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Report

Corrective Action Study

Brenntag Southwest, Inc.

1520 N. Barwise, Wichita, KS

Project I.D.: 12B477.00

Prepared for Brenntag Southwest, Inc.

March 2015

Foth

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March 30, 2015

Mr. Ryan Weiser
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Dear Mr. Weiser:

RE: Corrective Action Study - Brenntag Southwest, Inc. 1520 Barwise, Wichita, KS

This letter is to transmit the Corrective Action Study for the Brenntag Southwest, Inc. facility at 1520 Barwise, Wichita, KS.

A complete electronic version of this Corrective Action Study is available on the included DVD.

Please contact Robert Kick at (417) 836-3621 or bob.kick@foth.com with any questions or comments.

Sincerely,

Foth Infrastructure & Environment, LLC

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cc: Shawn Wiram, Brenntag North America, Inc.
Ken Potrykus, Foth Infrastructure & Environment LLC

Corrective Action Study

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1	Mr. Shawn Wiram, Brenntag North America, Inc. - electronic

Corrective Action Study

Project ID: 12477.00

Prepared for

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1520 North Barwise Street
Wichita, Kansas 67214

Prepared by

Foth Infrastructure & Environment, LLC

March 2015

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Corrective Action Study

Executive Summary

This Corrective Action Study (CAS) has been prepared by Brenntag Southwest, Inc. (Brenntag) to evaluate the feasibility of remedial alternatives at the 1520 Barwise Street in Wichita, Kansas (Site). This work was conducted under Consent Order 02-E-0279 entered into by Brenntag and KDHE on December 9, 2002.

This CAS supports the on-Site development of remedial alternatives and does not address groundwater impacts that may be attributed to Brenntag at off-Site locations. Such impacts, if any, are beyond the scope of this CAS.

The objectives of the CAS are as follows:

- Evaluate the feasibility, effectiveness, and cost of at least two (2) potential remedial actions for the Site based on the findings of the Comprehensive Investigation (CI), and to compare and contrast those alternatives to each other and the "no action" alternative; and

- Recommend and justify a specific corrective action for the Site.

The overall objective of the remedial action is to remediate groundwater at the Site impacted with volatile organic compounds (VOCs) and thereby mitigate potential exposure risks. The following remedial action objectives have been developed for the Site:

- Reduce the mass of VOCs (especially tetrachloroethene or PCE) in Site groundwater to the extent practicable.

- Reduce the concentration of PCE in Site groundwater to the extent practicable.

- Prevent potential exposure to contaminated groundwater at the Site.

The groundwater protection standard for the chemicals of potential concern (COPCs) at the Site, as provided in the Risk-Based Standards for Kansas Manual (October 2010, with tables revised March 2014) corresponds to the United States Environmental Protection Agency's (USEPA's) maximum contaminant level.

The corrective action study process includes the following five steps:

1. Establish remedial action objectives;
2. Identify and screen technologies;
3. Identify and screen remedial alternatives;
4. Perform detailed analysis of the remaining alternatives; and
5. Provide conclusions on the recommended remedial action alternative.

During screening of remedial technologies, potentially applicable technologies were reduced by evaluating the technologies with respect to technical implementability.

Remedial alternatives were developed by assembling combinations of technologies applicable to each impacted medium. Site-specific remedial alternatives were evaluated and screened based on their effectiveness, implementability, and cost. Alternatives with the most favorable composite evaluation were retained for detailed analysis of the following evaluation criteria:

- Overall protection of human health and the environment
- Compliance with Federal and State applicable, or relevant and appropriate regulations
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume of contamination through treatment
- Short-term effectiveness
- Implementability
- Cost
- Community acceptance

The remedial alternatives evaluated for this corrective action study included:

- Detailed Alternative 0: No Further Action
- Detailed Alternative 1: Monitored Natural Attenuation
- Detailed Alternative 2: Enhanced Biodegradation
- Detailed Alternative 3: Chemical Oxidation

Each of these detailed alternatives, except no further action, includes implementation of a groundwater monitoring program and environmental use controls as components of the alternative.

A comparative analysis of the four detailed alternatives addresses each alternative's ability to meet the eight evaluation criteria. The analysis demonstrated that all of the detailed alternatives, except Alternatives 0 and 1, would satisfactorily meet the following:

- Remedial action objectives
- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, and volume

The criteria which were not met equally by each of the detailed alternatives were short-term effectiveness, implementability and cost. These criteria are used to determine the best overall alternative. Community acceptance has not yet been evaluated.

Considering all criteria, the best alternative based upon data available at the time of this report is Alternative 3, Chemical Oxidation. The other alternatives are eliminated as follows:

- Alternative 1, Monitored Natural Attenuation, is eliminated due to the apparent persistence of PCE in Site groundwater monitoring well MW-3s subsequent to the soil

removal action and the indefinite time that might be required to meet groundwater RAOs through natural attenuation processes.

- Alternative 2, Enhanced Bioremediation, is an effective and cost competitive remedial alternative comparable to the selected remedy. However, this remedy was not selected due to more complex implementation.

Therefore, Alternative 3, Chemical Oxidation is the selected alternative and offers the following benefits:

- Cost effective
- Readily implementable
- Actively degrades VOC impacts to groundwater
- Promotes attainment of groundwater RAOs in a reasonable period of time
- Has a high likelihood of success

List of Abbreviations, Acronyms, and Symbols

1,2-DCA	1,2-dichloroethane
ARARs	applicable or relevant and appropriate requirements
AUL	activity and use limitation
Brenntag	Brenntag Southwest, Inc.
CAA	Clean Air Act
CAS	Corrective Action Study
CERCLA	Comprehensive Environmental Response, Compensation, & Liability Act
CI	Comprehensive Investigation
CI/CAS	Comprehensive Investigation/Corrective Action Study
cis-1,2-DCE	cis-1,2-dichloroethene
COPC	Chemical of Potential Concern
CWA	Clean Water Act
DCE	dichloroethene
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DPT	direct push technology
EC	electro-conductivity
ESTCP	Environmental Security Technology Certification Program
EUC	environmental use control
FEMA	Federal Emergency Management Agency
FS	Feasibility Study
ft	feet
ft/day	feet per day
ft/year	feet per year
HASP	Health and Safety Plan
KDHE	Kansas Department of Health and Environment
MCL	maximum contaminant levels
mg/L	milligrams per liter
MIP	membrane interface probe
MIP/EC	membrane interface probe/electro-conductivity
MNA	monitored natural attenuation
NIC	Northern Industrial Corridor
O&M	Operation and Maintenance
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Act
PCE	tetrachloroethene
PPE	personal protective equipment
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RSK	Risk-Based Standards for Kansas
SARA	Superfund Amendments and Reauthorization Act
SDS	Safety Data Sheets (formerly Material Safety Data Sheets)
Site	1520 Barwise Street, Wichita, Kansas
TBC	to be considered

TCE	trichloroethylene
TSCA	Toxic Substance Control Act
UIC	Underground Injection Control
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VC	vinyl chloride
VOC	volatile organic compounds

1 Introduction

This Corrective Action Study (CAS) has been prepared by Brenntag Southwest, Inc. (Brenntag) to evaluate the feasibility of remedial alternatives at 1520 N. Barwise Street in Wichita, Kansas (Site) that were conducted under the Kansas Department of Health and Environment (KDHE) Comprehensive Investigation/Corrective Action Study (CI/CAS) process. The site location is shown on Figure 1 and the site layout is shown on Figure 2. This work was conducted under consent order 02-E-0279 entered into by Brenntag and KDHE on December 9, 2002.

1.1 Site Background

The City of Wichita, Kansas is located at the confluence of the Arkansas and Little Arkansas Rivers in central Sedgwick County. The Brenntag Site consists of 0.7-acre property located in the west-central part of Wichita. The site is located in a mixed commercial/industrial part of Wichita. The land-based description of the Site is T27S, R1E, Sec 9, SW ¼, SE ¼, Sedgwick County, Kansas and the geographic coordinates for the site are approximately 37.7104 degrees north latitude and 97.3285 degrees west longitude.

The Site is located at 1520 N. Barwise which borders the western edge of the Site. Property west of the Site on N. Barwise is owned by Cargill. Railroad tracks border the eastern side of the Site. Cargill operates a soy bean processing plant south and east of the Site. A salvage yard is present north of the Site.

The Site contains a single building, which includes offices, warehouse and loading dock and occupies approximately 25% of the Site. The north yard is used to receive and ship packaged chemicals from the warehouse and is unpaved. The south yard is a used to receive, store and ship various materials and is paved. Aboveground storage tanks (5,000 to 6,000 gallons each) containing nitric acid, sulfuric acid, muriatic acid, sodium hydroxide and sodium hypochlorite were present in the south yard during historical operations. Smaller quantities of materials are currently stored in drums, totes and cylinders.

