four wells, the total estimated mass of BTEX and PAH compounds was calculated by the optimization team and is presented in Table 5-5 below. The estimated total mass removal for the groundwater extraction system is 2,382 pounds BTEX and 4,333 pounds PAH. Over 99 percent of the total mass removed has come from MW-09. Mass removal rates have declined significantly over the years due to decreasing influent concentrations. A portion of these concentration reductions are likely due to the contaminant mass removed from the vadose zone by the SVE system, which has reduced an ongoing source of contamination to groundwater. The amount of BTEX removed by groundwater extraction is approximately 25 percent greater than the total BTEX mass estimate for the saturated zone based on soil sampling results (1,871 pounds; Table 2-3). The original mass estimates based on soil sampling results therefore underestimate the amount of mass present in the subsurface.

Table 5-5. Annual BTEX and PAH Mass Removal Rates (lbs/yr) from Groundwater Wells (1997-2010)

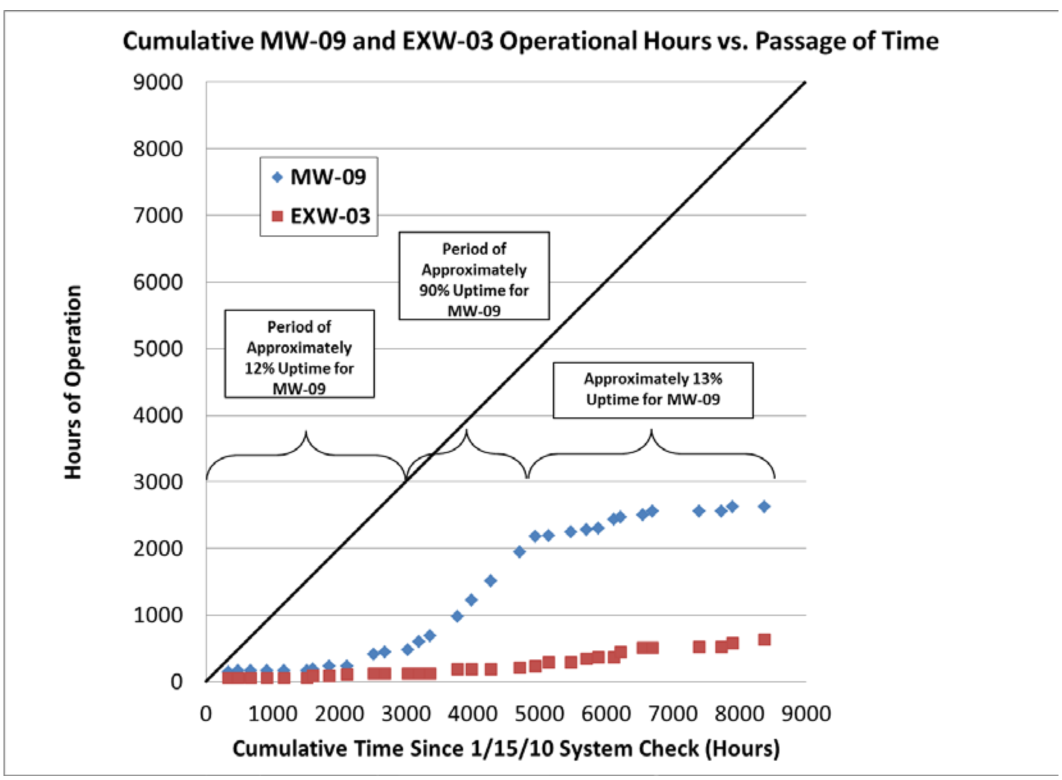
	BTEX					PAH				
	MW-09	EXW-1	EXW-2	EXW-3	Total	MW-09	EXW-1	EXW-2	EXW-3	Total
1997	8.1	12.4	0.2	-	20.7	13.5	2.9	0.0	-	16.4
1998	455.3	1.3	0.0	-	456.6	363.0	0.9	0.0	-	363.9
1999	455.2	0.1	0.0	-	455.3	831.2	0.0	0.0	-	831.2
2000	285.7	0.0	0.0	-	285.8	330.8	0.0	0.0	-	330.9
2001	191.8	0.0	0.0	-	191.8	223.6	0.0	0.0	-	223.6
2002	215.3	0.0	0.0	-	215.3	167.0	0.0	0.0	-	167.0
2003	147.7	0.0	0.0	-	147.7	492.9	0.0	0.0	-	492.9
2004	157.2	0.0	0.0	-	157.2	360.1	0.0	0.0	-	360.1
2005	74.2	0.0	0.0	-	74.2	161.8	0.0	0.0	-	161.8
2006	63.4	0.0	0.0	-	63.4	583.2	0.0	0.0	-	583.2
2007	82.0	0.0	0.0	1.4	83.4	102.3	0.0	0.0	5.7	108.0
2008	40.0	0.0	0.0	1.5	41.5	160.5	0.0	0.0	1.8	162.3
2009	59.7	0.0	0.0	1.7	61.3	144.5	0.0	0.0	2.7	147.2
2010	60.1	0.0	0.0	1.4	61.5	218.1	0.0	0.0	0.0	218.1
2011	64.4	0.0	0.0	1.3	65.8	166.6	0.0	0.0	0.0	166.6
Total	2360	13.9	0.2	7.3	2382	4319	3.9	0.1	10.2	4333

Given that MW-09 is only operating 37.5 percent of the time (Table 5-4) and extracting approximately 231 pounds of contamination per year (Table 5-5), approximately 385 pounds of contamination are migrating past MW-09 each year through the “expected” capture zone of MW-09. Additional contaminant mass is also likely migrating around MW-09 on a continuous basis. EXW-3 might capture some of this contamination; however, EXW-3 is only operating 7.5 percent of the time.

System Downtime

The downtime for the groundwater extraction and treatment system is unusually high because of the frequent system alarms and the time it takes to remedy alarm conditions. The primary reasons for system shutdowns are high alarms in the equalization tank, which indicate that the filter bags need to be changed, and high alarms in the air stripper sump, which indicate that the GAC unit is clogged. The primary reason for the extensive system downtime is the response times to address the alarms. For example, based on the City of Hastings 2010 operation reports, the system is often down for several days before a high equalization tank alarm is addressed. In addition, when the GAC unit is clogged, it is usually addressed by cleaning off the top layer of GAC. The GAC tanks are often allowed to drain for several days before the change is made. There may also be scheduling conflicts to get the roads department to assist with moving the GAC vessels into position, or cold weather conditions that prevent draining the vessels. A scheduling conflict resulted in approximately 10 continuous days of downtime in 2010, and cold weather conditions that prevented draining the GAC units caused more than 20 days of significantly reduced system operation in 2010. Many days of downtime were caused when several days passed after the system shutdown by a high alarm in the equalization tank.

The following chart illustrates cumulative hours of operation during 2010 on the x-axis and hours of well MW-09 and EXW-03 operation on the y-axis. The primary reason why well MW-09 does not operate is system shutdown. The primary reason why well EXW-3 does not operate is not known by the optimization team. For continuous operation, the two data series would be along the 45-degree line, representing an hour of operation for every hour that passes. It is evident, however, that the data series are both far below the 45-degree line, indicating significant downtime. There is a period when well MW-09 operated at approximately 90 percent uptime, but there were much longer periods when well MW-09 operated at less than 15 percent uptime. Source control was likely significantly compromised for the approximate 255 days that the system operated at less than 15 percent uptime.



The reasons for the frequent bag filter changes and GAC layer changes is presumably tar/hydrocarbon globules in extracted groundwater that clog the bag filters and GAC. Some hydrocarbons likely pass through the bag filters and affect the water quality in the air stripper and GAC. The period of 90 percent uptime for well MW-09 seemed to correspond to a time period of little to no operation of well EXW-3 and no overriding issues with GAC layer changes. This observed correlation where no GAC issues where encountered during periods of nonoperation of well EXW-3 suggests that the water quality responsible for the system clogging may be caused in part by pumping from EXW-3. Based on visual observations in the City of Hastings reports, poor water quality (for example, dark in color or evidence of floating particles) seems to be more prevalent throughout the system when well EXW-3 is operating. The site team indicated that the poor water quality observations may be caused by the higher EXW-3 operational flow rate (or combined wells EXW-3 and MW-09 flow rates), which results in more direct turbulence and mixing of settled materials in the EQ tank. If this is the case, the EQ tank should be cleaned out more frequently to remove the solids. The site team also reports that well EXW-3 is plumbed directly into the EQ tank (bypasses the OWS). As a result, overloading of the OWS caused by operation of well EXW-3 is not an issue. More retention time within the OWS and EQ tanks would be helpful. However, adding additional tankage is currently not possible because of limits on the amount of available space in the treatment building.

5.1.3 SOIL EXCAVATION

Soils excavated from the upper 20 feet of Areas 1, 3 and 4 removed an estimated contaminant mass of 18,606 pounds. Post-excavation sampling was performed only on Area 1 because deep vadose zone soils (20 to 120 feet bgs) in Areas 3 and 4 are targeted for treatment using ISCO. Post-excavation sampling in Area 1 (Figure 15) indicates excavation remediation goals were not achieved at the base of excavation (20 feet bgs) at eight out of 10 cells in the western part of Area 1.

5.1.4 PROPOSED ISCO

ISCO is proposed for the deep vadose zone (20 to 120 feet bgs) and saturated zone (120 to 140 feet bgs) soils in source Areas 2, 3, 4 and 5. The proposed application is with a combination of vertical permanent injection wells and temporary injection points. Based on calculations in the basis of design document, a total contaminant mass of 152,000 pounds was estimated to be present in the site soil to be treated by the ISCO RA component. The ISCO design assumes a stoichiometric ratio of 10 pounds oxidant to 1 pound contaminant. Based on the total mass of contaminants and the stoichiometric oxidant ratio, the total estimated amount of oxidant required for the ISCO remedial component was calculated to be approximately 1,500,000 pounds.

Based on the treatability study, the full-scale oxidant dosage rate was established at 15 pounds oxidant/foot (or 30 pounds RegenOx/foot) at a 3.6 percent oxidant injection solution strength. Using the 3.6 oxidant solution injection strength, the volumetric injection solution rate will be approximately 50 gallons/foot. Injections are proposed four times a year and, depending on the estimated contaminant mass in each area, injections could take up 16.5 years to complete.

The optimization team has concerns that the contaminant mass is underestimated. The mass estimate in the design document is based on the results from analysis of VOCs and PAH. However, coal tar is a complex mixture of light oils (up to 200^{o} C), middle oils (200 to 250^{o} C), heavy oils (250 to 300^{o} C), anthracene oils (300 to 350^{o} C), and pitch (above 350^{o} C). VOC and PAH analysis do not account for the heavier end fraction, which can be as much as 60 percent of the total coal tar mass. The optimization team does not believe that the heavier end fraction is of particular environmental concern because it is not expected to be mobile in the environment. Still, it can be a huge part of oxidant demand when it comes to ISCO.

The optimization team also has concerns about the proposed application of ISCO using vertical wells at the proposed spacing of 16 to 20 feet. At an assumed porosity of 25 percent, the 50 gallons/foot application rate would have a limited radius of influence of approximately 3 feet in the unsaturated zone based on the volume of pore space. The first concern is that the infiltrated injection solution would move vertically in the vadose zone until a layer with a contrasting hydraulic property is encountered. At these contacts, infiltrated water can be diverted laterally to an extent that depends on the hydraulic properties. Low-permeability silt/clay zones are of most significance for inducing lateral water flow when they are surrounded by higher conductivity material. The lateral movement of infiltrated injection solution was observed during the treatability test when ISCO solution being injected at INJ-1 at a level of 40 to 42 feet bgs started coming out at the surface of the INJ-2 well 15 feet away. The borehole logs for these two wells show no recovery (INJ-1) or sand (INJ-2) at 40 to 45 feet bgs and a clay layer at 45 to 50 feet bgs. Whereas lateral water movement would be most significant at clay layers, some lateral water movement can occur at most contacts with a layer of lower permeability overlying a layer of higher permeability. Some lateral water spreading can also occur as a result of capillary action in the vadose zone. However, transport will be primarily downward, even if there is significant overall lateral movement of the injected fluids. If downward movement is the case, the source area could have very clean 6-foot-diameter columns around each well and unremediated soil outside the effective radius.

The second concern is the potential increase in contaminant flux into the groundwater as a result of the vadose zone injections, as was observed during the treatability study. Without adequate controls and treatment for the groundwater, slugs of high-concentration contaminants would be released to the downgradient groundwater.

5.2 DOWNGRADIENT GROUNDWATER (OU 20)

5.2.1 PLUME DELINEATION

The existing monitoring well network is adequate to define the horizontal and vertical extent of the dissolved contaminant plume targeted for remediation. The SVE and P&T systems have removed substantial contaminant mass, and additional contaminant mass has likely degraded as a result of dissolved oxygen migrating into the source area from upgradient.

5.2.2 IWS

The two IWS wells (IWS-01 and IWS-02) located on Pine Avenue appear to be effective at reducing concentrations in the water extracted, treated, and injected by the IWS wells, as indicated by IWS-1S, IWS-2S, HWS-14 and SW-09 (which is adjacent to IWS-1S).

The two IWS wells appear to be effective at reducing concentrations at SW-10S in the 120 to 130 feet bgs interval, but it is unclear whether results from SW-10S are partially the result of mounding caused by the injection component of the IWS wells and a deflection of shallow groundwater contamination around the SW-10S location.

The concentrations at HWS-14 decreased before IWS operation. There was a significant decrease between 1999 and March 2001, prior to the start of IWS operation in May 2001. Although the IWS wells were developed in fall 2000, the optimization team believes based on the observed data that the decrease in concentrations at HWS-14 prior to March 2001 is more likely the result of source area remediation occurring between 1997 and 2001 than the effects of IWS well development. As a result, the optimization team does not believe that IWS operation is the primary reason for the decreases observed at HWS-14.

Concentrations in wells SW-5I, SW-6I, SW-7I and SW-8I, which are located at varying distances immediately east of the IWS wells, decreased to non-detect in 2002 and 2003. These decreases might be attributed to IWS operation, but might also be partially the result of source area remediation or a change in directions of groundwater flow from directly east to east-southeast around this time period. For example, concentrations at SW-8I (the most easterly/downgradient well) decreased to non-detect before concentrations in SW-5I, SW-6I, and SW-7I decreased to non-detect, which suggests that the IWS operation was not responsible for the decreases at SW-8I. Additionally, this time period is consistent with the sharp decline in the water table at the USGS observation well to the east-southeast and may result from a change in the direction of groundwater flow imparted from increased pumping from the community college, golf course or other properties in the vicinity of the USGS observation well.

Concentration increases in HWS-11, south of the IWS wells, increase substantially in the 2006 time period, perhaps as the result of releases from the Foote Oil site. The site team reports discovery of free product releases at the Foote Oil site between 2003 and 2007. Before the IWS began operation, this contamination might have migrated toward HWS-14; however, injection in the shallow zone associated with IWS operation during this period may have deflected the shallow contamination from the historical path toward HWS-14 to a new path toward HWS-11.

Thorough evaluation of the IWS system performance is difficult to evaluate with field data for the following reasons:

- There is no measured water flow rate through the wells;
- There is likely some unknown degree of recirculation in the aquifer adjacent to the well boring that limits the horizontal extent of the IWS system;
- Water level measurements are difficult to use for interpreting capture because of the mounding the shallow zone and the drawdown in the deep zone;
- There is potential for slight shifts in groundwater flow patterns that could also affect concentration trends; and
- Some observed contaminant concentration decreases are due to upgradient remedial activities.

Based on the difficulty in using field data to evaluate the IWS performance and the observations at SW-10I, the optimization team believes that, at present, the IWS wells are providing an unknown benefit to plume control and contaminant mass removal.