1.2 Purpose and Objectives

The CAS provides an objective and standardized process for evaluating, comparing and contrasting potential corrective action alternatives. The objectives of the CAS are as follows:

- Evaluate the feasibility, effectiveness, and cost of at least two (2) potential remedial actions based on the findings of the Comprehensive Investigation (CI), and to compare and contrast those alternatives to each other and the “no action” alternative; and

- Recommend and justify a specific corrective action for the Site.

A formalized risk assessment has not been conducted as part of the CI/CAS process; however, routes of potential exposure have been evaluated. Remedial action objectives presented in the Risk-Based Standards for Kansas (RSK) Manual are being utilized.

1.3 The Corrective Action Study Process

This CAS was prepared in accordance with the Scope of Work for a Corrective Action Study (KDHE-BER, 2005b); with additional guidance from the United States Environmental Protection Agency (USEPA) Feasibility Study (FS) process (USEPA, 1988).

The CAS process includes the following five steps:

1. Establish remedial action objectives.
2. Identify and screen technologies.
3. Identify and screen remedial alternatives.
4. Perform detailed analysis of the remaining alternatives.
5. Provide conclusions on the recommended remedial action alternative.

During screening of remedial technologies, remedial technologies determined to be unsuitable for the given site conditions were eliminated from the pool of potentially applicable remedies. Remedial technologies were evaluated with respect to technical implementability based on criteria discussed below. Remedial technologies are defined as:

> *"...appropriate waste management options that ensure the protection of human health and the environment. These options may involve the complete elimination or destruction of hazardous substances at the site, the reduction of concentrations of hazardous substances to acceptable health levels, and the prevention of exposure to hazardous substances via engineering or environmental use controls, or some combination of the above."* (USEPA, 1988)

Remedial alternatives were developed by assembling combinations of technologies applicable to each impacted medium. Site-specific remedial alternatives were evaluated and screened based on their effectiveness, implementability, and cost. Alternatives with the most favorable composite evaluation were retained for detailed analysis, in which the alternatives were analyzed with respect to the following evaluation criteria:

- Overall protection of human health and the environment;
- Compliance with Federal and State applicable, or relevant and appropriate regulations (ARARs);
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume of contamination through treatment;
- Short-term effectiveness;
- Implementability;
- Cost; and
- Community acceptance.

1.4 Report Scope and Organization

This CAS is presented in the following sections:

Section	Description
Section 1 – Introduction	Presents objectives and background information.
Section 2 – Comprehensive Investigation Summary	Summarizes key elements of the Comprehensive Investigation relevant to developing the remedial actions considered in this CAS.
Section 3 – Technology Screening	Evaluates prospective remedial technologies to identify technologies applicable to the Site and chemicals of potential concern.
Section 4 – Detailed Analysis of Alternatives	Analyzes remedial alternatives (combinations of technologies) for each area of the Site and media of concern.
Section 5 – Comparative Analysis	Discusses the relative advantages and disadvantages for each of the remedial alternatives.
Section 6 – References	Provides references cited throughout this report.

2 Comprehensive Investigation Report Summary

This section provides a summary of the CI Report including description of the history at the Site and Site climate, topography, and geology.

2.1 Purpose and Objectives of the Comprehensive Investigation

The objectives of the CI were as follows:

- Determine the lateral and vertical extent of soil and groundwater impacted by chemical of potential concern (COPCs) at the Site. The COPCs for this Site are volatile organic compounds (VOCs).
- Develop a preliminary Site Conceptual Model for human exposure.
- Collect data to support the evaluation and design of potential response actions.

The Site is located within the boundaries of the Northern Industrial Corridor (NIC) Site. Therefore, a secondary objective of the CI was to evaluate whether other VOC sources may impact groundwater at or near the Site.

2.2 Comprehensive Investigation Results

The following sections summarize the results of the CI activities.

2.2.1 Geology and Hydrogeology Overview

The eastern part of Kansas, including Sedgwick County and the City of Wichita, is part of the North American craton, which is an area that has been tectonically stable throughout most of geologic time. Therefore bedrock formations are flat-lying, undeformed, and laterally extensive.

The Arkansas River - Stream Valley Aquifer is present throughout Wichita and overlies Permian age rocks of the Western Interior province. The Stream Valley Aquifer System is a surficial aquifer that consists of unconsolidated sand and gravel limited to stream valleys. The Stream Valley Aquifer is primarily unconfined. This aquifer is ranked second in fresh water production in Kansas (United States Geological Survey [USGS], 1997).

At the Site, alluvial sediments comprise an upward fining sequence of sand grading to silt and then to silty clay at the surface. Overall, the unconsolidated interval is about 40 feet thick consisting of sand (grading upwards from coarse- to fine-grained sand) about 30 to 34 feet thick which grades to silt and clay in the upper 6 to 10 feet. The water table at the Site is generally about 11 to 15 feet below land surface and readily produces water for sampling.

Bedrock beneath the Site consists of the Wellington Formation, a shale-rich formation. The Wellington Formation forms the lower hydrologic confining layer for the alluvial aquifer.

The groundwater flow direction in alluvial sediments at and in the vicinity of the Site is to the southeast.

2.2.2 Chemicals of Potential Concern Occurrence and Migration

The following sections describe the COPCs that occur at the Site and discuss the potential migration of those COPCs. Physical properties of the COPCs and their respective RSK values are provided in Table 1.

2.2.2.1 Soil

As presented in the CI Report, investigations were conducted to determine the nature and extent of COPC impact in soil. Analytical results were compared to the KDHE Tier 2 Risk-Based Standards for Kansas (RSK) in effect at the time of sample collection. Those RSK standards are consistent with those in effect today.

Investigation results showed that shallow soil in the northeast portion of the Site does not exceed the RSK for the detected VOCs. However, limited areas of shallow soil impact in the southeast portion of the Site were found above the RSK standards for some VOCs, including tetrachloroethene (PCE), trichloroethylene (TCE), cis-1,2-Dichloroethene (cis-1,2-DCE), and 1,2-dichloroethane (1,2-DCA).

In addition to soil chemical characterizations, geotechnical investigations were also conducted, including soil boring and electro-conductivity logging. This work established that impacted soil primarily occurred in silty-clay soil within about 6 feet of the land surface and not in deeper sandy soil.

An Interim Remedial Measure for Soil was performed in 2007 and resulted in the removal of silt- and clay-rich soil that exceeded the RSK standards for the soil-to-groundwater pathway. The area of soil removal is shown in Figure 3. A description of the remedial design and implementation of the Interim Remedial Measure for Soil is presented in the CI Report.

2.2.2.2 Groundwater

Several early direct push technology (DPT) groundwater investigations were conducted to determine the nature and extent of COPC impact to groundwater at the Site. The following observations were made regarding the data:

- Groundwater results for pH were near neutral.
- Dense non-aqueous phase liquid (DNAPL) was not found, nor have groundwater VOC concentrations been detected at levels that would indicate the presences of DNAPL.
- The north and west part of the Site exhibited little if any VOC impacts in shallow groundwater though some VOC detections were found in the deeper groundwater. However, the south and east part of the Site exhibited the highest VOC concentrations in shallow groundwater.
- The highest recorded concentrations in DPT groundwater samples that exceeded RSK standards were:
  - Shallow Groundwater
    - PCE at 590 µg/L (RSK = 5 µg/L)

- TCE at 57 µg/L (RSK = 5 µg/L)
- cis-1,2 DCE at 200 µg/L (RSK = 70 µg/L)

- Deep Groundwater
  - TCE at 170 µg/L (RSK = 5 µg/L)
  - cis-1,2 DCE at 220 µg/L (RSK = 70 µg/L)
  - VC at 4.7 µg/L (RSK = 2 µg/L)
  - 1,2-DCA at 6.8 µg/L (RSK = 5 µg/L)

- The groundwater flow direction was determined to be toward the southeast.

2.2.2.3 Routine Groundwater Monitoring Results

Quarterly groundwater monitoring wells MW-1s/d, MW-2s/d, MW-3s/d and PZ-3 were installed and sampled on-site beginning in 2008. Subsequently in 2011, PZ-3 was closed and wells MW-4s/d were installed.

In 2011, two off-Site well pairs (MW-5s/d and MW-6s/d) were also installed and added to the quarterly sampling routine.

The wells were constructed as follows:

Well Name	Screen Depth	Total Depth
MW-1s	15.0 to 25.0	25.5
MW-1d	32.0 to 37.0	37.5
MW-2s	15.0 to 25.0	25.5
MW-2d	31.0 to 36.0	36.5
MW-3s	15.0 to 25.0	25.5
MW-3d	33.0 to 38.0	38.5
MW-4s	15.0 to 25.0	25.4
MW-4d	32.5 to 37.5	38.0
MW-5s	16.0 to 26.0	26.2
MW-5d	29.0 to 34.0	34.2
MW-6s	16.0 to 26.0	26.4
MW-6d	28.0 to 33.0	33.6

Quarterly sampling continued into for first and second quarter 2012 sampling events for all wells; however KDHE granted permission to begin semi-annual groundwater sampling in October 2012. Semi-Annual groundwater monitoring (in April and October of each year has continued to the present time with the corresponding submittal of semi-annual progress reports to KDHE. Detections of COPCs in groundwater monitoring wells and the RSK values are presented in Table 2.

The following is a summary of key conclusions derived from groundwater monitoring and representing current (October 2014) conditions.

- In October 2014, groundwater analytical results did not exceed Residential RSK values for groundwater in monitoring wells: MW-1s; MW-1d; MW-2s; MW-2d; MW-3d; MW-4s; MW-4d; and MW-5s.

- In October 2014, groundwater analytical results did exceed the Residential RSK values for groundwater for one or more COPCs for the following wells: MW-3s (for PCE); MW-5d (for TCE); MW-6s (for PCE and TCE); and MW-6d (for TCE).

- The compounds 1,2-DCE and vinyl chloride were not detected above the Residential RSK value for groundwater.

- The concentration COPCs detected in groundwater declined after the soil removal action conducted in 2007.

- On-to-Site migration of TCE and 1,2-DCE in both shallow and deep groundwater has occurred from properties upgradient of the Brenntag property; however, generally at concentrations below Residential RSK values.

2.2.2.3.1 PCE in Groundwater

- In October 2014, shallow-groundwater PCE concentrations in on-site monitoring wells (MW-1s, MW-2s, MW-3s, and MW-4s) ranged from less than 0.001 milligrams per liter (mg/L) to 0.0193 mg/L. Off-site monitoring wells (MW-5s and MW-6s) showed PCE concentrations ranging from 0.0043 mg/L to 0.0315 mg/L.

- In October 2014, deep-groundwater PCE concentrations in on-site monitoring wells (MW-1d, MW-2d, MW-3d, and MW-4d) were all less than 0.001 mg/L. Off-site monitoring wells (MW-5d and MW-6d) show PCE concentrations ranging from 0.00064J mg/L to less than 0.001 mg/L. These values do not exceed the Residential RSK PCE level of 0.005 mg/L.

2.2.2.3.2 TCE in Groundwater

- In October 2014, shallow-groundwater TCE concentrations in on-Site monitoring wells ranged from 0.00082J to 0.0024 mg/L. These values do not exceed the Residential RSK PCE level of 0.005 mg/L. Off-site monitoring wells showed TCE concentrations ranging from 0.0038 to 0.0136 mg/L.

- In October 2014, deep-groundwater TCE concentrations in on-site monitoring wells range from 0.0010 to 0.0019 mg/L. These values do not exceed the Residential RSK TCE level of 0.005 mg/L. Off-site monitoring wells show TCE concentrations ranging from 0.0116 to 0.0136 mg/L.

2.2.3 Groundwater Flow and Water-Level Variation

Groundwater flow is generally to the southeast based on groundwater measurements collected from 2008 to 2014. Annual groundwater fluctuations range from 0.58 to 1.39 feet for the period from 2008 to 2011 when quarterly water level readings were conducted. The highest water levels tend to be during the summer and the lowest in the winter.

2.2.4 Hydraulic Conductivity and Groundwater Seepage Velocity

Hydraulic testing of Site wells (MW-1s/d, MW-2 s/d, and MW-3s/d) was conducted on August 29, 2008 using a pneumatic slug testing device, pressure transducer, and a data logger. The resultant data was analyzed using AQTESOLV, a software program designed for the analysis of aquifer test data, to calculate hydraulic conductivity.

The average hydraulic conductivity for the shallow monitoring wells was calculated to be 138 feet per day (ft/day). The average hydraulic conductivity for the deep monitoring wells was calculated to be 304 ft/day.

Using Darcy's Law, the groundwater seepage velocity was determined to range from about 292 feet per year (ft/year) for groundwater in the upper part of the water bearing zone dominated by fine sand to 460 ft/year for groundwater in the lower part of the water bearing zone dominated by coarse sand.

2.2.4.1 Mass Balance

Mass balances for PCE and daughter compounds were developed based on October 2014 groundwater analytical data and Site-specific soil types from soil boring descriptions and membrane interface probe/electro-conductivity (MIP/EC) results. For computing the mass balance calculations, the subsurface media were subdivided by type (soil or groundwater) and soils were further subdivided into the upper and lower saturated zones. Groundwater concentrations and soil physical properties were used to calculate equilibrium concentrations in saturated soils. Unsaturated zone sand beneath the finer grained excavated clay was considered unimpacted and thus the mass of VOCs in the unexcavated vadose zone soils was estimated to be zero. This conclusion will be verified through soils sample collection and analysis conducted during installation of the proposed injection wells. The detailed mass balances for PCE and degradation compounds are provided in Appendix A.

The following amounts are estimated to be present in the saturated soil zone and dissolved in groundwater:

- A mass of 0.013 pounds of PCE in the groundwater and 0.0499 pounds in the saturated soil.
- A mass of 0.009 pounds of TCE in the groundwater and 0.007 pounds in the saturated soil.
- A mass of 0.003 pounds of 1,1-DCE in the groundwater and 0.0023 pounds in the saturated soil.
- A mass of 0.152 pounds of cis-DCE in the groundwater and 0.0694 pounds in the saturated soil.
- A mass of 0.004 pounds of VC in the groundwater and 0.0002 pounds in the saturated soil.

2.2.4.2 Conceptual Model Summary

The following points summarize the conceptual model for the study area as developed in the CI Report.

- The release of CEs impacted Site soil. The COPCs include the following chlorinated ethenes including tetrachloroethene (PCE), trichloroethylene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and vinyl chloride (VC).

- The lateral and vertical extent of soil impacted above Kansas RSK standards was determined to be limited to an area on the southern portion of the Site and did not extend off-Site.

- An Interim Remedial Measure for Soil was conducted in 2007 which resulted in the excavation and off-Site disposal of soil impacted above the Kansas RSK "soil to groundwater protection pathway" criteria.

- Shallow groundwater at the Site occurs in an unconfined alluvial aquifer dominated by unconsolidated sand above shale bedrock. Groundwater flow is primarily to the south-southeast. Groundwater flow at the Site appears to be stratified with shallow groundwater in fine sand moving more slowly than groundwater in coarser sand.

- TCE and particularly DCE, at concentrations generally less than Kansas RSK standards, are flowing onto the Brenntag property from up-gradient, off-site sources. These CEs contribute to the CE mass observed at the Site.

- The release of CEs that impacted soil also impacted groundwater at the Site.

- Groundwater quality improved after completion of the Interim Remedial Measure for Soil. As of October 2014, on-Site groundwater shows PCE impacts above Kansas RSK standards only in well MW-3S at a concentration of 0.0193 mg/L as compared to the Kansas RSK standard of 0.005 mg/L. However, PCE concentrations in this well have remained approximately constant since about 2010.

- Residual PCE in on-Site groundwater is being degraded by reductive dechlorination, as demonstrated by decreasing concentrations of PCE and co-varying concentrations of dechlorination products TCE and DCE. Reductive dechlorination is also degrading TCE formed from on-site PCE.

- PCE is found in both on-Site and off-Site shallow wells, but not deep wells, indicating that PCE impacting shallow groundwater undergoes limited vertical migration.

- DCE is the dominant CE in deep groundwater under the Site and is uniformly present at much greater levels than in shallow groundwater near the past on-Site PCE source. As the impacts related to historical Site operations attenuate, up-gradient, off-Site sources are becoming the dominant source of TCE and DCE in groundwater under the Brenntag property.

- An Environmental Use Control (EUC) has been implemented at the Site which prohibits non-commercial land use and groundwater use.

2.3 Human and Ecological Exposure Model

The following sections describe the current Site conditions and potential human and ecological exposure pathways that may be present.

2.3.1 Potential Human Receptors

Potential exposure scenarios associated with on-Site soil, on-Site groundwater, and off-Site groundwater are described below.

2.3.1.1 On-Site Soil – Current Conditions

- Soil at the Site was remediated to meet RSK values for the soil-to-groundwater pathway. RSK values for this pathway are more conservative than other pathways for soil. Therefore, the soil dermal contact and ingestion pathways are currently incomplete.

- Buildings are not present over the paved area of former soil impact at the Site. The vapor intrusion pathway is currently incomplete.