5.2.3 IN SITU BIOREMEDIATION

The in situ bioremediation injections using ORC also have mixed results. Well SW-13I (155 feet bgs, Figure 17) and SW-03 (170 feet bgs, Figure 18) located about 200 and 300 feet downgradient of the Pine Ave fence show no good correlation between ORC injections and observed trends in contaminant concentration. Results at SW-13I were not available before the ORC was injected, but the increases over time suggest that the primary path of groundwater contamination may have changed such that a higher concentration pathway of contaminant migration was directed toward well SW-13I. This change in groundwater flow (and contaminant transport) direction may have been caused by operation of the IWS or to regional changes in groundwater flow before and after 2005. Regardless of the cause of the increases observed at well SW-13I and the fluctuations in the concentrations at SW-03, the concentrations at these locations appear to be more influenced by what is coming from upgradient rather than the addition of

ORC. Dissolved oxygen measurements at wells SW-13I and SW-03 continue to be low. It is often challenging to obtain reliable dissolved oxygen measurements. If these dissolved oxygen measurements are reliable, it would suggest that insufficient dissolved oxygen is available to fully address the contamination migrating through this area. To address the contaminant variability and the apparent dissolved oxygen deficit at well SW13I, well IP-16 was installed in 2011 and located immediately downgradient of well SW-13I. The site team reports that the spring 2012 DO data for well SW-03, while still low, is at least measureable, and therefore an improvement over the next several sampling rounds is anticipated.

BTEX and naphthalene concentrations at OW-4D and the BW-14 cluster appear to be positively affected by the ORC injections, with concentrations declining sharply since injections began. Sampling of all depths of distal plume well MLW-1 shows decreasing TCE concentrations. In addition, BTEX and naphthalene have decreased in the intervals between 186 feet bgs and 220 feet bgs. However, at a depth of 175 feet bgs (Figure 19) there has been an increase in BTEX and naphthalene concentrations beginning in 2009. The nearest ORC application is at BW-01, approximately 850 feet upgradient. Continued monitoring will help determine if these concentrations decrease as remediation progresses at upgradient locations or if contamination is bypassing upgradient remedial efforts.

5.2.4 GROUNDWATER CONTAMINANT CONCENTRATIONS

Contaminant concentrations in the extracted soil vapor and extracted groundwater have decreased significantly over the past 15 years of operation. Part of this decrease is from the blending of clean air and water through the subsurface as part of the extraction process; therefore, some degree of concentration rebound would be expected if extraction were discontinued. BTEX and naphthalene concentrations downgradient of the source area have been variable over the past several years, reflecting a likely lack of source control from both the SSSA and the Foote Oil sites and the uncertain performance of the IWS, ORC and Foote Oil remedies.

5.3 REGULATORY COMPLIANCE

BTEX and PAH concentrations in groundwater within the plume continue to exceed MCLs and likely will exceed MCLs for many decades (or longer). National Pollutant Discharge Elimination System (NPDES) discharge permit standards are routinely met by the treatment system.

5.4 COMPONENTS OR PROCESSES THAT ACCOUNT FOR MAJORITY OF ANNUAL COSTS

Table 5-6 summarizes the costs for the various ongoing remedies at the site. Labor provided by the City of Hastings and consulting labor provided by the EPA's contractor was not provided and are estimated by the optimization team. The costs associated with the City of Hastings are incurred by the city and are not paid for by the EPA. Laboratory analysis is conducted as part of the Contract Laboratory Program (CLP) (costs are not incurred by the site) and are therefore not included in the following table.

Table 5-6. Estimated Annual Costs

Item	Estimated Annual Cost	Percentage of Estimated Annual Cost
SVE System		
Electricity	$5,300	
Supplies	$2,000	
City labor (assume 2 hours per week at $65 per hour)*	$6,800	
Consultant PM, support, and reporting (assume $1,000 per month)	$12,000	
Estimated Subtotal	**$26,100**	**6.9%**
P&T System		
Electricity	$7,900	
GAC (6,000 lbs every 9 months, plus an extra 2,000-lb pallet every other year)	$22,000	
Waste disposal	$1,400	
Supplies	$1,000	
City labor (assume 12 hours per week at $65 per hour)*	$40,500	
Consultant PM, support, and reporting (assume $1,000 per month)*	$12,000	
Estimated Subtotal	**$84,800**	**22.5%**
IWS System		
Electricity	$20,500	
Well fouling prevention	$4,500	
GAC (2,000 lbs every 2 years)	$4,500	
Well redevelopment	$12,000	
Supplies	$500	
Subcontractor to Consultant labor (weekly checks)	$6,600	
Rent for spacing housing IWS equipment	$16,800	
Consultant PM, support, and reporting (assume $1,000 per month)*	$12,000	
Estimated Subtotal	**$77,400**	**20.5%**
ORC Injections and Monitoring		
Injection labor	$32,800	
Well redevelopment	$12,000	
Sampling support and miscellaneous work	$12,000	
Supplies (ORC and socks)	$52,400	
Consultant PM, support, oversight, reporting (assume $10,000 per event)*	$10,000	
Chemical injection data evaluation report*	$20,000	
Estimated Subtotal	**$139,200**	**36.9%**
Performance Monitoring (BTEX and Naphthalene) and reporting*	**$50,000**	**13.2%**
Estimated Total	**$377,500**	

** Estimated by optimization team*

5.5 APPROXIMATE ENVIRONMENTAL FOOTPRINTS ASSOCIATED WITH REMEDY

The environmental footprint of a remedy is described in the February 2012 EPA document titled *Methodology for Understanding and Reducing a Project's Environmental Footprint*. Environmental metrics related to materials use, waste generation, water use, energy use, and air emissions are described. The following items associated with the environmental footprint are noted:

- The primary materials used on site are the GAC and ORC.

- The primary potential waste generated on-site is the GAC, which is burned at the Whelan Energy Center.
- The water footprint includes extracted groundwater (a valuable local resource) that is discharged to surface water through the sewer system.
- The water footprint also includes the use of potable water for ORC injections.
- The primary contributors to the energy footprint are likely the energy associated with electricity use and materials manufacturing.
- The primary contributors to the air emissions footprints are likely electricity use and materials manufacturing.

5.6 SAFETY RECORD

The site team did not report any safety concerns or incidents.

6.0 RECOMMENDATIONS

Several recommendations are provided in this section related to remedy effectiveness, cost control, technical improvement, and site closure strategy. Note that while the recommendations provide some details to consider during implementation, the recommendations are not meant to replace other, more comprehensive, planning documents such as work plans, sampling plans, and QAPPs.

Cost estimates provided in this document have levels of certainty comparable to those for Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) feasibility studies (-30%/+50%), and these cost estimates have been prepared in a manner generally consistent with EPA 540-R-00-002, *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study*, July 2000. The costs presented do not include potential costs associated with community or public relations activities that may be conducted before field activities begin. The cost impacts of these recommendations are summarized in Table 6-1.

More than half of the current remedy costs (excluding site-wide long-term groundwater monitoring and reporting) are applied to the downgradient plume. With better source control, the downgradient O&M costs can eventually be reduced or eliminated. Additional capture zone analysis and enhancements to the SVE and groundwater extraction and treatment systems are needed to improve source control. Several recommendations are provided in Section 6.1 to address these issues. There may be an opportunity to slightly reduce future annual monitoring and maintenance costs, as identified in Section 6.2. In Section 6.3, a few ideas are presented for improving data management and presentation. Finally, recommendations related to implementation of a site closure strategy are presented in Section 6.4.

6.1 RECOMMENDATIONS TO IMPROVE EFFECTIVENESS

6.1.1 CONDUCT A GROUNDWATER CAPTURE-ZONE ANALYSIS

The groundwater extraction and treatment system has been effective at mass removal migrating from the source area and partially effective in preventing downgradient contaminant migration. Nearly all the mass removal (99 percent) has been through well MW-09. But the extent of the capture that well MW-09 provides has not been established, especially given the intermittent operation of the system and an average flow rate of approximately 10 gpm. Contaminant concentrations in on-site well PZ-1 would appear to be outside the zone of capture of well MW-09. PZ-1 is downgradient of the south gas holder (Area 3), which is a source of contaminant flux to the downgradient plume. Other areas of saturated groundwater contamination may also be present that are not within the expected capture zone of well MW-09.

A new capture zone analysis should be conducted to assess the capture performance of the existing extraction rates and to evaluate the requirements of additional treatment capacity needed to achieve full capture. This new analysis should use independent pump test data from each extraction well and incorporate those results into numerical or analytical flow modeling of capture. The capture zone analysis should also include a refinement of the target capture zone. Some areas of dissolved contamination may be sufficiently low to be addressed by monitored natural attenuation. Other areas not currently captured may have sufficiently high concentrations that hydraulic capture is needed. The 2005 soil sampling using sonic drilling provides a good indication of where contamination is present in the saturated zone along the eastern property boundary. These results also indicate that the contamination is generally limited to the top 10 feet of the saturated zone. Wells MW-09 and PZ-1 (also referred to as P-1) are both screened in the upper 20 feet of the saturated zone (approximately 120 to 140 feet bgs). By contrast, EXW-1 and EXW-2 are screened from 15 feet below the water table to 35 feet below the water table (135 to 155 feet bgs). The optimization team did not review the boring logs from the sonic drilling, but it is possible that a potential explanation for the elevated concentrations at well PZ-1 and the general absence of contamination from wells EXW-1 and EXW-2 may be caused by the screen interval of EXW-1 and EXW-2, especially if EXW-1 and EXW-2 preferentially extract water from deeper portions of their screened intervals or there is a somewhat lower permeability zone between the top of these extraction well screens and the zone of contamination.

Based on the 2005 data, the optimization team suggests two new 4-inch shallow monitoring wells (screened in the upper 20 feet of the water table): one to be installed 30 feet north of well MW-09 and one to be collocated with well EXW-1. The 4-inch wells should be sampled via low-flow sampling from the upper 10 feet of the screened intervals. Based on the field photoionization detector (PID) readings and field observations during drilling, the site team may decide to install another well an additional 30 feet north of well MW-09 (a total of 60 feet north of well MW-09). The site team is already planning a new extraction well downgradient of the south holder and well PZ-1. This additional well was incorporated in some revised plans for the ISCO remedy. While in the field, the site team should also consider redeveloping wells MW-09 and EXW-3 (if appropriate) to reduce solids or tar in the extracted water. The optimization team estimates that installation of two shallow 4-inch wells, installation of one shallow 6-inch well, and redevelopment of two wells will cost approximately $75,000, including oversight and waste disposal. Sampling the wells will cost an additional $2,000. The site team reports that the vent wells (VW-1 through VW-5 on Figure 9) are completed within the shallow portion of the aquifer and may provide a similar function. If after further review the site team believes comparable information can be provided using these existing wells, a significant portion of the $75,000 could be saved.

The new wells (or existing vent wells) can be used as observation wells during the pumping tests. The optimization team estimates that the costs for pumping tests, associated modeling, and interpretation with the new data would be approximately $60,000 as follows: approximately $5,000 for planning the tests, $20,000 for collecting the field measurements (labor and equipment) associated with the aquifer tests, and $35,000 for interpreting the data and evaluating plume capture. The optimization team assumes a relatively simplistic numerical model is developed and calibrated using the aquifer test data. The optimization team recommends using the model to simulate the aquifer tests and identify the associated hydraulic parameters for the model.

6.1.2 EXPAND GROUNDWATER EXTRACTION AND TREATMENT CAPACITY

Based on the results of the capture zone analysis, additional extraction well locations may be needed to improve capture. The new 6-inch well could be used for extraction, and if they are appropriately located, the new 4-inch wells could be used for extraction. The optimization team expects that the extraction rate needed for adequate capture (allowing fringes of the plume to be addressed by monitored natural attenuation) is beyond the hydraulic capacity of the treatment system and that additional capacity and space will need to be provided.

The optimization team estimates that finishing three wells as extraction wells and piping them to the treatment system will cost approximately $80,000. Operating the system with a higher flow rate will likely involve more electricity usage and GAC usage, but should not significantly affect other costs. The additional electricity and GAC costs would depend on the quantity and quality of the water extracted.

It is important to note that this additional investment in source control will hasten cleanup of the downgradient plume, shorten the duration of the downgradient remedies, and provide necessary hydraulic control during source area ISCO activities.

The optimization team suggests considering reinjecting the treated water into the aquifer to maintain the valuable water resource and to inject water with a high dissolved oxygen into the subsurface. Conditioning the water would be required to prevent scaling and biofouling of the injections wells, and frequent well rehabilitation and redevelopment efforts would be needed to maintain the injection capacity of the wells. Installation of two injection wells and associated piping and controls may cost an additional $150,000. Additional conditioning and maintenance costs might be on the order of $10,000 per year but is subject to further analysis. The optimization team recognizes that this approach may be mandated by the city or state based on the general need to maintain the groundwater resource in the area. As an alternative or complement to this suggestion, the site team might also advertise the treated water as a potential resource for beneficial use such as irrigation or as a heat source/sink for a water source heat pump.

6.1.3 Reduce System Downtime

The P&T system operates approximately 35 percent to 40 percent of the time. A review of the City of Hastings operational reports indicates that the primary causes for system down time are high alarms in the equalization tank, high pressure alarms in the GAC units, and extended response time to provide the appropriate maintenance. This issue is likely to be become worse as flow is added to the system if changes are not made. One root cause of the issues appears to be tar or hydrocarbons in the extracted water that clog the bag filters or GAC. Another root cause appears to be turbulence of settled materials in the EQ tank. Assuming these possible causes are the case, the following suggestions are made.

- Increase the frequency of removal of settled materials from the EQ tank.
- Evaluate the cause of globule and particle buildup in the EQ tank by evaluating OWS performance and confirming EXW-3 is not contributing solids to the EQ tank.
- Evaluate the need for replacing or increasing the capacity of the OWS.
- Hang oliophilic absorbent socks in the EQ tank and OWS to attempt to wick hydrocarbons from water in these tanks prior to filtration. Maintain and or change these socks as needed.
- Consider using oliophilic bag filters, adding oliophilic material to the bag filter housing, or using organoclay filter units.
- Install an autodialer that calls the system operator when the system is shut down.
- Require a response to all alarms within 24 hours.
- Require and enforce a minimum uptime performance requirement.
- Make changes to GAC vessels that allow them to drain sufficiently in 1 hour to allow timely changeout of the top GAC layer. Also modify the draining procedure to allow GAC vessels to be drained during cold weather conditions.
- If after the above changes, bag filter changeouts are more frequent than once every 3 days, then consider installing additional bag filter units in parallel to reduce loading to each bag filter or changing the filtration method.

The above changes (excluding the last bullet) should require less than $10,000 in capital costs. Any increase in cost for materials or maintenance of the absorbent socks should result in a larger reduction in other O&M items such that there is no cost increase. Responding to the alarms within 24 hours may result in a cost increase.

6.2 RECOMMENDATIONS TO REDUCE COSTS

No recommendations are provided in this category. The optimization team believes that the primary focus of the site team should be on improving the effectiveness of the source control remedy and the considerations provided in Section 6.4.

6.3 RECOMMENDATIONS FOR TECHNICAL IMPROVEMENT

6.3.1 IMPROVE AND REFINE REPORTING

Multiple reports are prepared to convey the subsurface performance of the remedies, causing relevant information to be dispersed between multiple documents. For example, the ORC performance monitoring is in a separate report from the water quality monitoring, and the water level measurements are included in a separate report. The optimization team suggests that all routine subsurface performance information be included in a single report. In addition, the optimization team suggests that the single report include the following information:

- Well construction table
- All groundwater sampling results in tabular and chart form
- Operational history of the various remedies (to correlate trends with remedy operation)
- Water level measurements and potentiometric surface maps, indicating all pumping that was occurring at the time of the water level measurements (including nearby production wells)
- Plume maps illustrating current benzene and naphthalene concentrations
- Cross-sections illustrating current benzene and naphthalene concentrations

The optimization team believes that the tables using “higher,” “lower,” or “same” to describe the change in concentrations from the previous event can be removed. Evaluation of the long-term trends is more meaningful.

Implementing this recommendation should not increase reporting costs.

6.4 CONSIDERATIONS FOR GAINING SITE CLOSE OUT

The optimization team suggests a remedial strategy that focuses on source control and remediation with timely discontinuation of the downgradient remedies. The following elements of a strategy are provided in the following sections.

6.4.1 ACHIEVE SOURCE CONTROL WITH THE P&T SYSTEM

Controlling the plume source as discussed in Section 6.1 will not only eliminate continued contaminant mass flux to the downgradient plume, it will also allow the influx of dissolved oxygen from upgradient of the site to assist with degradation of the downgradient plume. Dissolve oxygen measurements at upgradient well OW-5D suggest dissolved oxygen is over 5 milligrams per liter (mg/L) and typically around 8 mg/L. Given the relatively fast groundwater flow and contaminant transport and the potential for natural degradation in the absence of an ongoing source, the optimization team believes that the downgradient remedies including IWS and in situ bioremediation could be shut down in a few years or perhaps earlier with a favorable outcome of a monitored natural attenuation analysis.