2.3.1.2 On-Site Groundwater – Current Conditions

- An Environmental Use Control has been recorded with the property deed that prohibits residential land use and also prohibits the use of shallow groundwater. Furthermore, groundwater at the site is at a depth of about 15 feet below land surface and so likely would not be contacted by workers installing or maintaining utilities or engaged in new construction. Therefore the groundwater dermal contact and ingestion contact pathways are currently incomplete.

- A combined office and warehouse building is present on-Site but no on-Site structures currently exist over the area of groundwater impact. Therefore, the vapor intrusion pathway from groundwater is currently incomplete.

2.3.2 Potential Ecological Receptors

Land use near the Brenntag study area is urbanized with a mixture of industrial, commercial, residential and public properties. The vast majority of land at and near the Site is developed with extensive pavement, buildings and roads. With the possible exception of wetland areas along the Arkansas River located 1 mile or more to the west and southwest, there are no sensitive ecological areas or wildlife habitat at or near the Site. There are no sensitive geologic features such as karst. Residual soil impacts and current COPC levels in groundwater are not likely to be associated with significant aquatic or terrestrial toxicity.

2.4 Development of Corrective Action Objectives

2.4.1 Corrective Action Goals

The Remedial Action Objectives (RAOs) include a short-term objective of source reduction and a long-term objective of groundwater restoration.

The Interim Remedial Measure for Soil has removed essentially all VOC impacted soil at the Site. The target removal efficiency for the planned remedial action for groundwater is 90% of the total VOC mass in saturated soil and groundwater below the former source area. In addition, the planned action will eliminate or greatly reduce residual source loading to groundwater and the continued desorption of VOCs from saturated soil to groundwater. As a result, the selected remedial action will reduce source area impacts in the short term and facilitate restoring groundwater to meet the Kansas RSK standards in the long-term.

With respect to groundwater restoration, the dissolution rate that regulates the contaminant mass release from soil to groundwater is slow with chemical-specific half-lives ranging from years to decades. Thus any VOCs adsorbed to saturated soil in the subsurface will act as an ongoing source of dissolved-phase impact to groundwater. This mass-transfer limitation, therefore, contributes to the inefficiency of groundwater extraction and treatment systems requiring the extraction of large amounts to water to remove only small amounts of VOCs.

This understanding leads to several conclusions with respect to remedy selection at this Site:

- The rate at which VOCs adsorbed to aquifer materials can be remediated is not limited by the ability to remove contaminants from the aqueous phase. Rather, it is limited by the rate at which these constituents are released to groundwater. Therefore, the time scales for remediation of source materials using groundwater extraction are very long.

- The stability of a groundwater plume is related to the rate of attenuation of the COPCs within the aquifer. Given that the vast majority of impacted soil at the Site was removed and can no longer act as an ongoing source to groundwater, the rate of COPC degradation through natural attenuation may be sufficient to negate the slow rate at which COPCs will partition from soil to groundwater. This can be measured through the groundwater monitoring program.

2.4.2 ARARs Analysis

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)(1980), as amended by the Superfund Amendments and Reauthorization Act (SARA)(1986), stipulates that the cleanup standards or controls for hazardous substances, pollutants or contaminants be at least in accordance with any ARARs, designated under state or federal law (CERCLA121(d)). Applicable requirements are those cleanup standards or controls that are promulgated under state or federal law that specifically address a hazardous substance, pollutant or contaminant, action, location or other situation at the Site. Relevant and appropriate requirements are those cleanup standards or controls that do not specifically or fully address a hazardous substance, pollutant or contaminant, action, location or other situation at a site, but address similar situations.

There are three general categories of ARARs: (1) chemical-specific; (2) location-specific; and (3) action-specific. Chemical-specific ARARs are those that pertain to handling or control of certain chemicals based on health concerns or risks. Location-specific ARARs are those that control activities based on the location such as flood plains, wetlands, historic sites or sensitive ecosystems. Action-specific ARARs are those that govern discrete actions that may include the use of certain technologies for remedial actions or use of certain types of equipment. Other policies or guidelines that are to be considered (TBC) standards for the site may also be required.

The TBC standards have not been promulgated but are used in conjunction with ARARs to achieve acceptable risk levels at a site.

A summary of the ARARs analysis is presented in the CI Report.

2.5 Conclusion

The results obtained from Site characterization activities provide sufficient basis to support the evaluation and design of potential response actions. Specific design data, if any, that might be needed to support the application of specific technologies at the Site will be discussed in Section 4, Detailed Analysis of Alternatives.

3 Screening of Technologies

This section describes the process used to identify and screen prospective remedial technologies. The initial technology screening is explained in Section 3.1. Technologies that are considered appropriate for the Project Site are explained in the remaining sections. Section 3.2 discusses appropriate technologies that address impacted groundwater and saturated soil. Section 3.3 summarizes the technology screening presented in this section.

3.1 Initial Screening of Technologies

Appropriate technologies to be considered for remediation at the Site were identified and preliminary evaluations were conducted. These technologies were identified using the methodology described by the USEPA and the Remediation Technologies Screening Matrix table (USEPA, 2002).Technologies whose target COPCs are halogenated volatile organics were considered. As shown in Table 3, the following technologies were considered:

- Air Sparging
- Enhanced Bioremediation
- Chemical Oxidation
- Environmental Use Controls
- Monitored Natural Attenuation
- Pump and Treat
- In-Situ Thermal Treatment
- Vacuum Enhanced Recovery
- Zero-Valent Iron Passive Reactive Barrier

Technologies were screened using the following criteria: technical feasibility, including effectiveness and implementability; and economic feasibility, including capital costs, initial costs, and annual operation.

Based on this evaluation only technologies appropriate to the Site were retained including:

- Monitored Natural Attenuation
- Enhanced Bioremediation
- Chemical Oxidation

3.2 Retained Treatment Technologies

VOC concentrations in Site groundwater exceed RSK values and remedial action for groundwater will be necessary to achieve Site-specific short-term and long-term RAOs. Remedial alternatives retained for groundwater remediation at the Site are described below. Table 4 presents a summary of each retained treatment technology relative to overall protection, compliance with ARARS, long-term effectiveness and permanence, short-term effectiveness, implementability, and cost.

3.2.1 Monitored Natural Attenuation

Natural attenuation relies on natural processes to remediate impacted groundwater. These processes include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or

concentration of COPCs in groundwater. This approach requires monitoring of concentration trends with time and distance, geochemical conditions, and other site-specific factors to determine if natural processes, either biotic or abiotic, are acting to mitigate impacted groundwater. KDHE's policy for monitored natural attenuation (MNA) requires a Site-specific evaluation to determine whether MNA is appropriate for a site (KDHE, 2005a).

3.2.2 Enhanced Bioremediation

Enhanced bioremediation is a technology that utilizes injection of a natural or synthetic compound to enhance in-situ biodegradation rates of chlorinated ethenes by fueling anaerobic reductive dechlorination processes. Lactate and molasses are commonly used as microbiological energy sources, but other chemicals may also be effective such as emulsified oils. These materials are metabolized by naturally occurring or artificially added microorganisms, resulting in the creation of anaerobic aquifer and the metabolism of the COPCs.

Treatment compounds are injected using direct push equipment or injection wells. In the case of direct push injection, rods are pushed to the target depth and then the chemical is injected as the rods are withdrawn. Compounds can also be injected using injection wells. Injection wells are advantageous when multiple injections are likely.

3.2.3 Chemical Oxidation

Chemical oxidation technology utilizes the injection of a single chemical or combination of chemicals to degrade chlorinated ethenes to non-toxic components. Various proprietary chemicals may be injected into the subsurface to provide chemical oxidation of COPCs. For example, PCE can be reduced to carbon dioxide, chloride ions, and hydrogen ions. This process differs from enhanced bioremediation in two primary ways: 1) degradation takes place in an oxidizing environment rather than a reducing environment as with enhanced bioremediation; and 2) the chemicals that are injected directly act to break down the COPCs, whereas the enhanced bioremediation chemicals act to promote the activity of microbes which reduce COPC concentrations.

Typically, oxidation chemicals are applied using direct push equipment or injection wells. In the case of direct push injection, rods are pushed to the target depth and then the chemical is injected as the rods are withdrawn. The proper flow rate and pressure should be maintained while applying the chemical to ensure the correct vertical application. The flow rate is typically within 3 to 10 gallons per minute at pressures up to 300 psig. However, injection pressures greater than about 20 to 30 psig may require a variance from typical KDHE Underground Injection Control (UIC) program guidelines. Permanent injection wells can also be installed to facilitate multiple injections. Groundwater monitoring is performed before and after chemical application to ensure the effectiveness of chemical oxidation.