6.4.2 EVALUATE MONITORED NATURAL ATTENUATION FOR THE DOWNGRADIENT PLUME WHEN THE SOURCE IS CONTROLLED

Once the source has been reliably controlled by the P&T system, the optimization team suggests conducting an evaluation for monitored natural attenuation (MNA) of the downgradient plume. Although the SSSA is a much older source than the sources of TCE in other Hastings plumes, the BTEX and naphthalene plume emanating from the SSSA is much shorter than the TCE plumes. This shorter plume is primarily the result of the natural attenuation (degradation, adsorption and dispersion) of BTEX and naphthalene that is occurring. It is therefore known that natural attenuation plays a significant role at the SSSA. To conduct this MNA evaluation after the source has been reliably controlled by the P&T system, the optimization team suggests temporarily discontinuing operation of the downgradient remedies (IWS and ORC injections). They would be shut down so that they do not interfere with the evaluation of MNA by either artificially adding dissolved oxygen or changing groundwater flow paths. With the source controlled and no operating downgradient remedies to interfere with the evaluation, monitoring can occur quarterly for 2 years for BTEX, naphthalene, dissolved iron, nitrate, sulfate, ferrous iron, oxygen reduction potential (ORP), and other field parameters. Trends in these parameters over eight quarters should give an idea of the plume stability or the potential extent of contaminant migration that could be expected in the absence of a contaminant source and downgradient remedies. The optimization team suggests quarterly sampling for this period because groundwater flow and contaminant transport are sufficiently fast that meaningful trends should become apparent in this time frame. The monitoring program should likely include the same wells that are currently sampled for analysis of BTEX and naphthalene, the wells that are sampled for analysis of dissolved oxygen and other parameters as part of the ORC monitoring, and a few other wells, for a total of approximately 50 wells. The monitoring (excluding laboratory analysis, which is conducted by the CLP program) would cost approximately $200,000 over 2 years ($25,000 per event for eight events). Analytical modeling, data interpretation, and a report will likely cost another $30,000. Some of this monitoring is already conducted and there will also be costs avoided by not operating the remedies, so this approach will actually save approximately $200,000 over the 2-year period.

At the end of the analysis, the site team can evaluate whether natural attenuation is sufficient to adequately limit plume migration and remediate the plume in a timely manner. If natural attenuation is determined to be sufficient, then the downgradient remedies can remain shut down and the groundwater monitoring program can be streamlined appropriately. If natural attenuation is determined not to be sufficient, then the site team will need to evaluate whether the existing downgradient remedies will make a meaningful contribution to remediation, if different locations for the remedies are needed, or if other remedial technologies are merited. With robust source control, persistent BTEX concentrations downgradient would likely be the result of ongoing contamination from the Foote Oil site.

6.4.3 USE SVE FOR SOURCE AREA VADOSE ZONE INSTEAD OF ISCO

The site team should also simultaneously focus on mass removal to accelerate site closure. In light of the concerns the optimization team highlighted regarding ISCO in the vadose zone coupled with the success of SVE in the vadose zone, the optimization team highly recommends that the site team abandon the use of ISCO in the vadose zone and use SVE for vadose zone remediation. Although SVE will not remove the heavier fraction PAHs, it will remove the BTEX and lighter PAHs (such as naphthalene) through volatilization and aerobic degradation. The heavier fraction PAHs in the vadose zone will be sufficiently immobile that they will not continue to impair groundwater once the lighter PAHs have been removed. Furthermore, remaining heavier PAHs will be sufficiently deep to avoid concerns related to direct contact for future potential receptors because of the source area excavations conducted in 2011. The focus of SVE upgrades will be on remediating the intermediate and deep vadose zones by adding new intermediate and deep SVE wells.

The optimization team recommends conducting up to 20 borings using sonic drilling based on the 2003 direct-push sample results and the 2005 (sonic sample results). Cores should be field screened with a PID and soil samples should be collected every 10 feet and analyzed for BTEX and naphthalene. Although the borings are primarily intended for screening the vadose zone, the borings should extend to 140 feet bgs (into the saturated zone) so that the saturated zone can be characterized for future saturated zone remedial efforts. Where appropriate based on field screening, the borings should be completed as 2-inch wells. The wells could include screened intervals for vapor extraction, groundwater extraction and injection, or both. The wells with screened intervals in the vadose zone could then be tested for vapor concentrations, flow rate, and radius of influence. Some of the new wells and the existing wells can be used to measure induced vacuum when evaluating the radius of influence. The site team may choose to coordinate this drilling with the drilling described in Section 6.1.1 to reduce mobilization costs because this recommendation can be implemented simultaneously with Section 6.1.1. The optimization team expects that the large majority of the 20 borings will be converted into SVE wells and therefore has suggested this approach in place of separate characterization and well installation activities.

New SVE wells with high potential for mass removal can be plumed into the existing SVE system. Sufficient blower capacity is available to add several SVE wells, and more capacity is available if existing wells with low vapor concentrations are operated on a rotating basis. There should be no need to add blower capacity.

The optimization team estimates that the costs for the borings and well installation, including planning, drilling, oversight, field screening, laboratory analysis, and well installation may be as high as $400,000. The vapor concentration, flow, and radius of influence testing may cost an additional $50,000, and connecting the wells to the existing SVE system may cost an additional $60,000. The optimization team believes these are upper-range costs based on a large number of the borings being converted to SVE wells. Operation of the SVE system with the additional wells would be approximately the same as the current system unless thermal treatment is needed for the off-gas. If thermal treatment is needed or used for the off-gas, the optimization team recommends considering reinjection of the hot treated air into the subsurface to enhance volatilization and mass removal. Heated air would need to be injected through steel pipe and steel wells because of the high temperatures. It may be necessary to heat soils only in the upper 50 or 75 feet because the majority of the remaining contamination is located in these shallow and intermediate soils. A cost evaluation of this heating approach is not provided because it is heavily dependent on the results of the testing and the composition of the off-gas.

While the borings, testing, and SVE operation are conducted, the site team should keep in mind that the primary targets for remediation are the BTEX and lighter PAHs such as naphthalene. Oxygen and carbon dioxide can be monitored in the extracted air to attempt to quantify mass removal through aerobic degradation, which may help eventually transition the remedy to bioventing.

6.4.4 CONSIDER ISCO FOR SOURCE AREA SATURATED ZONE

After several years of enhanced SVE operation, the mobile fraction of contamination should be removed from the vadose zone, and the only remaining residual source for groundwater contamination will be in the saturated zone. Data from the 2005 sonic drilling and from the sonic drilling suggested above should provide a reasonable target volume for ISCO application. The site team can evaluate the P&T system, the soil characterization data, and potential ISCO costs to determine if ISCO can meaningfully and cost-effectively reduce the duration of the remedy. ISCO will likely be costly because of the depth of application and the high oxidant demand. Wells with saturated zone screened intervals installed per Section 6.4.3 could be used for pilot testing ISCO applications to refine estimates of oxidant demand and the radius of influence of the injections. The site team could use the pilot test results to refine cost estimates and evaluate the merits of ISCO. Assuming pilot injection wells are in place based on the drilling described in Section 6.4.3, a meaningful pilot test could be planned, executed, and evaluated for under $100,000. Full-scale implementation would likely cost several million dollars.

6.5 RECOMMENDATIONS RELATED TO GREEN REMEDIATION

No specific green remediation recommendations are provided, but the focus of a remedial strategy on source control and timely discontinuation of the downgradient remedies will generally reduce resource use and waste generation. Additional considerations provided above—including reinjecting treated water, converting exploratory borings into remedy wells, and reinjecting process heat into the subsurface—also reduce resource use and waste generation.

6.6 SUGGESTED APPROACH TO IMPLEMENTING RECOMMENDATIONS

The suggested approach to implementing the recommendations is described in Section 6.4 as part of the suggested remedial strategy.

Table 6-1. Cost Summary Table

Recommendation	Category	Additional Capital Cost	Change in Annual Cost	Change in Life-Cycle Cost (3% discount rate)
6.1.1 CONDUCT A GROUNDWATER CAPTURE-ZONE ANALYSIS	Effectiveness	$137,000 (lower if existing vent wells can be used)	$0	$137,000 (lower if existing vent wells can be used)
6.1.2 EXPAND GROUNDWATER EXTRACTION AND TREATMENT CAPACITY	Effectiveness	$80,000 to $230,000	Higher but not estimated	Not quantified
6.1.3 REDUCE SYSTEM DOWNTIME	Effectiveness	$10,000	$0	$10,000
6.3.1 IMPROVE AND REFINE REPORTING	Technical Improvement	Negligible	Negligible	Negligible
6.4.1 ACHIEVE SOURCE CONTROL WITH THE P&T SYSTEM	Site Closure	See 6.1.1, 6.1.2, and 6.1.3		
6.4.2 EVALUATE MONITORED NATURAL ATTENUATION FOR THE DOWNGRADIENT PLUME WHEN THE SOURCE IS CONTROLLED	Site Closure	($200,000) Over a 2-year period	Not quantified	Not quantified
6.4.3 USE SVE FOR SOURCE AREA VADOSE ZONE INSTEAD OF ISCO	Site Closure	$510,000	Not quantified	Not quantified
6.4.4 CONSIDER ISCO FOR SOURCE AREA SATURATED ZONE	Site Closure	$100,000 for pilot test Several million dollars for full-scale implementation		

ATTACHMENT A

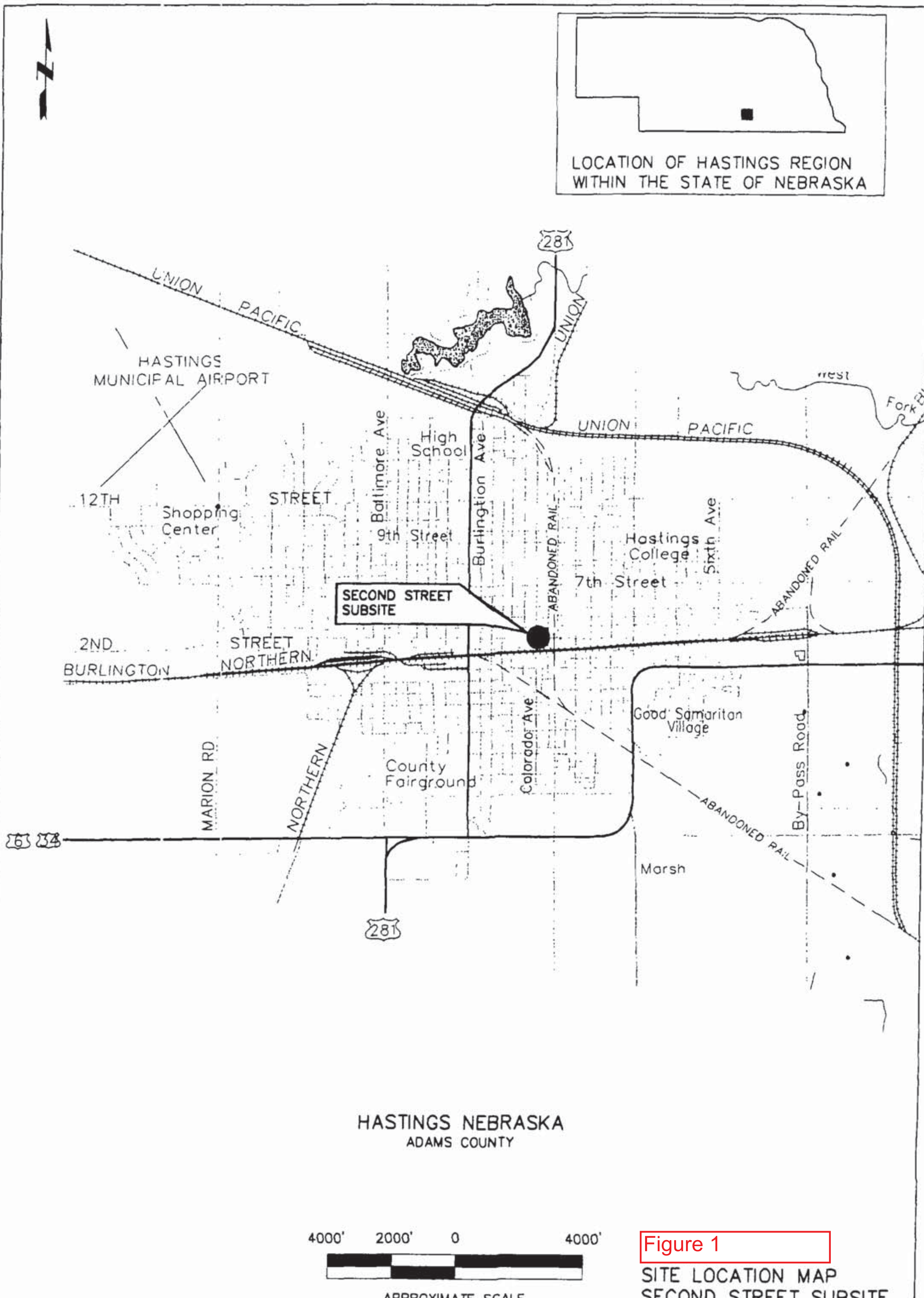
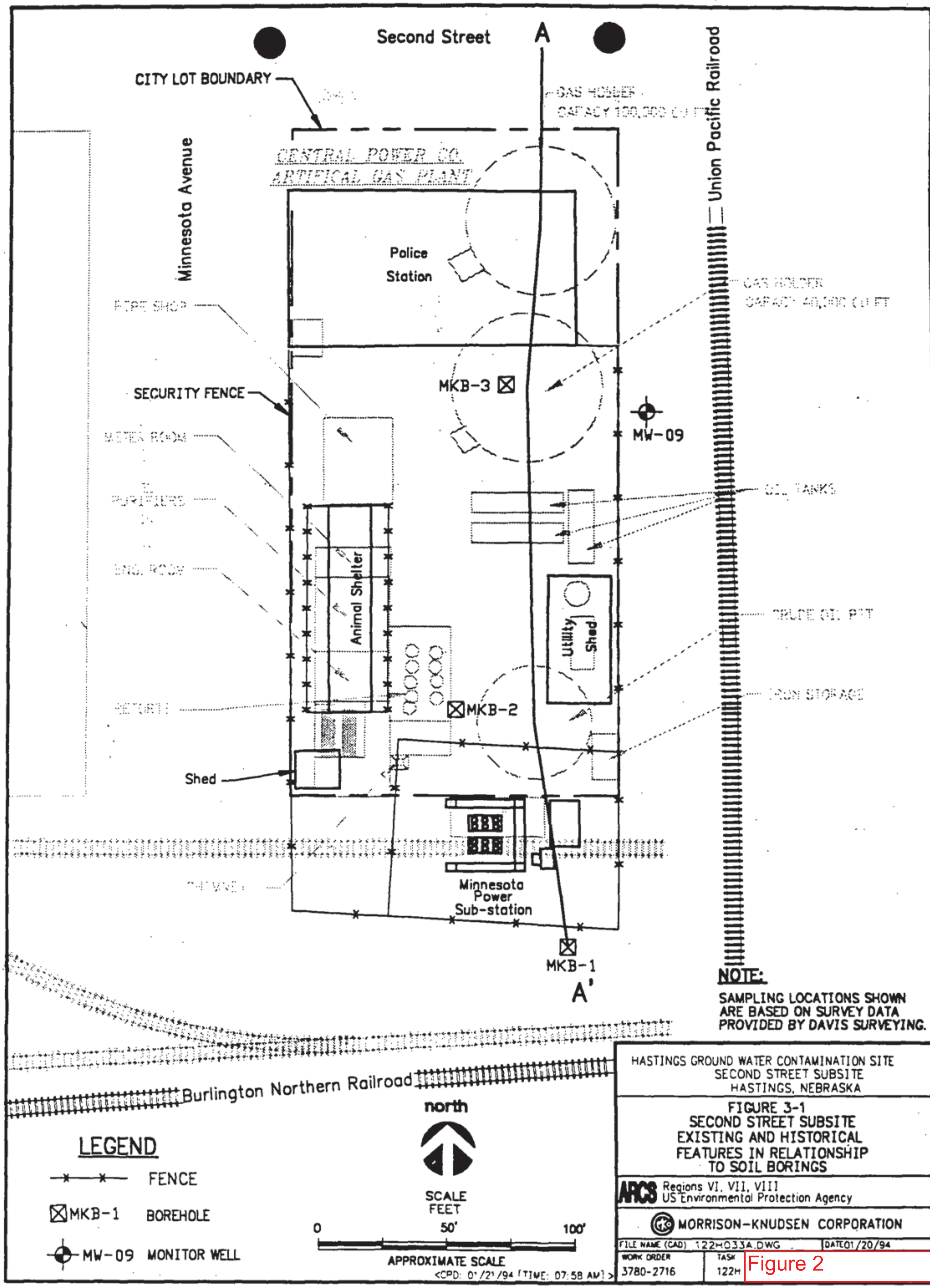


Figure 1

SITE LOCATION MAP
SECOND STREET SUBSITE
HASTINGS NEBRASKA
INTERIM REMEDIAL ACTION REPORT

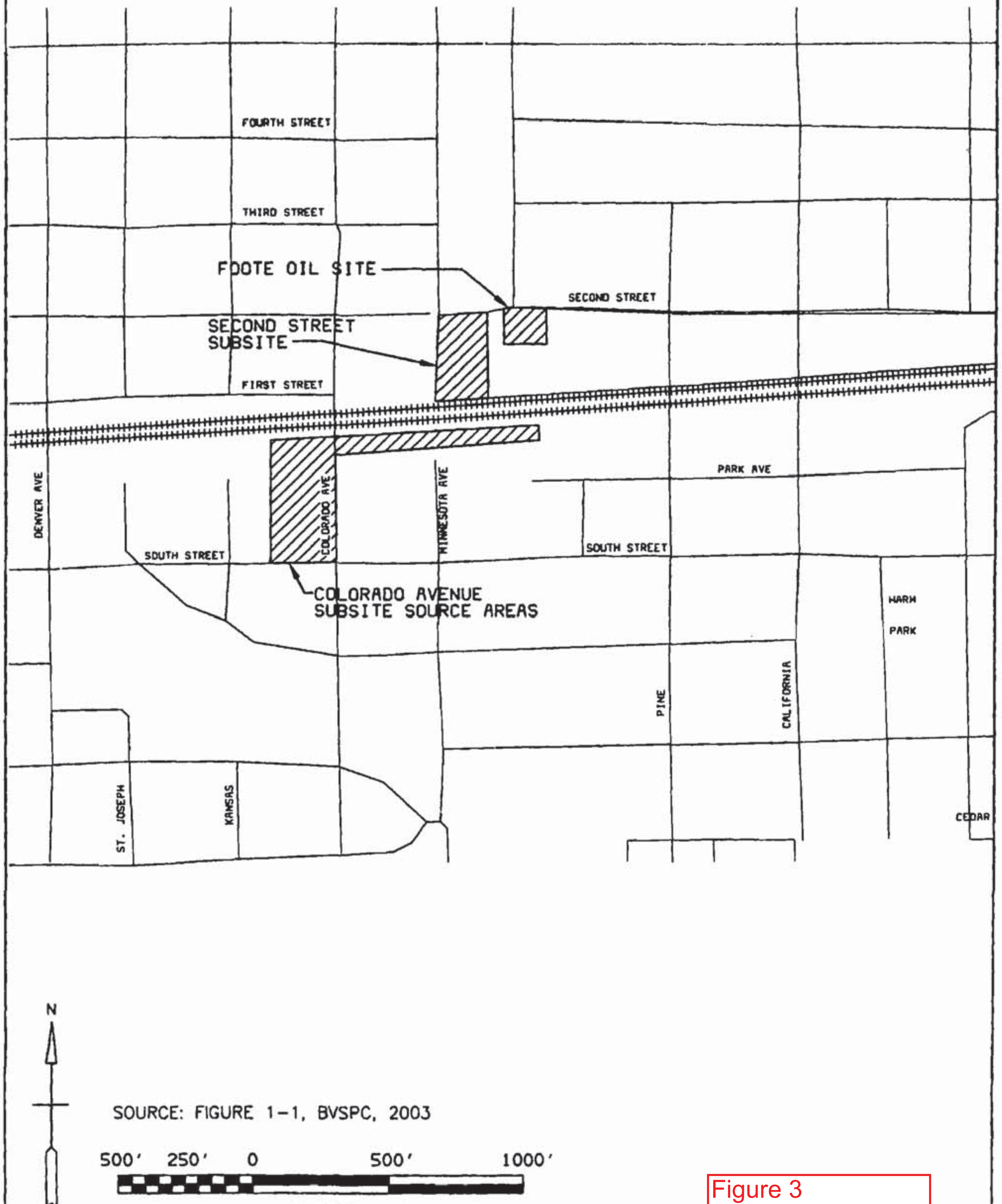
PLOTTER: HP1055 PEN TABLE: Half PLOT SCALE: 1=1 Original dwg size 17 x 11 Revised By: new02908 ON Mar 13, 2007 @ 6:27pm
Drawing: Z:\Projects\44718-Hastings. NE\Dwg\C0008169.dwg ACAD 16.1s (LMS Tech) Plot By: pro03299 Mar 28, 2007, 04:17pm Attached Xref: LOCATION-MAP



Second Street
A
CITY LOT BOUNDARY
Union Pacific Railroad
Minnesota Avenue
CENTRAL POWER CO.
ARTIFICAL GAS PLANT
Police
Station
SECURITY FENCE
MKB-3
MW-09
OIL TANKS
Animal Shelter
Utility
Shed
IRON STORAGE
MKB-2
Shed
Minnesota
Power
Sub-station
MKB-1
A'
NOTE:
SAMPLING LOCATIONS SHOWN ARE BASED ON SURVEY DATA PROVIDED BY DAVIS SURVEYING.
Burlington Northern Railroad
north
LEGEND
FENCE
MKB-1 BOREHOLE
MW-09 MONITOR WELL
SCALE
FEET
0
50'
100'
APPROXIMATE SCALE
HASTINGS GROUND WATER CONTAMINATION SITE
SECOND STREET SUBSITE
HASTINGS, NEBRASKA
FIGURE 3-1
SECOND STREET SUBSITE
EXISTING AND HISTORICAL
FEATURES IN RELATIONSHIP
TO SOIL BORINGS
ARCS Regions VI, VII, VIII
US Environmental Protection Agency
MORRISON-KNUDSEN CORPORATION
FILE NAME (CAD) 122H033A.DWG
DATE 01/20/94
WORK ORDER 3780-2716
TASK 122H

Figure 2

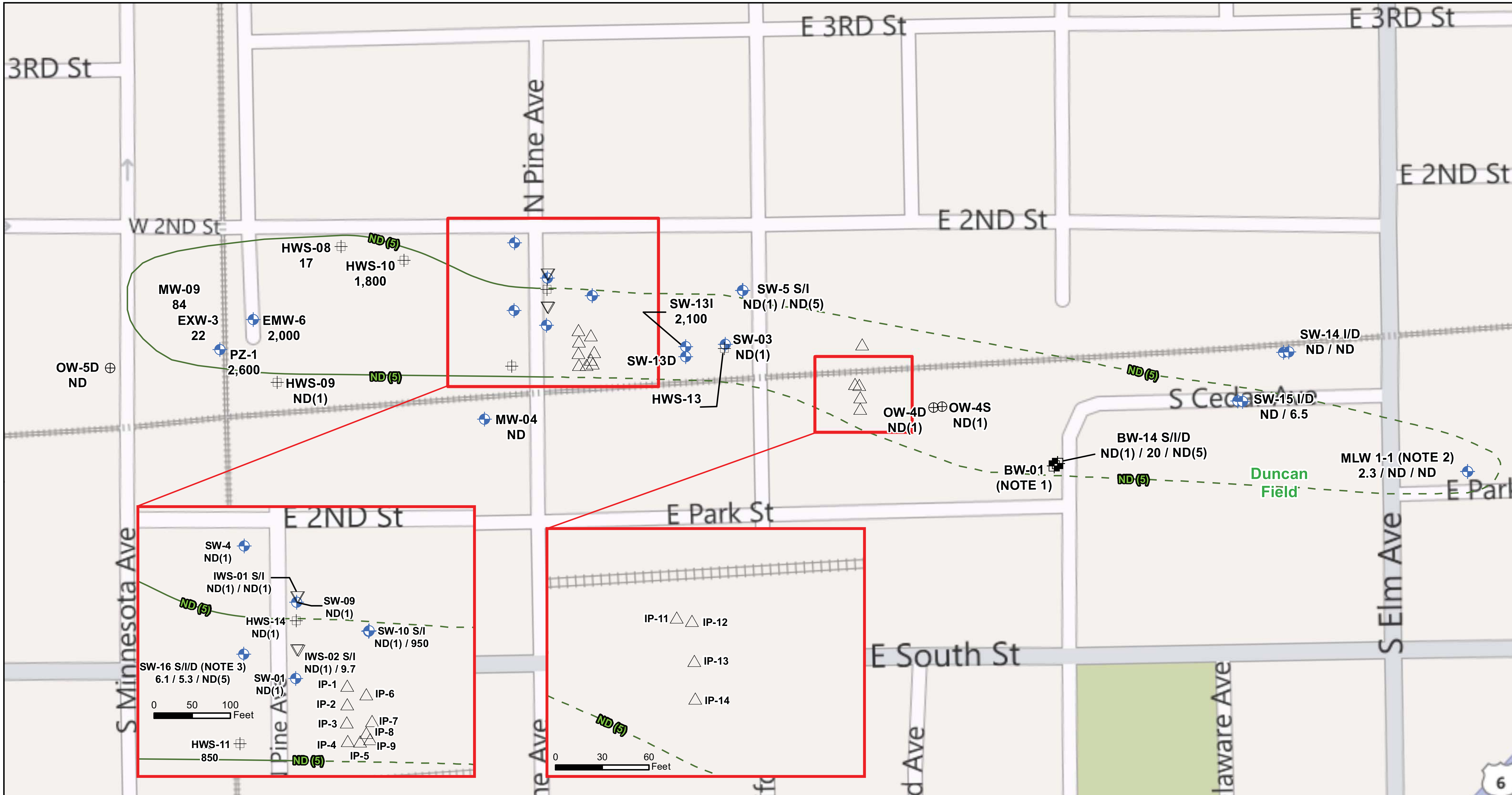
Attachment A



SOURCE: FIGURE 1-1, BVSPC, 2003

Figure 3

LOCATION MAP



Legend

- EPA Monitoring Well
- State Monitoring Well
- Foote Oil Monitoring Well
- Colorado Avenue Monitoring Well
- Treatment Point
- Passive Treatment Well
- Extraction Well
- IWS Treatment Well

ND (2) Benzene not detected at concentration in µg/L shown in parantheses

NS Not Sampled

Estimated Benzene Concentration Contour (µg/L) (Dashed where inferred)

Notes:

1. Well BW-1 not sampled. It is shown for clarity because it is a slow oxygen release treatment well.
2. Four depths of well MLW-1 sampled: 155, 175, 195, and 210 feet bgs.
3. Three depths of well SW-16 sampled: 144, 150, and 195 feet bgs.
4. Lowest Benzene contour set at Benzene MCL, 5 µg/L.

N

0 200 400
Feet
1 in = 200 ft

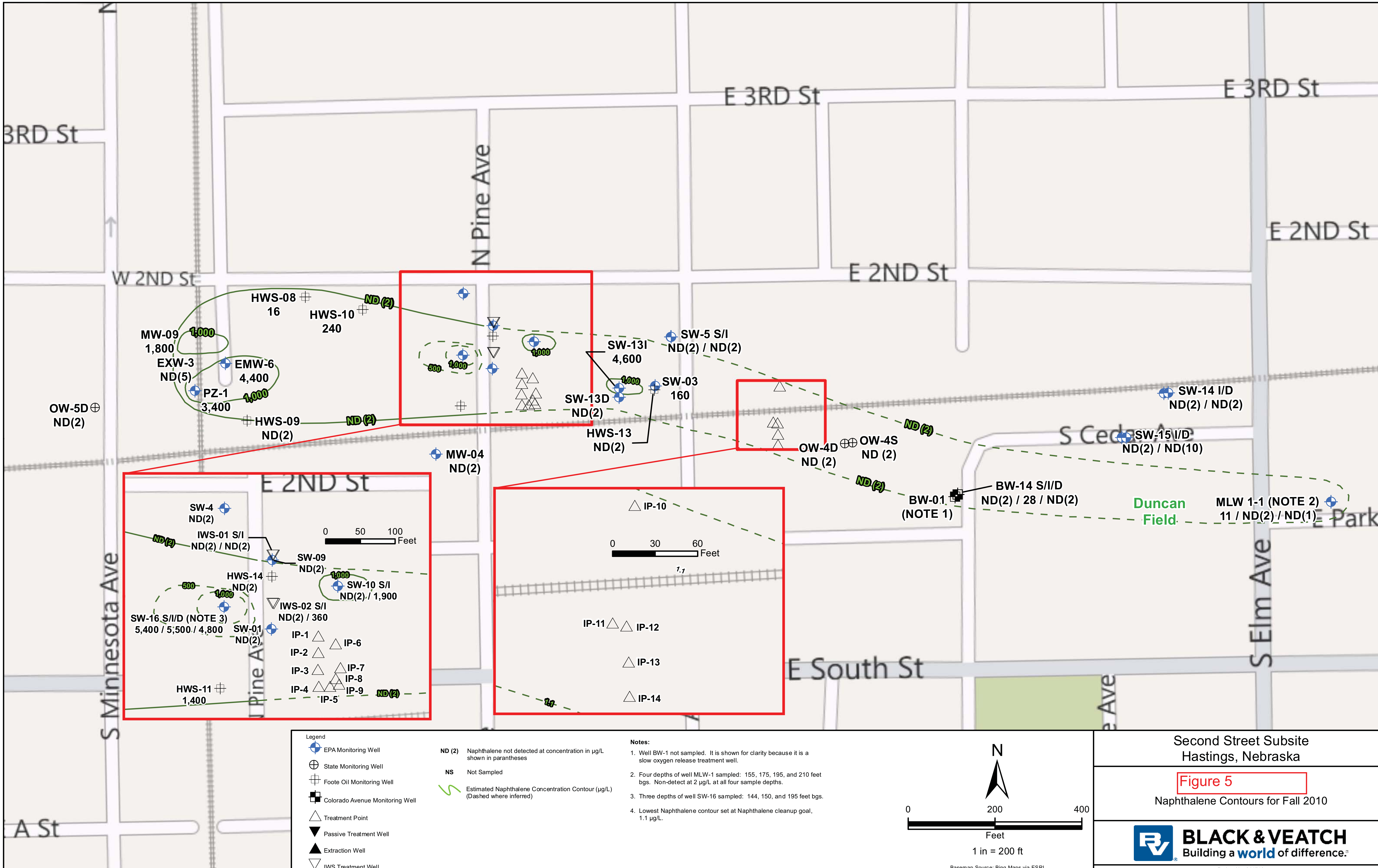
Second Street Subsite
Hastings, Nebraska

Figure 4

Benzene Contours for Fall 2010

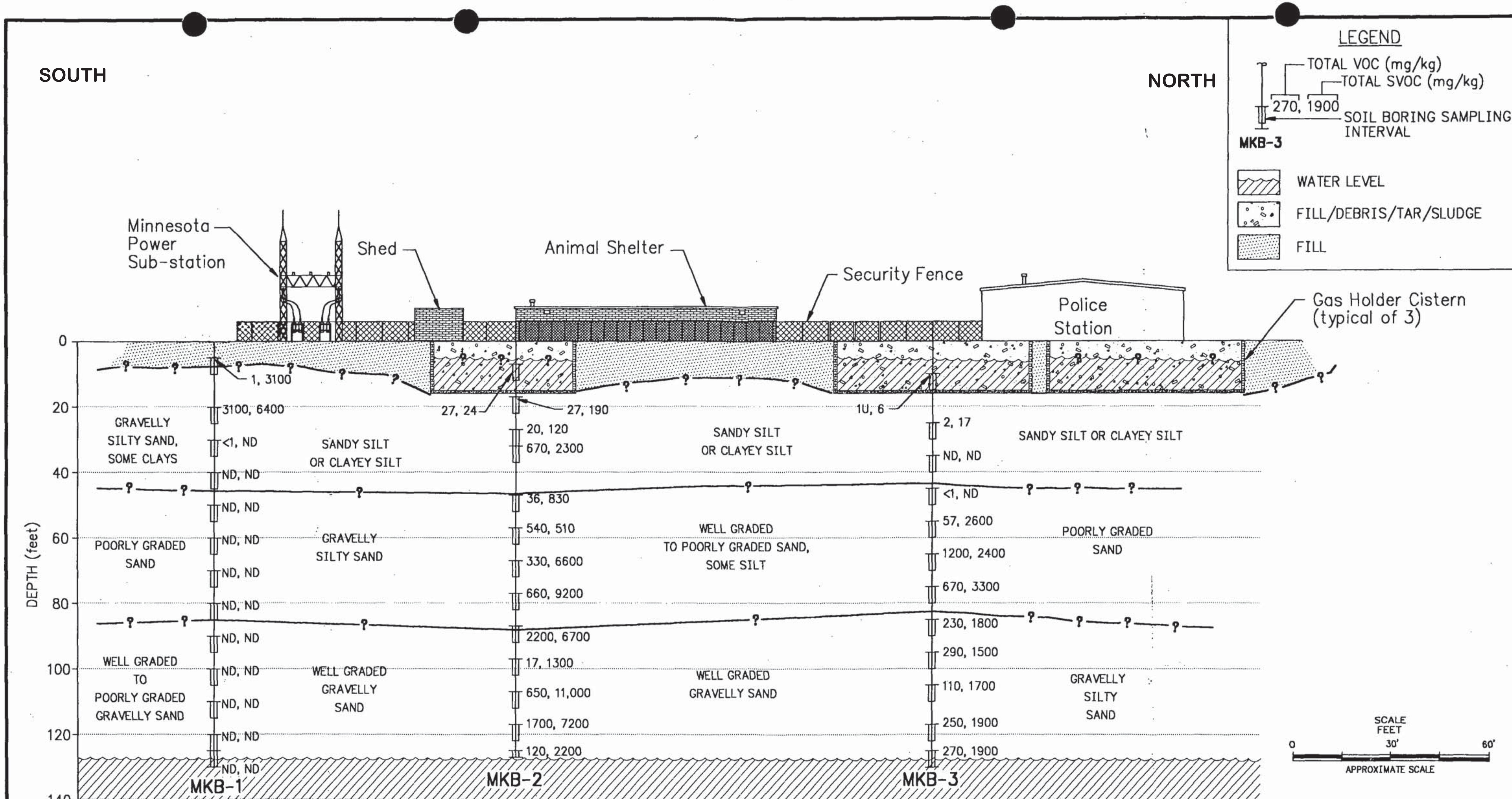
BLACK & VEATCH
Building a world of difference.