3.3 Summary

Remedial technologies potentially applicable for the Site were identified utilizing USEPA's Remediation Technologies Screening Matrix table. Technologies were screened using the following criteria: effectiveness, implementability, and relative cost. These technologies will be utilized to create remedial alternative for VOC remediation at the Site, as discussed in Section 4.

After the initial screening summarized in Table 3, three remedial alternatives were retained for further consideration for groundwater remediation including MNA, enhanced bioremediation, and chemical oxidation (Table 4).

Although not a remedial technology, EUCs have been established at the Site to reduce the potential risk of exposure to impacted groundwater.

4 Detailed Analysis of Alternatives

This section presents a detailed evaluation of the alternatives considered for use at the Site. Section 4.1 presents the rationale behind the detailed analysis, defines the nine criteria used to evaluate each remedial alternative, and presents the assembly of technologies that were retained as options for further consideration. Section 4.2 provides detailed descriptions of the four alternatives and presents an evaluation of the remedial alternatives with respect to the evaluation criteria.

The detailed analysis is a multi-step process of evaluating options to allow comparison of the alternatives and to identify the key trade-offs among them. During the detailed analysis, each option is assessed against the evaluation criteria described in the subsections that follow. The results of the detailed analysis provide relevant information needed to allow selection of the most appropriate remedy.

4.1 Definition of Evaluation Criteria

4.1.1 Overall Protection of Human Health and the Environment

The assessment of this criterion describes how the remedial option, as a whole, provides adequate protection of human health and the environment and meets the remedial action objectives. This evaluation focuses on how the remedial action objectives are met through treatment, engineering, or activity and use limitations (AULs).

4.1.2 Compliance with ARARs

Remedial actions must meet Federal, State or local standards, requirements, criteria, or limitations that are determined to be legally applicable or ARARs. Each remedial option was evaluated based on three general ARAR categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs, as discussed in more detail below.

4.1.2.1 Chemical-Specific ARARs

Chemical-specific ARARs are standards pertaining to the amount or concentration of a chemical allowed or discharged in the environment. These values are derived from health- or risk-based calculations incorporating the chemical characteristics, the media of concern, and potential exposure pathways. Groundwater MCLs for the COPCs were identified in Federal standards (40 CFR 141.61) and in the Kansas RSK values and are listed in Table 1.

4.1.2.2 Location-Specific ARARs

Location-specific ARARs are used to identify and protect unique or sensitive areas, such as historic areas, wetlands, ecosystems, and endangered species, but also serve to prevent potential hazards associated with working in floodplains or geologically unstable regions. Additional regulations regarding zoning ordinances are also location-specific ARARs.

4.1.2.3 Action-Specific ARARs

Action-specific ARARs are utilized to determine activity or technology based restrictions on remediation proposals. These requirements may be imposed based on the chemical and disposal/treatment method employed. Several regulations were identified that may impose

restrictions on the remediation proposals, including standards outlined in the Occupational Safety and Health Act (OSHA), the Clean Air Act (CAA), the Clean Water Act (CWA), the Resource Conservation and Recovery Act (RCRA), and the Toxic Substance Control Act (TSCA) and analogous state rules and regulations. Additional action-specific ARARs include requirements for construction permits and adhering to building codes.

4.1.3 Long-Term Effectiveness and Performance

The evaluation of remedial options for long-term effectiveness addresses the results of a remedial action in terms of the risk remaining at the Site after remedial action has been implemented. This assessment includes an analysis of the magnitude of residual risk and the adequacy and reliability of engineering or EUCs. The magnitude of residual risk analysis takes into account the following:

- Residual risk, expressed in cancer risk levels, volumes, or concentrations, remaining from untreated waste or treatment residuals at the conclusion of remedial activities; and
- The volume, toxicity, and mobility of residuals remaining after remedial activities.

The adequacy and reliability of engineering or EUCs are evaluated in terms of the long-term reliability of controls used to manage treatment residuals or untreated waste remaining at the Site, and consider the following:

- The likelihood that the technology would meet required process efficiencies or performance specifications;
- The type and degree of long-term management and monitoring;
- Operation and maintenance (O&M) functions required to maintain process efficiency or performance specifications; and
- Difficulties of long-term maintenance, including the potential need for replacement of technical components and the degree of confidence that controls can adequately handle potential problems.

4.1.4 Reduction of Toxicity, Mobility or Volume through Treatment

This criterion is based on a preference for treatment technologies that irreversibly reduce toxicity, mobility, or volume of the COPCs. The primary concern is whether the detailed alternative would satisfy this preference for treatment as a principal element (treatment is defined in the USEPA guidance as the destruction of toxic COPCs, reduction of the total mass of toxic COPCs, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media).

The focus of this criterion is whether the proposed detailed alternative reduces the principal threats through treatment. Some considerations under this detailed alternative include the following:

- Whether the treatment process addresses the principal threats and any special process requirements or limitations.
- The mass and volume of material destroyed or treated.
- The extent to which the total mass, mobility, and volume of toxic COPCs is reduced, and whether or not the reduction is irreversible.
- The type, quantity, and characteristics of treatment residuals, and the risks posed by the residuals.
- The statutory preference for treatment as a principal element.

4.1.5 Short-Term Effectiveness

Short-term effectiveness addresses the effects of the remedial alternative during the construction and implementation phases until remedial action objectives are met, and considers the following:

- The risks to Site remediation workers and building occupants and how the risks would be avoided, mitigated, or controlled;
- The risks to the community during the remedial action, and how the risks would be avoided, mitigated, or controlled;
- The risk of environmental impacts during the remedial action and how the risks would be avoided, mitigated, or controlled;
- The duration of time until remedial objectives is met.

4.1.6 Implementability

This criterion addresses the technical and administrative feasibility of implementing a remedial alternative and the availability of various services and materials required during its implementation. Assessment of this criterion relies heavily on previous evaluations of technologies described in Section 3. Specific considerations include the following:

- The ability to construct and operate the remedial alternative, the difficulties and uncertainties which may be encountered during construction, and the likelihood of technical problems which may lead to schedule delays;
- The ease of undertaking additional remedial action, and what those additional actions may be;
- The coordination required between agencies over the long term, and the ability to obtain permits for the remedial activities;
- The availability of capacity at treatment, storage, and/or disposal services, and the measures required to ensure that capacity is available;

- The availability of necessary equipment and specialists, and whether a lack of equipment and specialists prevents implementation; and

- The degree to which technologies are available and sufficiently demonstrated for the specific full-scale application.

4.1.7 Cost

Cost analysis includes estimates of capital costs (both direct and indirect) and annual O&M costs associated with each component of a remedial option. The target level of accuracy is +50% to -30%.

The cost may play a significant role in comparing remedial options which are similar in long-term effectiveness, or in which the treatment methods provide a similar performance. The remedial options with costs that are high when compared to the overall effectiveness of the remedial option will not be selected as the final remedy. Similarly, non-treatment options that have low initial capital costs may be more costly overall than a treatment option when long-term O&M costs are considered. An improved performance or greater long-term risk reduction may justify higher costs. The preferred remedial option is generally the one that satisfies the criteria at the most reasonable cost.

4.1.8 Community Acceptance

This criterion evaluates the issues and concerns the public may have regarding each of the detailed alternatives. It is expected that the proposed Alternatives will be accepted by the community. The community acceptance criterion will be fulfilled as part of the Corrective Action Decision process.

4.2 Assembly of Detailed Alternatives

The technologies retained from Section 3 were selectively combined into remedial alternatives that most effectively address VOC impacts to groundwater at the Site. The criteria for assembling and combining technologies into remedial options include the following:

- Enhanced effectiveness of technologies operating as part of a treatment train;
- Compatibility of treatment technologies to work together; and
- Ability of the combined technologies to address all impacted media.

The technologies retained from Section 3 are assembled into remedial alternatives, as described below.

4.2.1 Alternative 0: No Further Action

Alternative 0 includes no additional remedial effort at the Site. This alternative is considered as a baseline from which to compare the other alternatives.

4.2.2 Alternative 1 – Monitored Natural Attenuation

Alternative 1 involves the use of natural attenuation processes to remediate on-Site groundwater. MNA would be conducted using periodic groundwater sampling of on-Site wells to document VOC levels and the effects of attenuation process over time. Monitoring would include sampling

and analysis for parameters such as pH, specific conductance, oxidation-reduction potential (ORP), dissolved oxygen (DO), and VOCs at an appropriate frequency to evaluate groundwater conditions over time. The monitoring frequency would be semi-annual until analytical monitoring data establish the criteria for Site closure.

4.2.3 Alternative 2: Enhanced Bioremediation

Alternative 2 consists of enhanced reductive dechlorination technology to remediate on-Site VOC groundwater impact. Injection points would be installed within the source area and a nutrient substrate would be injected to feed naturally occurring microorganisms. Cultured microorganisms could also be added to augment those naturally present.