Project No: 044718



Date Saved: 7/12/2011 8:45:01 AM

User: gal45834
C:\Projects\EPA\Hastings\MXDs\Fig42_Naphthalene_Contours_Fall2010.mxd



NOTES:

1. MKB-2 WAS ACTUALLY DRILLED WEST OF THE GAS HOLDER CISTERN.
2. ND = INTERVAL SAMPLED BUT CONTAMINANTS WERE BELOW ANALYTICAL DETECTION LIMITS.
3. TOTAL VOC AND SVOC NUMBERS ARE ROUNDED TO TWO SIGNIFICANT FIGURES.
4. LOCATIONS AND DEPTHS OF GAS HOLDERS ARE ESTIMATED BASED ON HISTORICAL MAPS AND INFORMATION.
5. CISTERN WATER LEVEL WAS MEASURED IN BORING MKB-3. WATER LEVELS IN OTHER CISTERNS ARE ASSUMED TO BE THE SAME.

HASTINGS GROUND WATER CONTAMINATION SITE
SECOND STREEET SIBSITE
HASTINGS, NEBRASKA

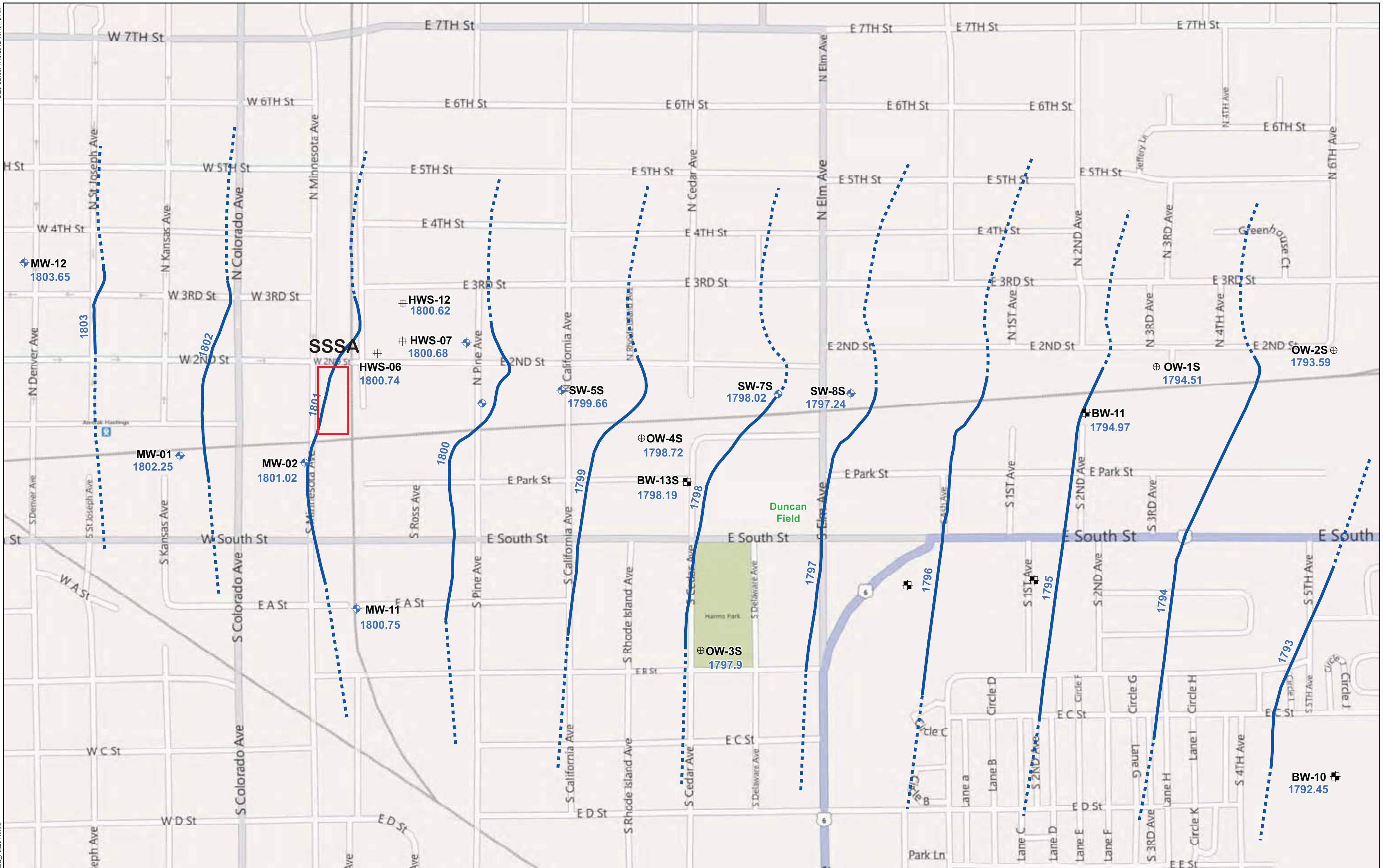
FIGURE 3-2
SECTION VIEW OF EXISTING SURFACE AND VADOSE ZONE FEATURES AND LEVELS OF CONTAMINATION

ARCS Regions VI, VII, VIII
US Environmental Protection Agency

MORRISON-KNUDSEN CORPORATION

FILE NAME (CAD) 122H034A.DWG		DATE 9/21/93
WORK ORDER 3780-2716	TASK 122H	Figure 6

<CPD: 05/09/94 [TIME: 10:12 AM] >



Legend

1802.12 EPA Monitoring Well & Groundwater Elevation, ft above MSL

1802.12 State Monitoring Well & Groundwater Elevation, ft above MSL

1802.12 Foote Oil Monitoring Well & Groundwater Elevation, ft above MSL

1802.12 Colorado Avenue Monitoring Well & Groundwater Elevation, ft above MSL

N

0 350 700

Feet

Second Street Subsite
Hastings, Nebraska

Figure 4
Groundwater Elevation Contours
Upper Portion of Aquifer Wells
Fall 2011

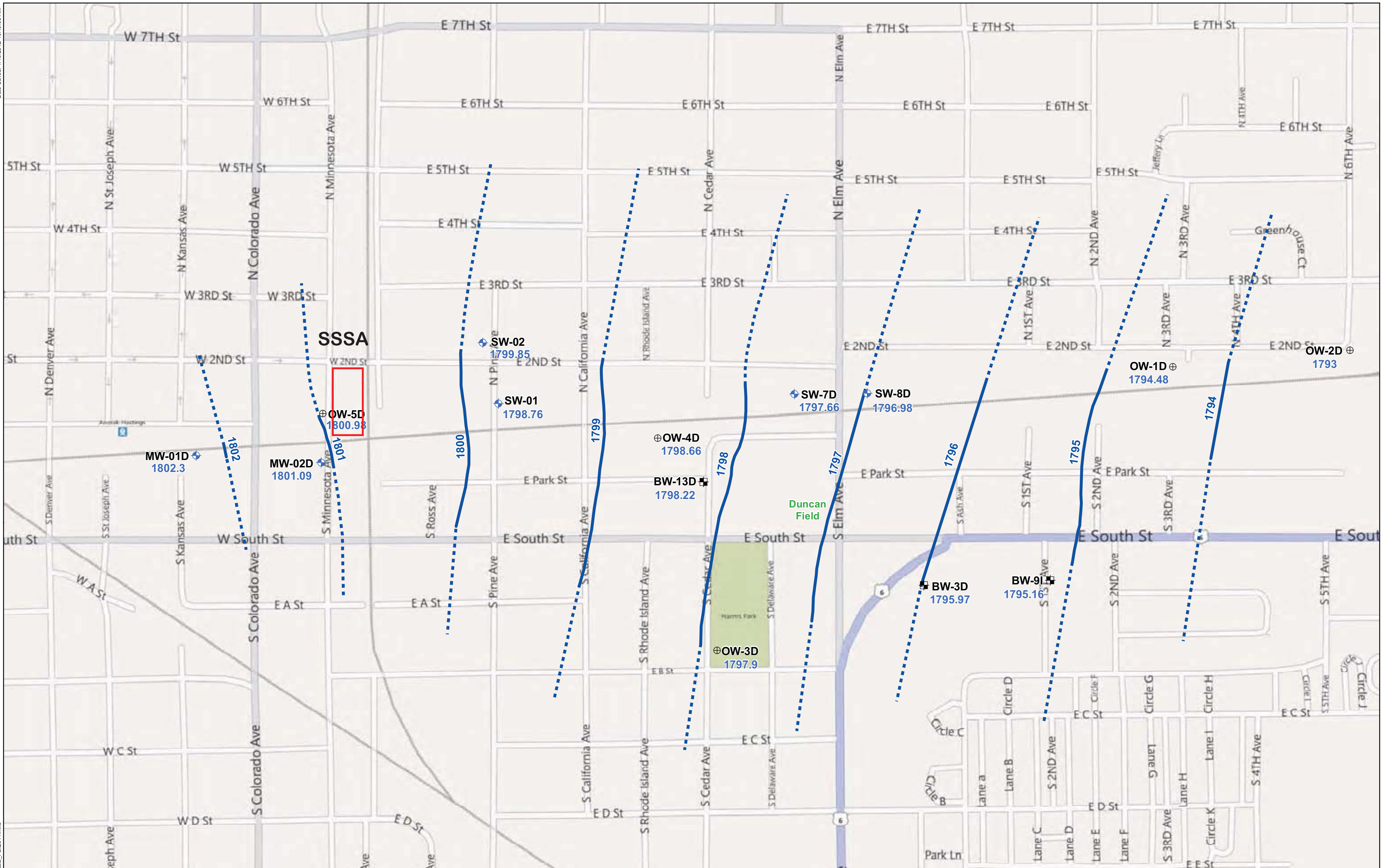
BLACK & VEATCH
Building a world of difference.

Project No: 044718

Figure 7

Date Saved: 1/10/2012 10:10:10 AM

User: fre47957
Path: C:\Projects\Hastings_NE\MXDs\UpperAquifer\GW_Contour_Update_Fall2011.mxd



Second Street Subsite
Hastings, Nebraska

Figure 5
Groundwater Elevation Contours
Lower Portion of Aquifer Wells
Fall 2011

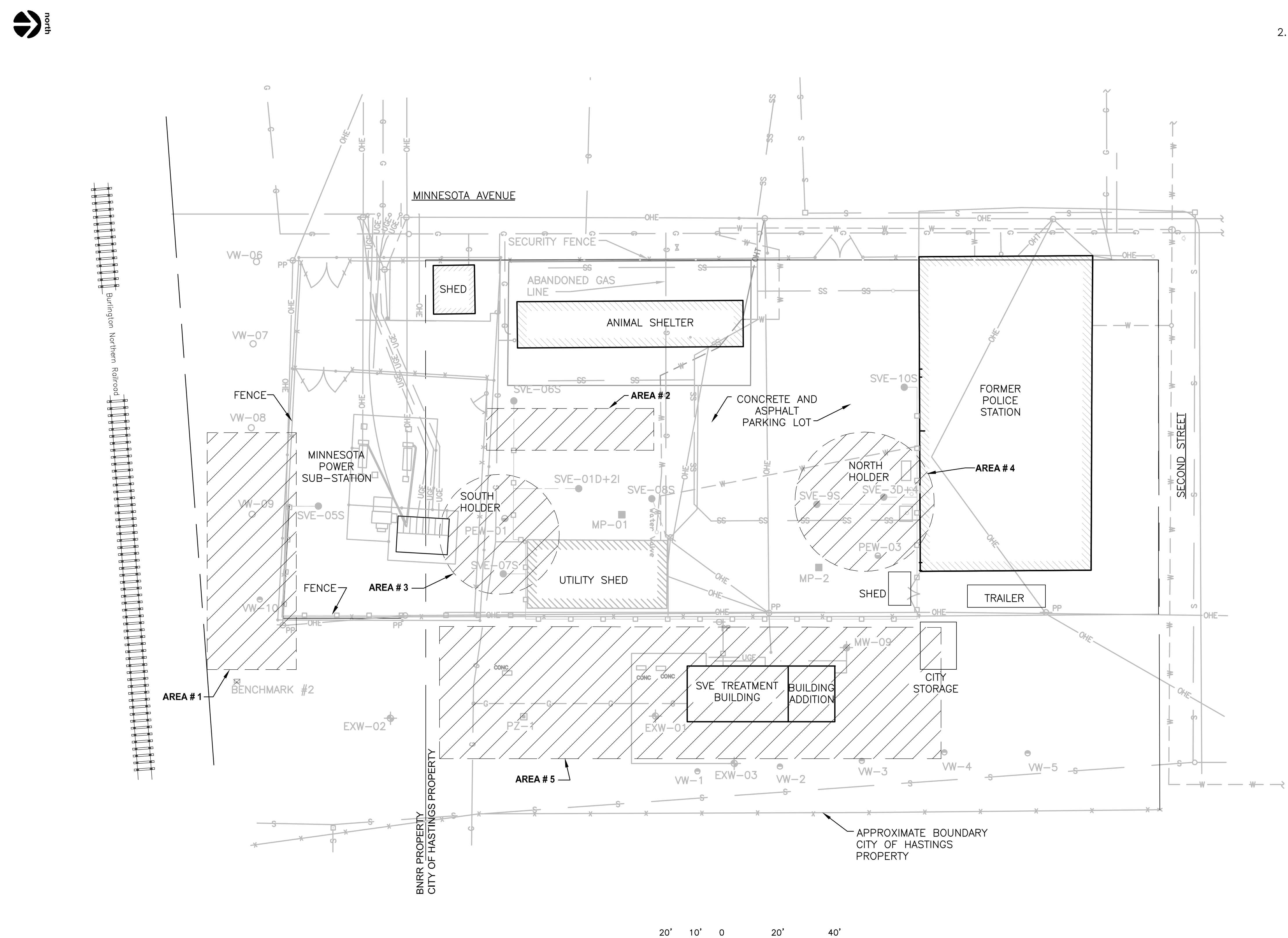
BLACK & VEATCH
Building a world of difference.

Project No: 044718

Figure 8

Date Saved: 1/10/2012 10:49:38 AM

User: fre47957
Path: C:\Projects\Hastings_NE\MXDs\LowerAquifer\GW_Contour_Update_Fall2011.mxd



NOTES

1. LOCATIONS OF EXISTING BUILDINGS, RAILROAD CENTER LINES AND FENCE CORNERS OF THE MINNESOTA SUBSTATION ARE FROM DAVIS SURVEY COMPANY. (1996)
2. PROPERTY BOUNDARY ABSTRACTED FROM MINNESOTA SUBSTATION SITE PLAN DWG NO. E-OH-193 WERE PROVIDED BY HASTINGS UTILITIES.

LEGEND

AREAS TO REMEDIATE
G GAS
S STORM SEWER
W WATER
OHT OVERHEAD TELEPHONE LINE
OHE OVERHEAD ELECTRICAL LINE
UGE BURIED ELECTRICAL LINE
X FENCE LINE
SS SANITARY SEWER
PP POWER POLE
MANHOLE
CATCH BASIN GRATE
GUYWIRE
EXISTING GROUNDWATER PIPE AND POWER CABLE (BELOW GROUND)
SVE AND GROUNDWATER PIPING (ABOVE GROUND)
PROPERTY BOUNDARY LINE
EXTRACTION WELL
VENT WELL
VENT/GROUNDWATER WELL
PERCHED WATER COLLECTION
PIEZOMETER
SVE WELL
MONITORING PROBE
GROUNDING GRID
ABOVE GROUND SVE LINE

Figure 9

EXISTING CONDITIONS
SECOND STREET SUBSITE
OPERABLE UNIT 12

PLOTTER: HP PEN TABLE: Full PLOT SCALE: 1=1 Original dwg size 17 x 11 Revised By: new02908 ON Sep 29, 2008 @ 12:45pm
Drawing: Z:\Projects\044744\dwg\C0008324.dwg ACAD 16.1s (LMS Tech) Plot By: new02908 Sep 29, 2008, 01:24pm Attached Xref: X-Plan

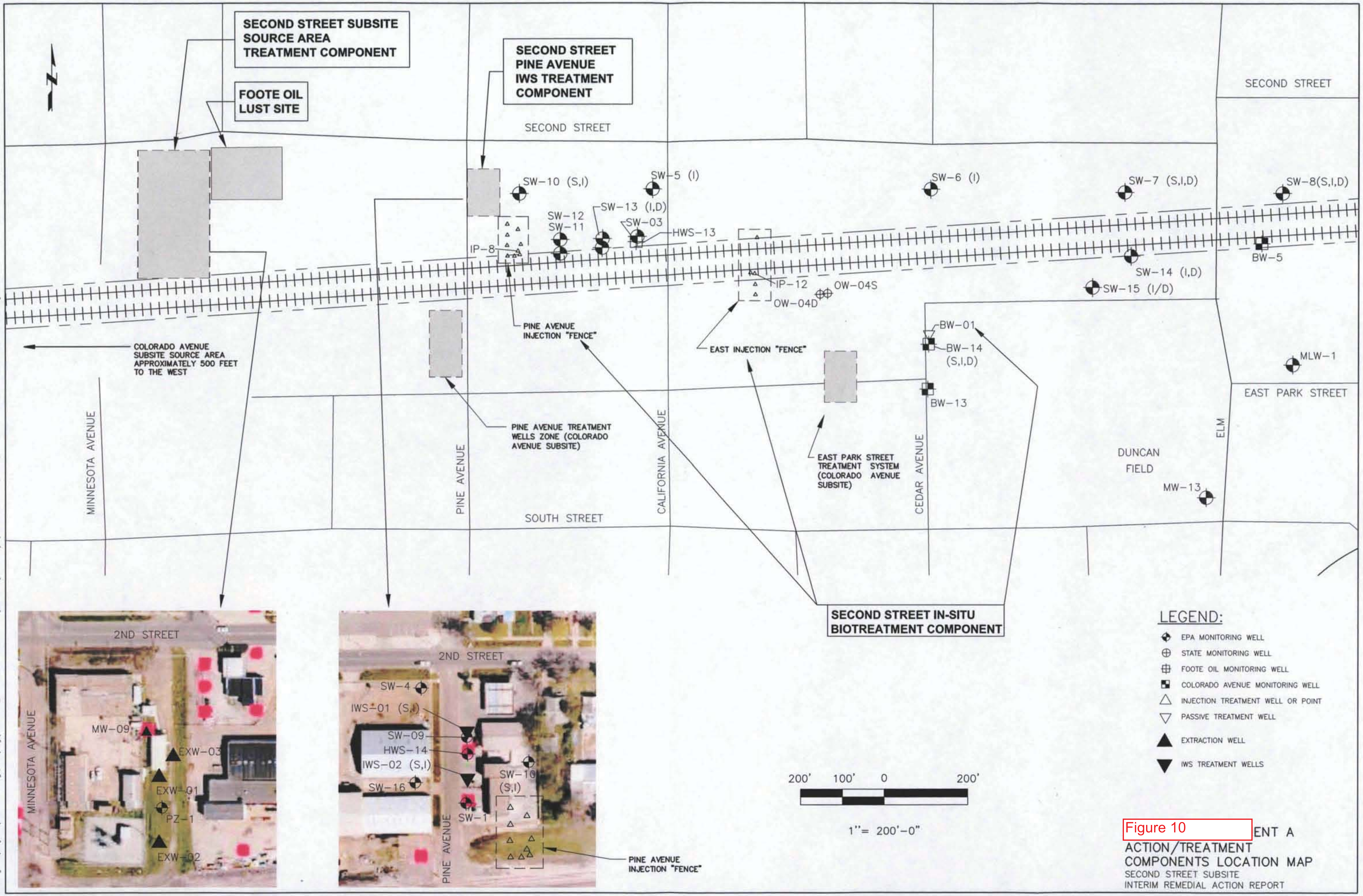
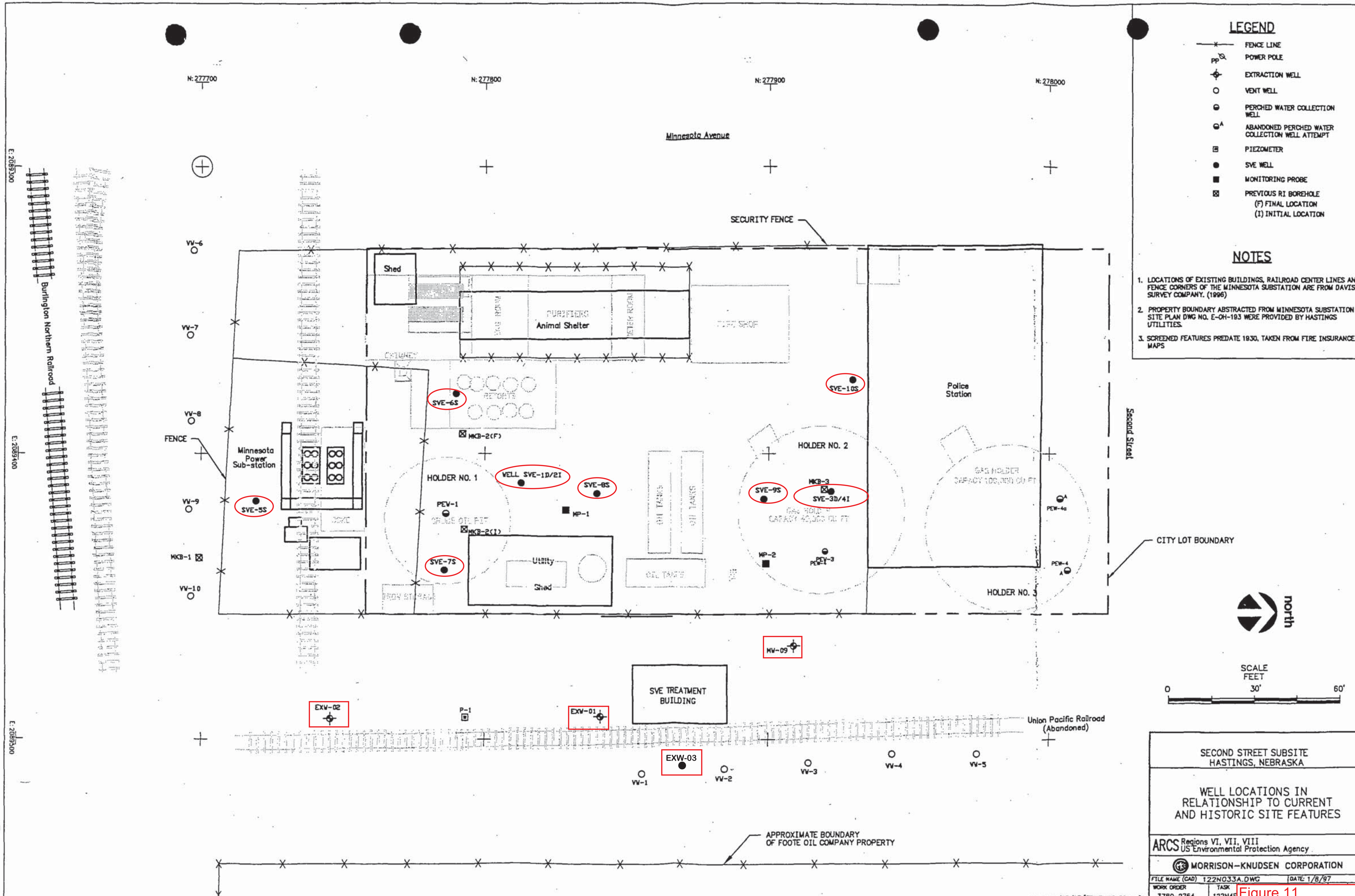


Figure 10 ENT A
ACTION/TREATMENT COMPONENTS LOCATION MAP
SECOND STREET SUBSITE
INTERIM REMEDIAL ACTION REPORT



LEGEND
FENCE LINE
POWER POLE
EXTRACTION WELL
VENT WELL
PERCHED WATER COLLECTION WELL
ABANDONED PERCHED WATER COLLECTION WELL ATTEMPT
PIEZOMETER
SVE WELL
MONITORING PROBE
PREVIOUS RI BOREHOLE
(F) FINAL LOCATION
(I) INITIAL LOCATION
NOTES
1. LOCATIONS OF EXISTING BUILDINGS, RAILROAD CENTER LINES AND FENCE CORNERS OF THE MINNESOTA SUBSTATION ARE FROM DAVIS SURVEY COMPANY. (1996)
2. PROPERTY BOUNDARY ABSTRACTED FROM MINNESOTA SUBSTATION SITE PLAN DWG NO. E-OH-193 WERE PROVIDED BY HASTINGS UTILITIES.
3. SCREENED FEATURES PREDATE 1930, TAKEN FROM FIRE INSURANCE MAPS
N: 277700
N: 277800
N: 277900
N: 278000
Minnesota Avenue
E: 2089300
E: 2089400
E: 2089500
Burlington Northern Railroad
SECURITY FENCE
Shed
PURIFIERS
Animal Shelter
SVE-10S
Police Station
SVE-6S
MKB-2(F)
FENCE
Minnesota Power Sub-station
HOLDER NO. 1
WELL SVE-1D/2I
SVE-8S
HOLDER NO. 2
SVE-9S
MKB-3
SVE-3D/4I
Second Street
PEW-4a
SVE-5S
PEV-1
MP-1
MKB-2(I)
CITY LOT BOUNDARY
SVE-7S
Utility Shed
MP-2
PEV-3
PEW-4
HOLDER NO. 3
VV-6
VV-7
VV-8
VV-9
MKB-1
VV-10
MW-09
north
SCALE FEET
0
30'
60'
SVE TREATMENT BUILDING
EXW-02
P-1
EXW-01
Union Pacific Railroad (Abandoned)
EXW-03
VV-1
VV-2
VV-3
VV-4
VV-5
APPROXIMATE BOUNDARY OF FOOTE OIL COMPANY PROPERTY
SECOND STREET SUBSITE
HASTINGS, NEBRASKA
WELL LOCATIONS IN RELATIONSHIP TO CURRENT AND HISTORIC SITE FEATURES
ARCS Regions VI, VII, VIII
US Environmental Protection Agency
MORRISON-KNUDSEN CORPORATION
FILE NAME (CAD) 122NO33A.DWG
DATE: 1/8/97
WORK ORDER 3780-2764
TASK 122N48
CPD: 02/27/97 [TIME: 09:22 AM]

Figure 11

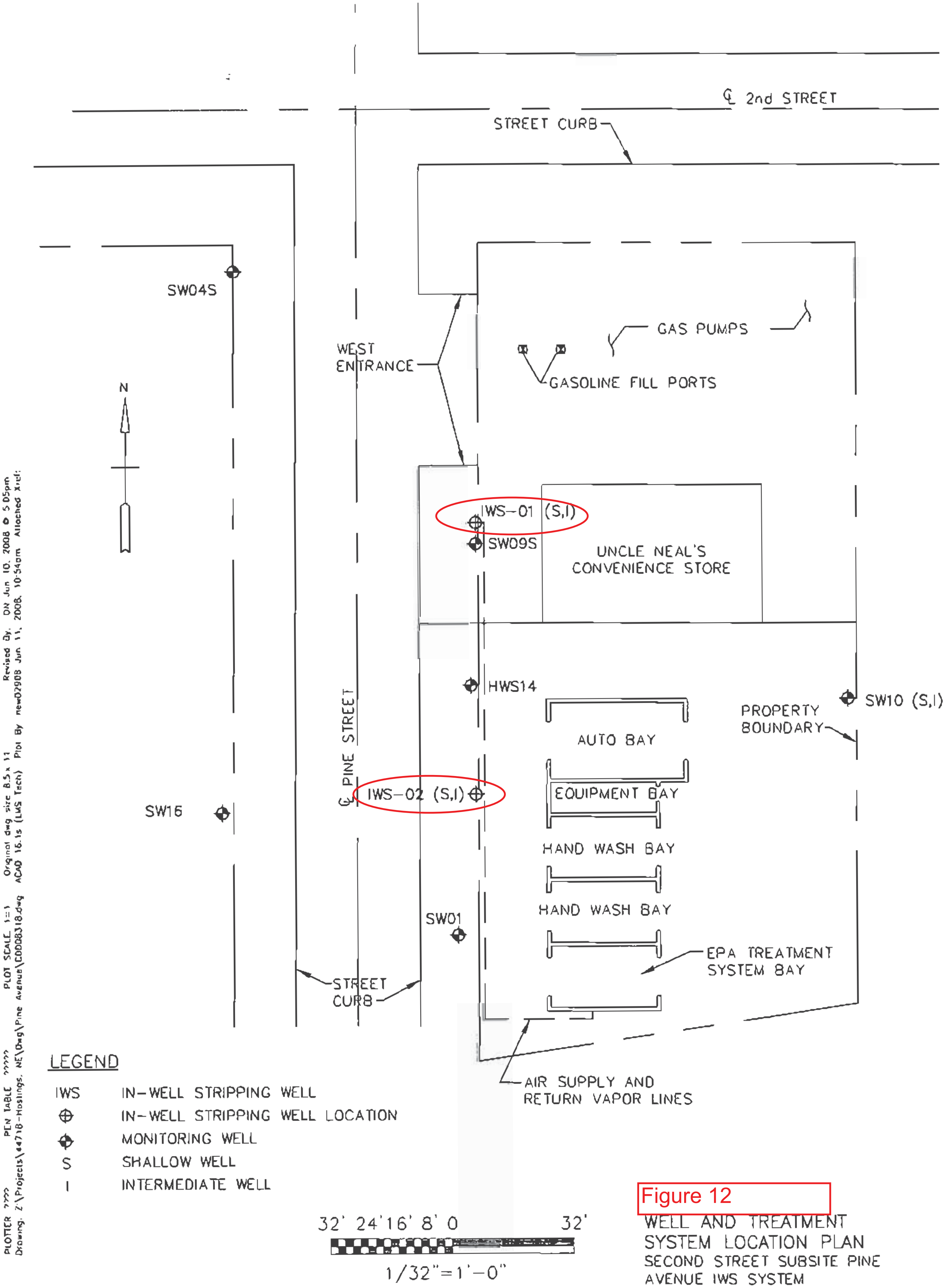
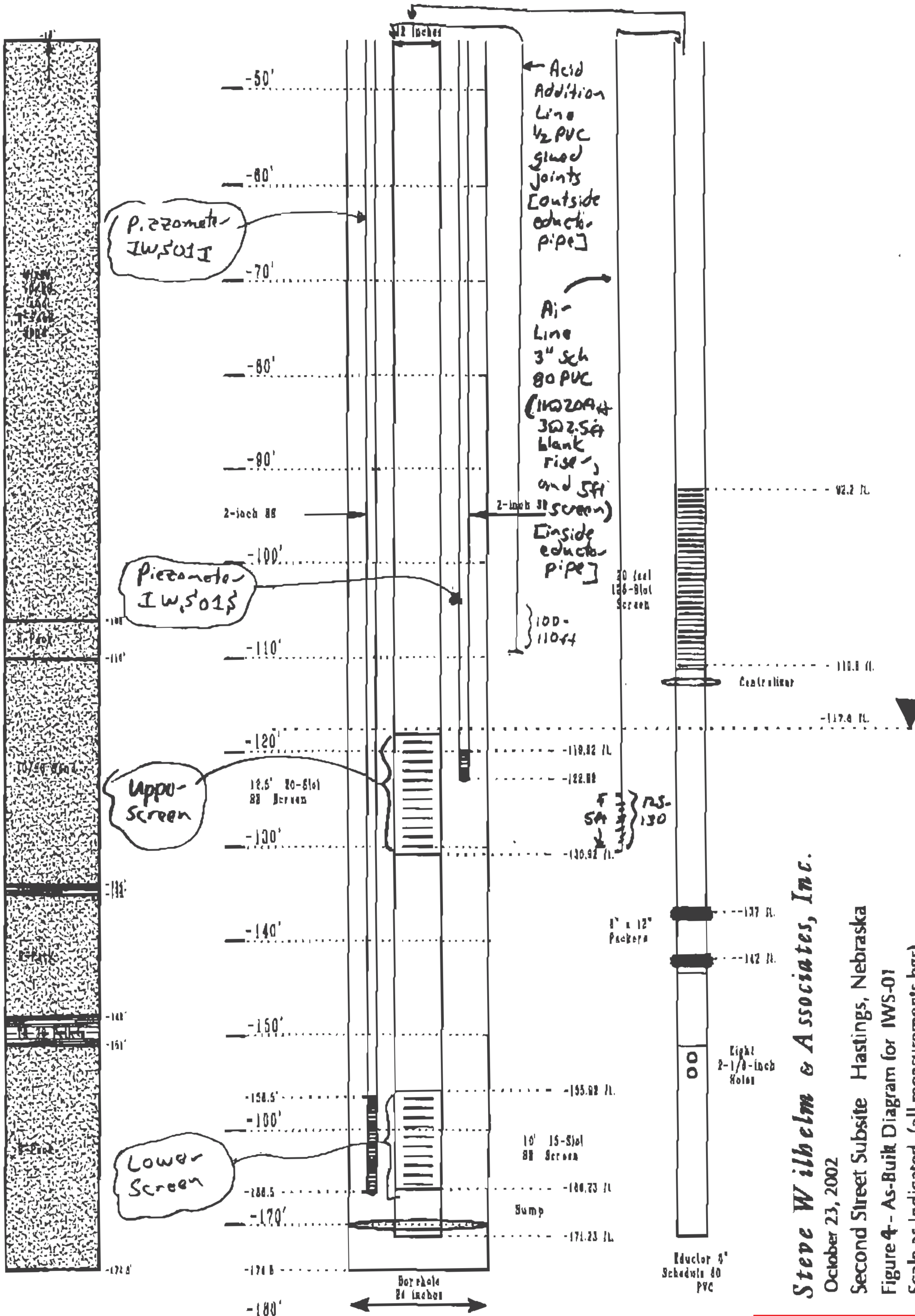