Periodic groundwater sampling and analysis, as discussed for Alternative 1, would be conducted to monitor and evaluate groundwater conditions over time.

The location of the source area treatment zone for Alternative 2 is shown on Figure 4.

4.2.4 Alternative 3: Chemical Oxidation

Alternative 3 consists of *in-situ* chemical oxidation to remediate on-Site VOC groundwater impact. Injection points would be installed within the source area and an oxidant substrate would be injected to physically react with and destroy dissolved VOCs. A treatability study would be performed as part of the final remedial design to determine the proper oxidant dosage.

Periodic groundwater sampling and analysis would be conducted to monitor and evaluate groundwater conditions over time.

The location of the source area treatment zone for Alternative 3 is shown on Figure 4.

4.3 Common Elements of Each Detailed Alternative

Several elements are common to all of the detailed alternatives and include the following:

- Action, chemical, and location-specific ARARs;
- Implementation considerations;
- Groundwater monitoring program; and
- EUCs that have already been implemented at the Site.

4.3.1 ARARs

Several ARARs, including chemical, location, and action-specific ARARs, are applicable to many of the detailed alternatives. These common elements are described below.

4.3.1.1 Chemical-Specific ARARs

As discussed in Section 2.5.1, the target for the groundwater/saturated soil remediation is to reduce COPCs to levels below levels summarized in Table 1, which correspond with USEPA drinking water maximum contaminant levels (MCLs). An Interim Remedial Measure for Soil was previously implemented to meet the RSK standard for the soil-to-groundwater pathway.

4.3.1.2 Location-Specific ARARs

Most location-specific ARARs are independent of the specific alternative. These ARARs include the Endangered Species Act, the National Historic Preservation Act, RCRA location standards, and analogous regulations found in Kansas Title 115 Non-Game, Threatened or Endangered Species, and Title 118 Historic Preservation Act. Each alternative meets the location-specific ARARs as follows:

- No endangered species habitats lie within the site boundaries and the proposed activities will not disrupt any endangered species.
- The Site is not part of an historic district.
- Remedial actions are not located in the 100-year floodplain, according to the Federal Emergency Management Agency (FEMA).
- Additionally, certain components of these alternatives may require compliance with zoning ordinances.

4.3.1.3 Action-Specific ARARs

The action-specific ARARs which would apply to each of the alternatives are listed below.

- The Kansas Board of Technical Professions has standards of conduct for professions including engineers, geologists, and land surveyors.
- OSHA regulates workplace health and safety, and all remedial activities will comply with these rules and regulations. All work will be performed under a written Health and Safety Plan. Periodic breathing zone monitoring for organic vapors will be conducted during construction activities. Also, Safety Data Sheets (SDS) for COPCs and any treatment chemicals will be made available to all site workers.
- KDHE guidance for the implementation of MNA at the Site will be required with respect to Alternatives 1 and 2.

4.3.2 Implementation Considerations

Several implementation considerations are common to all remedial action alternatives presented in this CAS. Drilling into the subsurface and groundwater sampling are associated with all of the proposed remedial alternatives. Therefore, Site workers may be exposed to impacted soil and/or groundwater. However, based upon previous investigation and Interim Remedial Measure for Soil at the site, Level D personal protective equipment (PPE) will be sufficient to mitigate potential exposure associated with these activities.

All proposed remedial actions will be conducted on Site property and no active remediation will be conducted off-Site. Additionally, a utility clearance will be performed at each drilling location prior to initiation of work in order to avoid subsurface utilities during implementation of the remedial action.

Soil cuttings, waste water, and solid wastes may be generated during remedy implementation. If produced, these materials will be appropriately containerized, labeled, and sampled to determine appropriate off-Site disposal alternatives.

4.3.3 Groundwater Sampling and Analysis Program

A groundwater sampling and analysis program is common to all remedial alternatives so the effectiveness of the remedial action can be measured and progress toward or attainment of RSK values can be documented. The groundwater monitoring program will include all existing on-Site wells. Though certain on-Site wells have not recently shown groundwater impact above RSK values; however, these wells will continue to be monitored during remediation so background conditions and effects of the remediation can be evaluated.

Two new wells would be installed within the source area (MW-7s/d shown on Figure 4) to monitor the source area remediation effectiveness and to provide additional groundwater data near the source area boundary.

For the purposes of this CAS, it is assumed that the groundwater monitoring will be conducted quarterly for two years and then semi-annually afterwards. Groundwater monitoring will extend two years beyond the time estimated to attain RAOs to demonstrate the effectiveness of the remedy.

4.3.4 Environmental Use Controls

EUCs are generally used to reduce the risk of chemical exposure to receptors by providing legal notice and/or restricting access or use of property containing impacted media. Such controls may be applied to both soil and groundwater. EUCs are commonly developed to address issues at sites owned by a particular individual or business. When this is impractical, such as when impacted groundwater extends beneath a residential area, EUCs may be developed by state or municipal governments.

An EUC has been established for the Site which prohibits residential land use and the use of groundwater. Regardless of the selected remedy this EUC will remain in force until groundwater protection standards are met after which the EUC may be removed.

4.4 Organization of Detailed Evaluation

Each detailed alternative presented above is evaluated in one of the following subsections. These subsections are organized into two parts: a description of the detailed alternative, including implementation requirements; and an evaluation of the detailed alternative against seven of the eight criteria. The community acceptance criteria will not be evaluated in this report.

4.5 Detailed Alternative 0: No Further Action

Alternative 0 consists of no further remediation or other work at the Site. This alternative is considered as a baseline from which to compare the other alternatives.

4.5.1 Overall Protection

No remedial actions are proposed under Alternative 0; therefore the overall remedial goals will not be met. This alternative provides no protection to human health or the environment.

4.5.2 Compliance with ARARs

This alternative does not meet chemical-specific ARARs for target COPCs. Since no action is proposed, action-specific ARARs are not applicable for this alternative.

4.5.3 Long-Term Effectiveness and Permanence

The no action alternative proposes no actions or controls to reduce risk or exposure so all current risks remain the same under this alternative.

4.5.4 Reduction of Toxicity, Mobility, or Volume

No reduction of toxicity, mobility, or volume will take place outside of currently documented natural attenuation processes.

4.5.5 Short-Term Effectiveness

As discussed in Section 4.5.3 all current risks will remain the same under this alternative.

4.5.6 Implementability

Since no remedial action is specified under Alternative 0, there are no technical issues or difficulties associated with implementation.

4.5.7 Cost

The total cost for Alternative 0 is zero since no action is proposed. The cost for this baseline alternative is summarized alongside the other alternatives in Appendix B.

4.6 Detailed Alternative 1 – Monitored Natural Attenuation

MNA is presented as the presumptive remedy to address dissolved-phase groundwater impacts. MNA has been widely used at other sites to achieve clean-up goals. For this strategy, naturally occurring processes are relied upon to reduce COPC concentrations to levels that meet Project Site clean-up goals. The progress of natural attenuation is monitored to ensure that the processes continue to reduce concentrations within an acceptable time frame and that adverse effects do not result.

COPC concentrations in groundwater have begun to attenuate since corrective actions in the source area were implemented. Based upon current data available it is anticipated that the application of MNA is appropriate at this Site.

Existing Site wells would be utilized to monitor progress toward groundwater remedial action objectives. Groundwater monitoring would be conducted semi-annually.

EUCs have already been established for the Site.

4.6.1 Overall Protection

Site personnel implementing this remedy may have limited exposure to impacted materials (e.g. soil cuttings and groundwater) when installing wells (if needed) and during routine groundwater monitoring. Therefore, proper protective equipment would be required.

4.6.2 Compliance with ARARs

Several ARARs are applicable to this remedial alternative in relation to professional standards, chemicals and location. A complete listing of ARARs is given in the CI Report. ARARs common to all alternatives are discussed in Section 4.3.1.

Location-specific ARARs, such as permitting and restrictions, would also be applicable to this alternative. The installation of monitoring wells, if any, would require permitting by KDHE.

ARARs which specifically refer to waste generation would be applicable. Purge water from sampling events and soil cuttings from well installation, if any, would be disposed of in accordance with waste disposal ARARs.

4.6.3 Long-Term Effectiveness and Performance

The application of MNA would be implemented for the long-term goal of reducing COPC levels below the remediation goals identified in Table 1. The remediation goal for the Site is to reduce COPCs to levels below RSK levels, which correspond with USEPA Drinking Water MCLs. It is projected that this alternative would meet these long-term goals. The technologies utilized in this remedial alternative have been proven effective in demonstrating the reduction of chlorinated solvent concentrations below drinking water standards at other sites.

4.6.4 Reduction of Toxicity, Mobility or Volume

The main focus of the remedial effort would be in the source area. Using naturally occurring COPC reduction pathways, the mobility, toxicity, and volume of COPCs in the subsurface would occur through biological degradation, advection, and sorption to aquifer media.

4.6.5 Short-Term Effectiveness

As indicated by improvements in groundwater quality after the soil removal action, this remedial alternative is already active and will continue to mitigate impacted groundwater. However, near static PCE levels in groundwater at well MW-3s indicates that short-term effectiveness may be limited. Groundwater monitoring would be utilized to determine the short-term effectiveness of this remedy and the progress toward attaining groundwater RAOs.

4.6.6 Implementability

This remedy can be readily implemented and may require the installation of groundwater monitoring wells. Some waste generation may occur during well installation, but this waste is minimal and created as a one-time event. There is no O&M associated this remedy. Groundwater monitoring is necessary to demonstrate successful reduction in COPC concentrations and also can be readily implemented.

4.6.7 Cost

The cost of this alternative involves the costs needed for well installation (if any) and for groundwater monitoring. Nine years of costs associated with groundwater sampling, analysis and reporting are included.

The cost to implement Alternative 1 is $251,000, as summarized in Appendix B.

4.7 Detailed Alternative 2: Enhanced Biodegradation

Alternative 2 consists of enhanced reductive dechlorination to address on-Site groundwater impacts, with groundwater monitoring to verify effectiveness.

Implementation would be performed using either direct-push injection or injection wells. The injection points would be installed on-Site in a grid pattern as depicted in Figure 4. The injections would be designed to treat the shallow groundwater to an approximate depth of 20 feet. Deeper groundwater, which at the Site is not impacted above RSK standards, would not be actively treated.

This alternative would address both background and on-Site groundwater impacts by creating conditions favorable to VOC mass reduction in groundwater.

Groundwater monitoring would be conducted quarterly for two years and then semi-annually thereafter to demonstrate RSK attainment.

EUCs have already been established for the Site.

4.7.1 Overall Protection

Enhanced bioremediation/reductive dechlorination is known to be a safe and effective method to remediate groundwater VOC impacts.

Site personnel implementing this remedy may have limited exposure to impacted materials (e.g. soil cuttings and groundwater) when installing wells (if needed) or temporary injection points (if used) and during routine groundwater monitoring. Site personnel would also need to demonstrate care in handling treatment compounds and equipment that might inject these compounds at elevated pressures. Therefore, proper protective equipment would be required.

Waste bags or buckets, in which the injection chemicals are delivered, will require proper handling and disposal.

4.7.2 Compliance with ARARs

Several ARARs are applicable to this remedial alternative in relation to professional standards, chemicals and location. A complete listing of ARARs is given in the CI Report. ARARs common to all alternatives are discussed in Section 4.3.1.

Location-specific ARARs, such as permitting and restrictions, would also be applicable to this alternative. Injections of products to the subsurface would comply with underground injection

control regulations. The installation of monitoring wells, if any, and injection points would require permitting by KDHE.

ARARs which specifically refer to waste generation would be applicable. Purge water from sampling events and soil cuttings from well installation, if any, would be disposed of in accordance with waste disposal ARARs.

4.7.3 Long-Term Effectiveness and Permanence

Enhanced bioremediation/reductive dechlorination would be implemented for the long-term goal of reducing COPC levels below Kansas RSK values identified in Table 1. It is projected that this alternative would meet these long-term goals. Enhanced bioremediation/reductive dechlorination is anticipated to create conditions that will accelerate natural processes to degraded VOCs in groundwater both in the source area and in downgradient areas. The technologies utilized in this remedial alternative have been proven effective in reducing chlorinated solvent concentrations below drinking water standards at other sites.

It is assumed that active treatment would occur over a two year period and groundwater monitoring would be performed for an additional two years to demonstrate the remedy effectiveness. Thus the groundwater RAOs would be achieved in a period of four years.

4.7.4 Reduction of Toxicity, Mobility, or Volume

The main focus of the remedial effort would be in on-Site groundwater at the former source area. Using enhanced bioremediation/reductive dechlorination, the reduction of toxicity, mobility, or volume would occur through chemical processes that will promote the growth of bacteria capable of degrading COPCs to non-toxic products.

4.7.5 Short-Term Effectiveness

This remedial alternative is expected to immediately begin alteration groundwater chemistry favoring reductive processes that will degrade COPCs. Groundwater monitoring would be utilized to determine the short-term effectiveness of this remedy and the progress toward attaining groundwater RAOs.

4.7.6 Implementability

This remedy can be readily implemented and involves direct push technology or installation of injection wells. Some waste generation may occur during well installation (if needed), but this waste is minimal and created as a one- time event. There is no O&M associated this remedy. Groundwater monitoring is necessary to demonstrate successful reduction in COPC concentrations and also can be readily implemented.

4.7.7 Cost

Capital costs include costs for well installation (if any), for the installation of injection points or injection wells, and for chemical products that would be injected. It is estimated that Alternative 2 can be implemented in two years of active remedial action. An additional two years of costs associated with groundwater sampling, analysis and reporting are included.

The cost to implement Alternative 2 is $491,000, as summarized in Appendix B.

4.8 Detailed Alternative 3: Chemical Oxidation

Alternative 3 consists of *in-situ* chemical oxidation to address source area impact. Injection would be performed using either direct-push technology or through injection wells. The injection points would be installed in a grid pattern throughout the chemical oxidation zone as depicted in Figure 4. The injections would be designed to treat the shallow groundwater to an approximate depth of 20 feet. Deeper groundwater, which at the Site is not impacted above RSK standards, would not be actively treated. A treatability study would be performed prior to final remedial design and implementation in order to determine the proper oxidant dosage.

In-situ chemical oxidation of groundwater impacted by VOCs offers several advantages. Chemical oxidation can address a wide range of VOCs. It provides an aggressive treatment and can produce rapid short-term results and permanent reductions in VOC mass. It is anticipated that this technology would achieve RAOs for source area groundwater within 1 year.

However, multiple treatments may be required to address VOCs adsorbed to soil and which may act as an ongoing source of groundwater impact. Also, while initially high VOC concentrations may show a rapid decline, low VOC concentrations may require longer time to reach RAOs.

Groundwater monitoring would be conducted quarterly for two years and then semi-annually thereafter to demonstrate RSK attainment.

EUCs have already been established for the Site.

4.8.1 Overall Protection

In-situ chemical oxidation is known to be an effective method to remediate groundwater VOC impacts and has been proven to reduce groundwater VOC concentrations at similar sites.

Site personnel implementing this remedy may have limited exposure to impacted materials (e.g., soil cuttings and groundwater) when installing wells (if needed) or temporary injection points (if used) and during routine groundwater monitoring. Waste soil and water will require proper management and disposal.

Even though *in-situ* chemical oxidation is a commonly employed technology there are some hazards associated with handling injection chemicals. Injection chemicals will be properly handled and stored in accordance with safety data sheets. The contractor will follow proper safety precautions and procedures as described in the Site health and safety plan (HASP). Proper protective equipment, identified in the HASP, will be worn at all times to avoid contact with chemical oxidants. Waste bags or buckets, in which the injection chemicals are delivered, will require proper handling and disposal.

4.8.2 Compliance with ARARs

Several ARARs are applicable to this remedial effort in relation to professional standards, chemicals and location. A complete listing of ARARs is given in the CI Report, Table 1. ARARs common to all alternatives are discussed in Section 4.3.1.

Location-specific ARARs, such as permitting and restrictions, would also be applicable to this alternative. Injections of chemicals to the subsurface would comply with underground injection control regulations. The installation of monitoring wells, if any, and injection points would require permitting by KDHE.

ARARs which specifically refer to waste generation would be applicable. Purge water from sampling events and soil cuttings from well installation, if any, would be disposed of in accordance with waste disposal ARARs.

4.8.3 Long-Term Effectiveness and Permanence

In-situ chemical oxidation would be implemented for the long-term goal of reducing COPC levels below Kansas RSK values identified in Table 1. It is projected that this alternative would meet these long-term goals. The *in-situ* chemical oxidation is anticipated to chemically react with and degrade VOCs in the groundwater thereby reducing their concentration. The technologies utilized in this remedial alternative have been proven effective in reducing chlorinated solvent concentrations below drinking water standards at other sites.

It is assumed that active treatment would occur over a two year period and groundwater monitoring would be performed for an additional two years to demonstrate the remedy effectiveness. Thus the groundwater RAOs would be achieved in a period of four years.

4.8.4 Reduction of Toxicity, Mobility, or Volume

The main focus of the remedial effort would be in the source area. Using *in-situ* chemical oxidation, the reduction of toxicity, mobility, or volume of COPCs would occur through the chemical oxidation of COPCs to nonhazardous or less toxic compounds that are more stable, less mobile, or inert, thus effectively reducing COPC concentrations.