Figure 12
WELL AND TREATMENT SYSTEM LOCATION PLAN
SECOND STREET SUBSITE PINE AVENUE IWS SYSTEM



Steve Wilhelm & Associates, Inc.

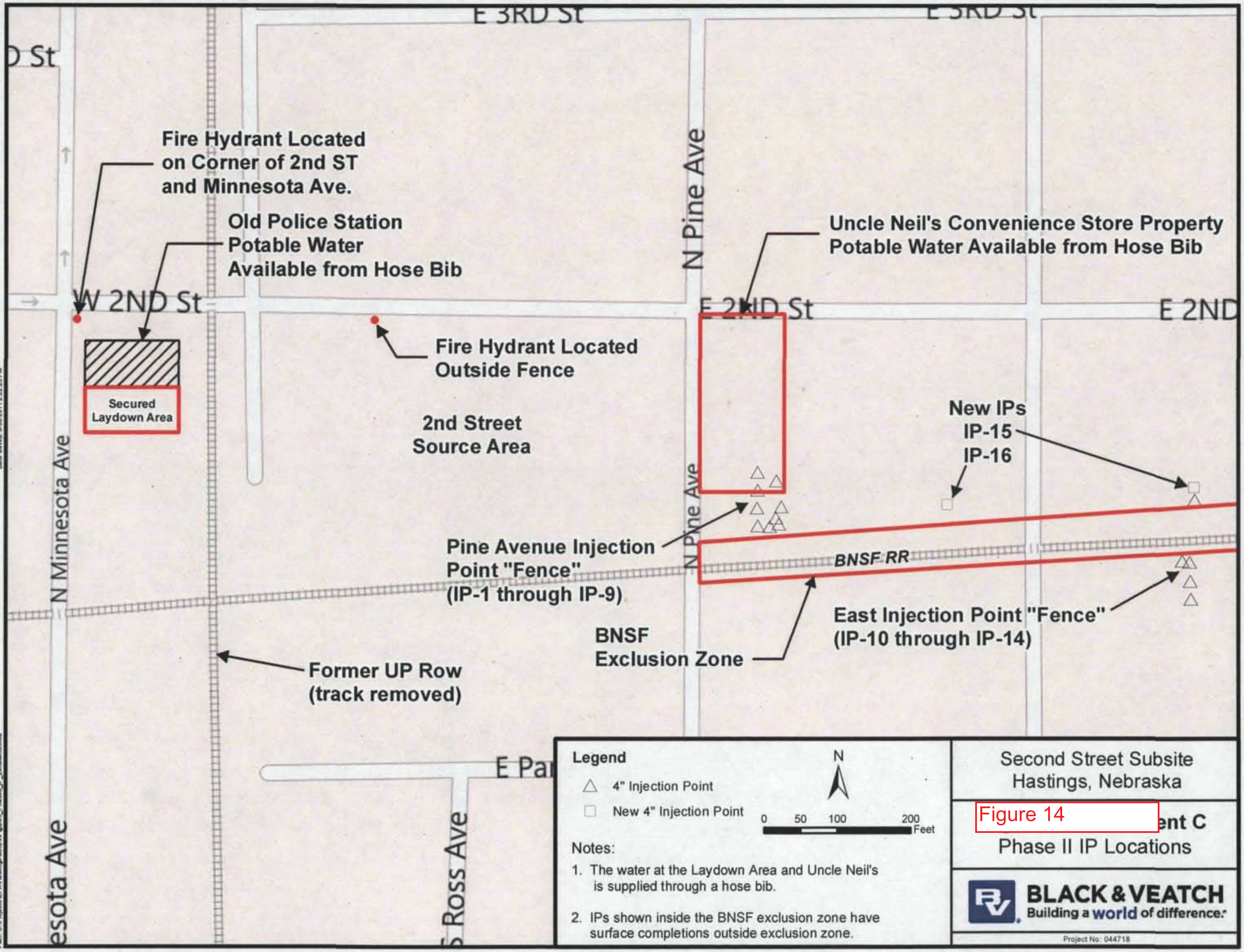
October 23, 2002

Second Street Subsite Hastings, Nebraska

Figure 4 - As-Built Diagram for IWS-01

Scale as Indicated (all measurements bgs)

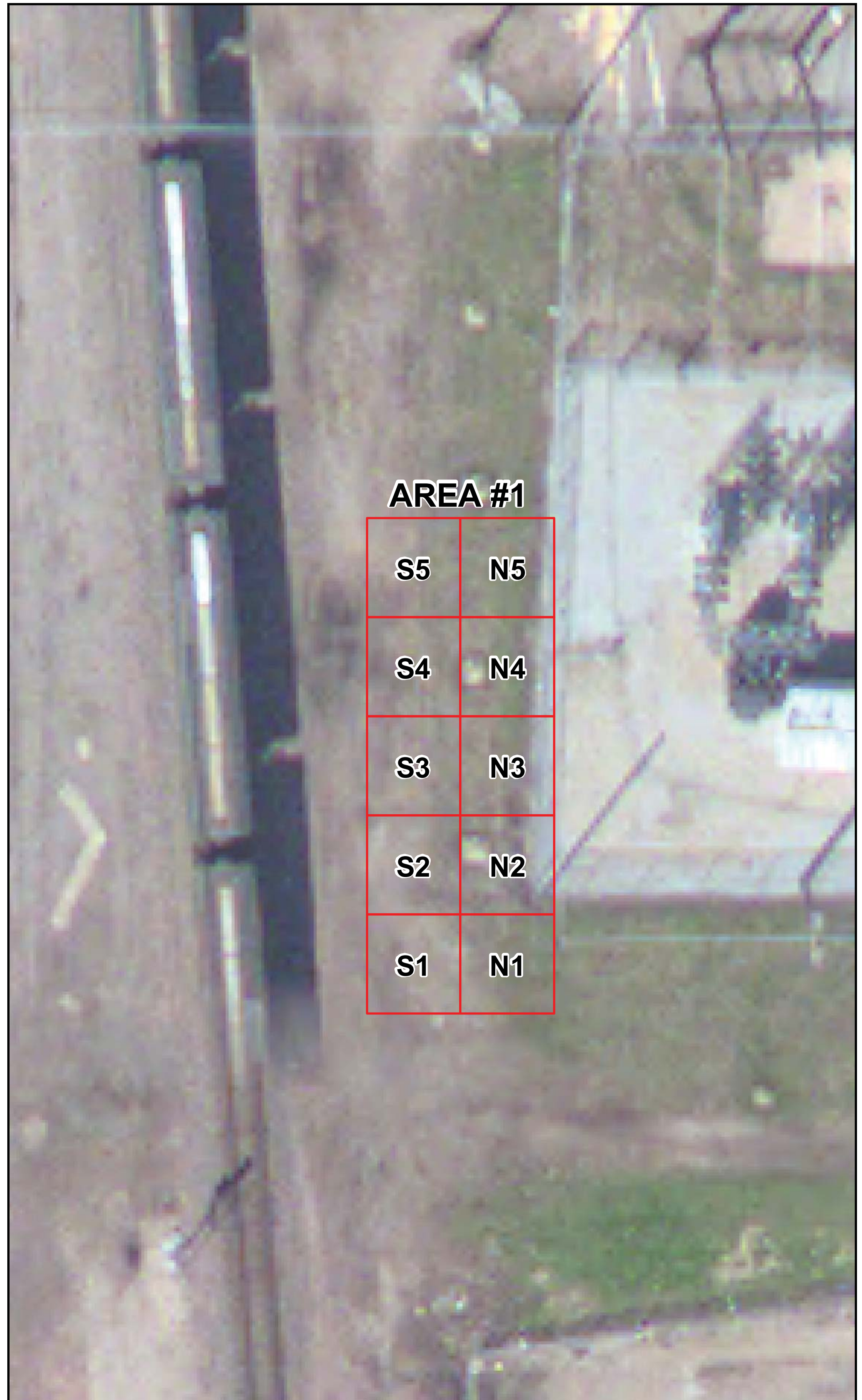
Figure 13


E 3RD St
E 3RD St
D St
Fire Hydrant Located
on Corner of 2nd ST
and Minnesota Ave.
Old Police Station
Potable Water
Available from Hose Bib
N Pine Ave
Uncle Neil's Convenience Store Property
Potable Water Available from Hose Bib
W 2ND St
E 2ND St
E 2ND
Fire Hydrant Located
Outside Fence
Secured
Laydown Area
2nd Street
Source Area
New IPs
IP-15
IP-16
N Minnesota Ave
N Pine Ave
Pine Avenue Injection
Point "Fence"
(IP-1 through IP-9)
BNSF RR
East Injection Point "Fence"
(IP-10 through IP-14)
BNSF
Exclusion Zone
Former UP Row
(track removed)
E Par
esota Ave
S Ross Ave
Legend
4" Injection Point
New 4" Injection Point
N
0 50 100 200
Feet
Notes:
1. The water at the Laydown Area and Uncle Neil's is supplied through a hose bib.
2. IPs shown inside the BNSF exclusion zone have surface completions outside exclusion zone.
Second Street Subsite
Hastings, Nebraska
Figure 14
ent C
Phase II IP Locations
BLACK & VEATCH
Building a world of difference.
Project No: 044718

Cell	Depth (ft)	BETX (mg/kg)	PAHs (Reg) (mg/kg)	PAHs (SIM) (mg/kg)	PID (ppm)
S5	10	3.435	185		0
	14	ND	1,244		16.85
	18	ND	22		6.1
	20 (P)	ND	128		21.2
	20 (BVSPC)	0.00465	703	696	21.2
S4	10	0.105	244		NR
	14	ND	1,621		NR
	18	2.285	2,501		NR
	20 (P)	ND	8		NR
	20 (BVSPC)	0.0447	50	62	NR
S3	4	2,590	15,722		NR
	10	1,211	9,228		NR
	14	25	4,323		NR
	18	76	5,830		NR
	20 (P)	16	2,735		NR
	20 (BVSPC)	1.5	3,140	4,148	NR
S2	10	0.44	64		NR
	12	0.105	167		NR
	14	0.5	116		NR
	16	0.045	622		2
	18	0.13	283		4.5
	20 (P)	0.365	130		2.25
	20 (BVSPC)	0.06275	282	646	2.25
S1	10	ND	ND		NR
	12	ND	92		NR
	14				
	16	ND	3.6		1.45
	18				
	20 (P)	ND	1.7		0.3
	20 (BVSPC)	0.00385	5.9	6.5	0.3

NR-Not reported.
Listed values provided are the totals of the individual contaminant averages from the cell samples for each depth.
Highlighted cells indicate that the average includes at least one result above the excavation remedial goals.

0 25 50
Feet



Imagery Source: City of Hastings GIS - April 2010

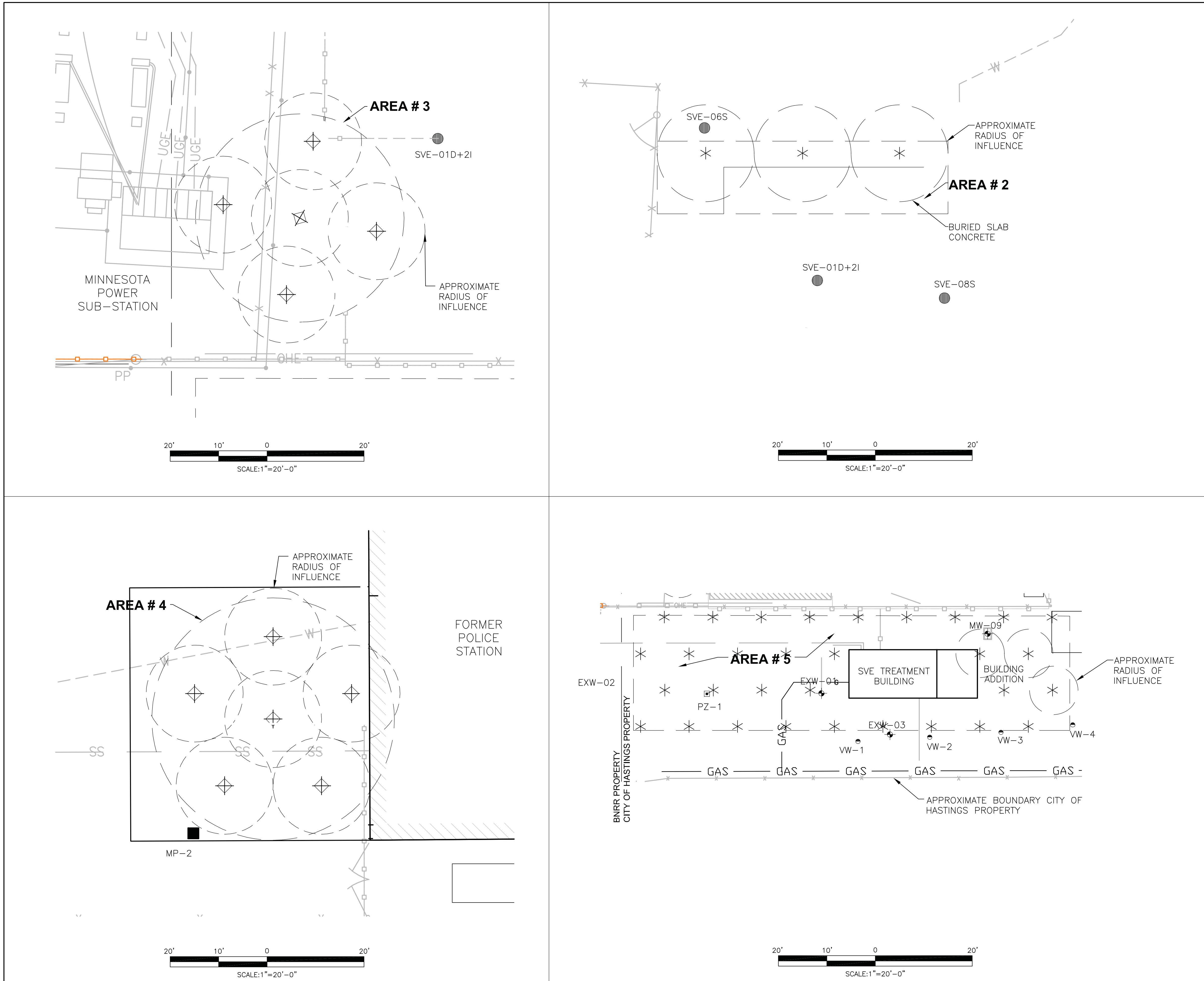
Cell	Depth (ft)	BETX (mg/kg)	PAHs (Reg) (mg/kg)	PAHs (SIM) (mg/kg)	PID (ppm)
N5	10	ND	97		1.5
	14	1.07	612		9.6
	18	1.46	346		20.5
	20 (P)	ND	0.74		5.5
	20 (BVSPC)	0.0062	158	145	5.5
N4	10	0.095	165		1.55
	14	ND	ND		3.2
	18	1.605	2,333		12.5
	20 (P)	0.23	435		32
	20 (BVSPC)	0.71	2,063	1,600	32
N3					
	10	ND	117		1.5
	14	0.145	306		0
	18	ND	20		11.05
	20 (P)	0.05	2,155		39.25
	20 (BVSPC)	1.38	2,401	3,375	39.25
N2	10	ND	349		0
	12				
	14	ND	224		0
	16				
	18	30	2,231		50.25
	20 (P)	1.6	247		34.3
	20 (BVSPC)	1.4	2,401	2,835	34.3
N1	10	ND	51		0
	12				
	14	ND	38		0
	16				
	18	1.09	1,160		5.2
	20 (P)	ND	ND		0
	20 (BVSPC)	0.00276	0.38	1.48	0

NR-Not reported.
Listed values provided are the totals of the indivdual contaminant averages from the cell samples for each depth.
Highlighted cells indicate that the average includes at least one result above the excavation remedial goals.

Figure 15

Total BETX and PAH Results for Area 1

BLACK & VEATCH
Building a world of difference.



NOTES:

1. AN OVERALL SITE MAP OF THE RELATIVE INJECTION AREAS IS PRESENTED IN FIGURE ISCO−1.
2. A SCHEMATIC OF THE PERMANENT INJECTION WELL CONSTRUCTION IS SHOWN IN FIGURE ISCO−3.

LEGEND

north

- PERMANENT INJECTION WELL
- TEMPORARY INJECTION POINT
- SVE WELL
- GROUNDWATER EXTRACTION WELL
- PIEZOMETER
- VENT/GROUNDWATER WELL

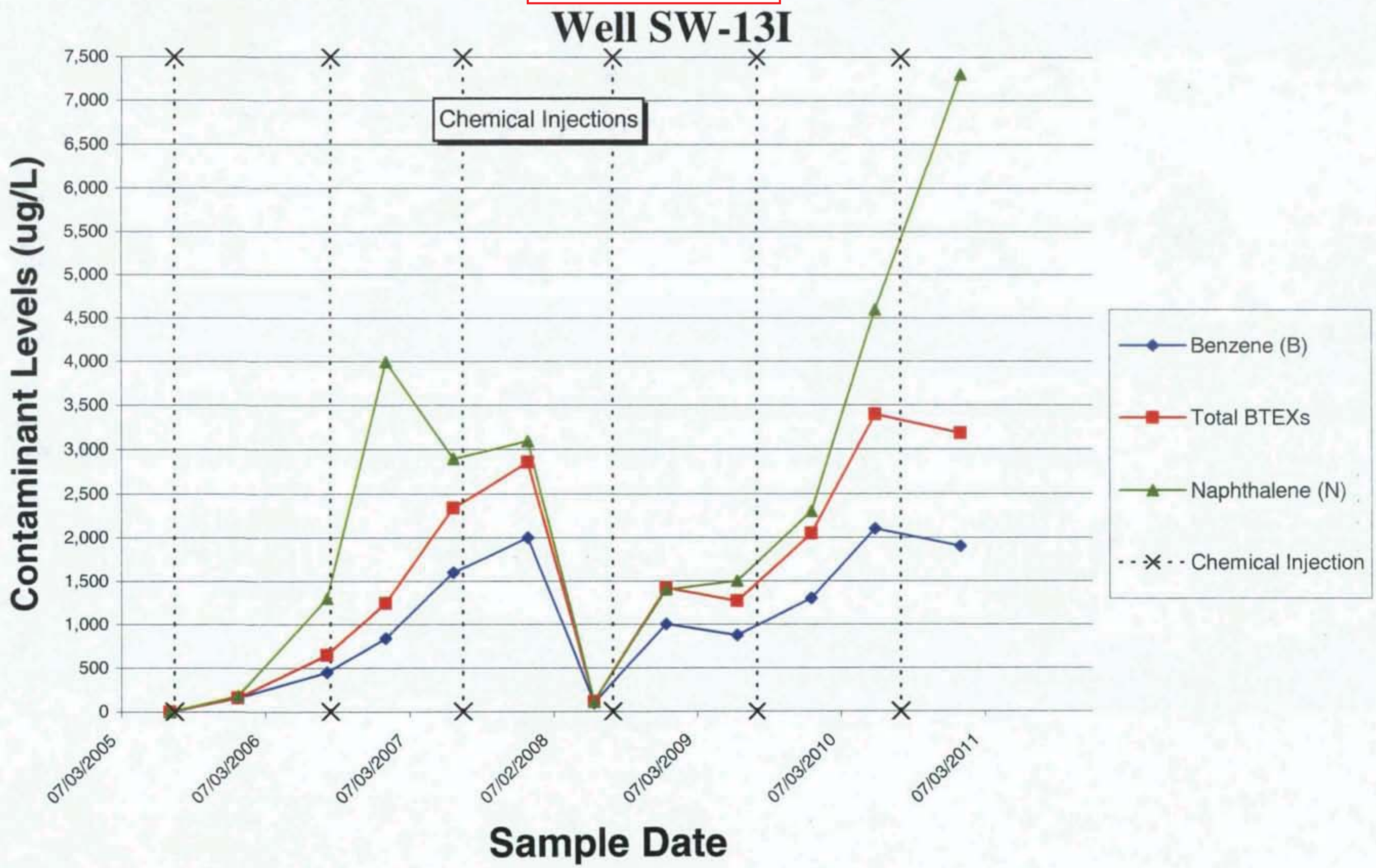
Figure 16

INJECTION WELL AND POINT LOCATIONS MAP

SECOND STREET SUBSITE OU12 RD

PLOTTER: HP PEN TABLE: Full PLOT SCALE: 1=1 Original dwg size 17 x 11 Revised By: new02908 ON Sep 29, 2008 @ 10:26am
Drawing: Z:\Projects\044744\dwg\C0008339.dwg ACAD 16.1s (LMS Tech) Plot By: new02908 Sep 29, 2008, 02:24pm Attached Xref: X−Plan

Figure 17



Well SW-13I
Chemical Injections
Contaminant Levels (ug/L)
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
07/03/2005
07/03/2006
07/03/2007
07/02/2008
07/03/2009
07/03/2010
07/03/2011
Sample Date
Benzene (B)
Total BTEXs
Naphthalene (N)
Chemical Injection

Figure 18

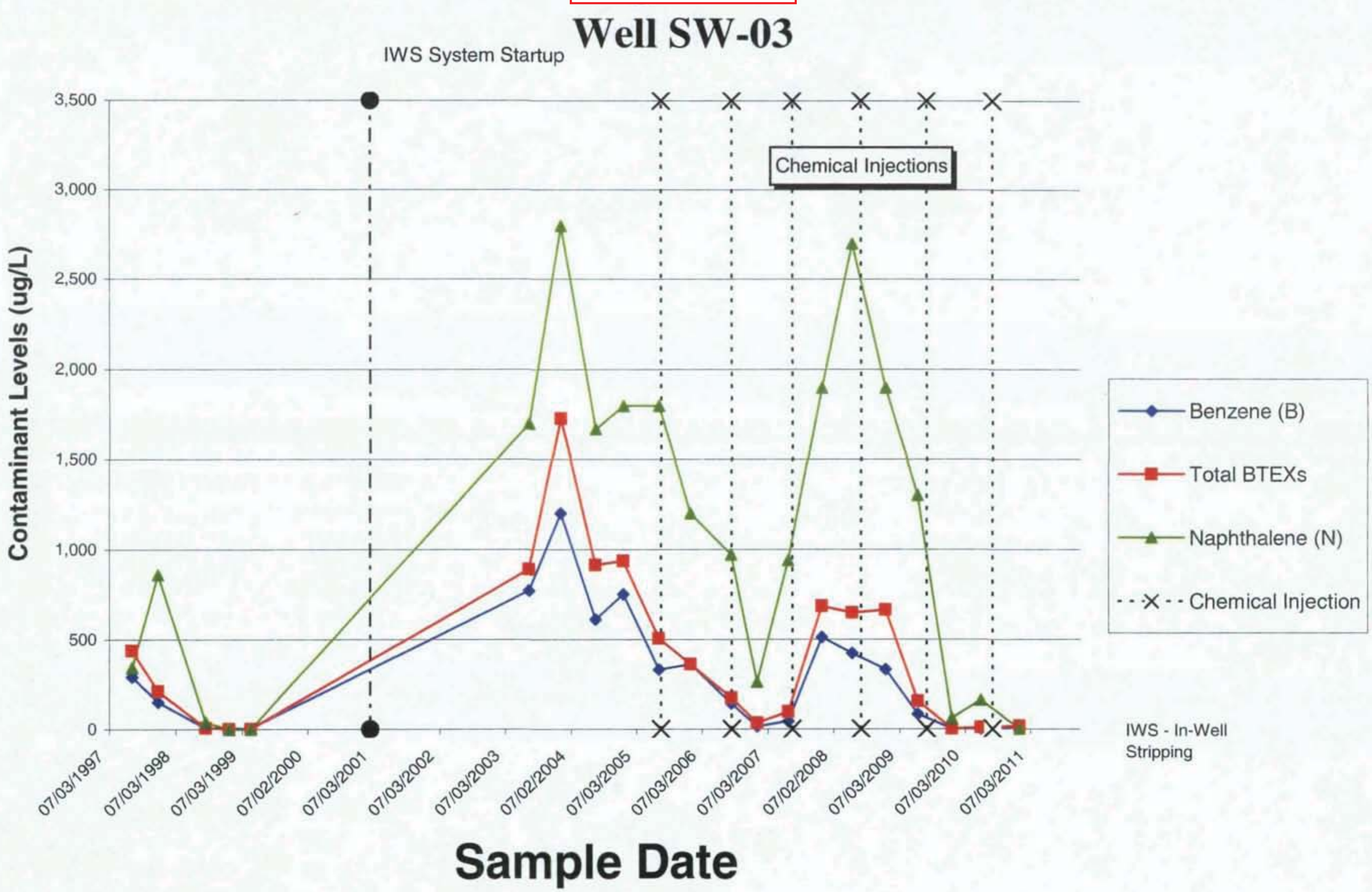
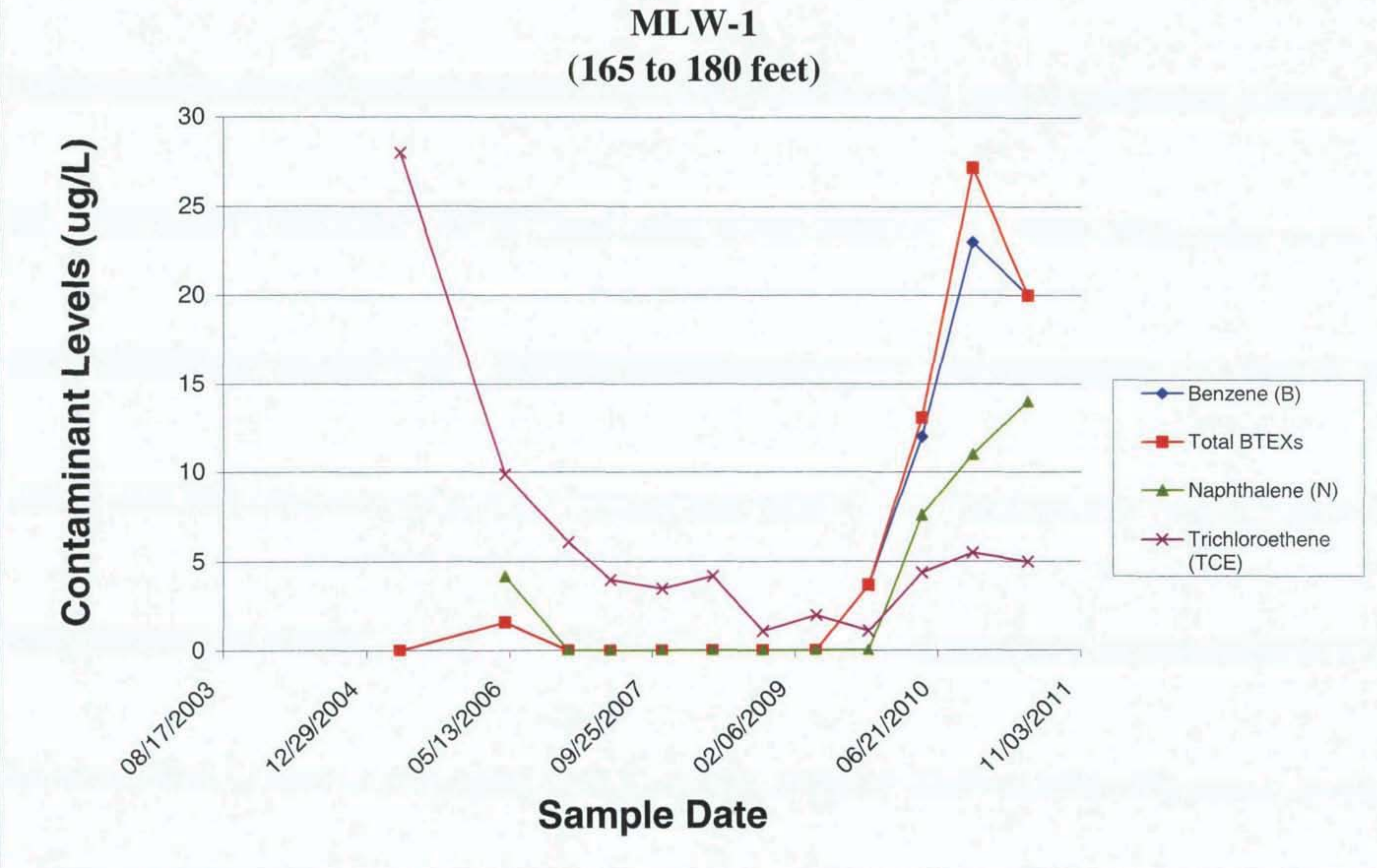

Well SW-03
IWS System Startup
Chemical Injections
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Contaminant Levels (ug/L)
07/03/1997
07/03/1998
07/03/1999
07/02/2000
07/03/2001
07/03/2002
07/03/2003
07/02/2004
07/03/2005
07/03/2006
07/03/2007
07/02/2008
07/03/2009
07/03/2010
07/03/2011
Sample Date
Benzene (B)
Total BTEXs
Naphthalene (N)
Chemical Injection
IWS - In-Well Stripping

Figure 19



MLW-1
(165 to 180 feet)
Contaminant Levels (ug/L)
30
25
20
15
10
5
0
08/17/2003
12/29/2004
05/13/2006
09/25/2007
02/06/2009
06/21/2010
11/03/2011
Sample Date
Benzene (B)
Total BTEXs
Naphthalene (N)
Trichloroethene (TCE)