4.8.5 Short-Term Effectiveness

This remedial alternative is expected to immediately begin oxidation of subsurface COPCs. Groundwater monitoring would be utilized to determine the short-term effectiveness of this remedy and the progress toward attaining groundwater RAOs.

4.8.6 Implementability

This remedy can be readily implemented and involves direct push technology or installation of injection wells. Some waste generation may occur during well installation (if needed), but this waste is minimal and created as a one- time event. There is no O&M associated this remedy. Groundwater monitoring is necessary to demonstrate successful reduction in COPC concentrations and also can be readily implemented.

4.8.7 Cost

Capital costs include costs for well installation (if any), for the installation of injection points or injection wells, and for chemical products that would be injected. Two rounds of chemical injection are included and could be implemented within two years. An additional two years of costs associated with groundwater sampling, analysis and reporting are included.

The cost to implement Alternative 3 is $470,000, as summarized in Appendix B.

5 Comparative Analysis

The four detailed alternatives have been described and individually assessed against seven of the eight criteria identified in Section 4. The community acceptance criteria will not be addressed in this document, but will be addressed during the subsequent Corrective Action Decision Process.

In this section, a comparative analysis of the four detailed alternatives addresses each alternative's ability to meet the seven evaluation criteria. The purpose of this analysis is to identify the relative advantages and disadvantages of each detailed alternative. For this reason, the analysis focuses primarily on the differences between the detailed alternatives. This approach allows for an evaluation of the unique advantages/disadvantages of each detailed alternative rather than emphasizing elements that do not affect the final selection of a preferred detailed alternative.

Table 4 provides a summary of the evaluation of each detailed alternative based on the seven criteria. Two of the criteria, overall protection of human health and the environment and compliance with ARARs, serve as threshold determinations, because they must be met before a detailed alternative can be considered further. The threshold criteria are presented in Sections 5.1 and 5.2. Sections 5.3 through 5.7 present the remaining five criteria. Section 5.8 presents a summary of the comparative analysis of the seven detailed criteria.

5.1 Overall Protection

Overall protection of human health and the environment is accomplished by all of the proposed alternatives except for Alternative 0: No Action. Impacted groundwater and saturated soil in the source area is addressed for all alternatives to provide overall protection for the entire Site. As discussed in Section 2.5, RAOs were developed to protect human health and the environment and to meet Kansas RSK values for groundwater.

The primary distinction among the alternatives is the remedial technology used to address on-Site groundwater in the former source area. The groundwater remediation alternatives include:

- Alternative 0 – No Action
- Alternative 1 – Monitored Natural Attenuation
- Alternative 2 – Enhanced Biodegradation
- Alternative 3 – Chemical Oxidation

Each of these alternatives, with the exception of Alternative 0, provides overall protection to human health and the environment and is considered equal when measured against the overall protection criterion.

5.2 Compliance with ARARs

All detailed alternatives, except Alternative 0, would comply with all action-, location-, and chemical-specific ARARs and are therefore considered equal when measured against this criterion (see Table 4 for comparison). Alternatives 2 and 3 would require compliance with underground injection requirements for chemical injection. Alternatives 2 through 3 would require drilling and well installation permits and compliance with applicable groundwater monitoring guidance.

5.3 Long-Term Effectiveness and Performance

Physical risks are reduced in all detailed alternatives by chemically or biologically degrading VOC impact to groundwater. All alternatives, except Alternative 0, greatly reduce the chemical concentrations over time. The remediation time for Alternative 0 is indefinite due to the apparent static PCE level concentration in groundwater at MW-3s and leaves residual risk following remediation due to a lack of groundwater monitoring. The remediation time for the Alternative 1 is also indefinite, though groundwater monitoring will show whether progress is being made. Remediation times for Alternatives 2 and 3 are estimated at two years with two additional years for groundwater performance monitoring.

5.4 Reduction of Toxicity, Mobility or Volume

Alternatives 2 and 3 would reduce mass and toxicity through biological or chemically mediated reactions with COPCs in groundwater.

All alternatives, except Alternative 0, result in a reduction of toxicity, mobility, and volume.

Alternative 1 is not equal to the Alternatives 2 and 3 due to near static concentrations of PCE in MW-3s. Provided sufficient time, Alternatives 2 through 3 are essentially equal in meeting the RAO criterion.

5.5 Short-Term Effectiveness

Alternative 3 is effective in immediately reducing source area groundwater concentrations using chemical oxidation. Enhanced biodegradation (Alternative 2) is slightly less effective in this regard due to the time required to establish and maintain anaerobic groundwater conditions.

5.6 Implementability

Actions similar to those proposed in each detailed alternative have been implemented at other sites. However, the level of complexity of installation and O&M vary with the alternatives.

As discussed in Section 4.5.6, there is no implementability issues associated with Alternative 0 since no action is proposed.

Alternative 1 is also readily implementable as it includes only groundwater monitoring.

Alternatives 2 and 3 may require laboratory and/or pilot-scale treatability studies to verify site-specific groundwater treatment parameters (e.g., treatment rates and destruction efficiency). The results of the treatability test may require an alternative substrate or more than one application of the substrate to the subsurface. Alternatives 2 and 3 require the injection of chemical substrates which is also readily implementable.

The installation of monitoring wells, if needed, and groundwater sampling and analysis are routine and readily implementable.

5.7 Cost

Estimated costs for implementation of the four detailed alternatives evaluated are summarized in Appendix B and listed below.

Alternative	Action	Cost
Alternative 0	No Action	$0
Alternative 1	Monitored Natural Attenuation	$251,000
Alternative 2	Enhanced Biodegradation	$491,000
Alternative 3	Chemical Oxidation	$470,000

5.8 Summary of Comparative Analysis

Four alternatives are considered in this CAS, including:

- Alternative 0 – No Action
- Alternative 1 – Monitored Natural Attenuation
- Alternative 2 – Enhanced Biodegradation
- Alternative 3 – Chemical Oxidation

In Sections 5.1 through 5.7, a comparative analysis of the four detailed alternatives addressed each alternative's ability to meet the seven evaluation criteria. The analysis demonstrated that all of the detailed alternatives, except Alternative 0, would satisfactorily meet the following:

- Remedial action objectives.
- Overall protection of human health and the environment.
- Compliance with ARARs.
- Long-term effectiveness and permanence.
- Reduction of toxicity, mobility, and volume.

The criteria which were not met equally by each of the detailed alternatives were short-term effectiveness, implementability and cost. These criteria are used to determine the best overall alternative. Community acceptance has not yet been evaluated.

Considering all criteria, the best alternative based upon data available at the time of this report is Alternative 3, Chemical Oxidation. The other alternatives are eliminated as follows:

- Alternative 1, Monitored Natural Attenuation, is eliminated due to the apparent persistence of PCE in Site groundwater monitoring well MW-3s, subsequent to the soil removal action, and the indefinite time that might be required to meet groundwater RAOs through natural attenuation processes.

- Alternative 2, Enhanced Bioremediation, is an effective and cost competitive remedial alternative comparable to the selected remedy. However, this remedy was not selected due to more complex implementation, but may be a viable contingency if Site conditions dictate an alternative to the selected remedy.

Therefore, Alternative 3, Chemical Oxidation is the selected alternative and offers the following benefits:

- Cost effective
- Readily implementable
- Actively degrades VOC impacts to groundwater
- Promotes attainment of groundwater RAOs in a reasonable period of time
- Has a high likelihood of success

Brenntag looks forward to discussing these alternatives with KDHE and to beginning the design phase of remedy selection to assure selection of the remedial alternative that offers the greatest opportunity for success.

6 References

KDHE-BER, 2002. *Consent Order, Case No.* 02-E-0279. 9 December.

KDHE-BER, 2005a. *Potential Applicable or Relevant and Appropriate Requirements (ARARs), (Policy #BER-RS-015).* December.

KDHE-BER, 2005b. *Bureau of Environmental Remediation Policy: Scope of Work For a Comprehensive Investigation/Corrective Action Study. (Policy #BER-RS-020).* 29 December.

KDHE, 2010. Risk-Based Standards for Kansas, RSK Manual-5th Version. October.

KDHE-BER, 2012. *Bureau of Environmental Remediation Policy: Monitored Natural Attenuation. (Policy #BER-RS-042).* June.

USEPA, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, (EPA/540/G-89/004; OSWER Directive 9355.3-01). October.

Tables

Table 1
Physical and Chemical Properties of Volatile Organic Contaminants of Potential Concern
Brenntag Southwest, Inc. Facility
Wichita, Kansas

Chemical Name	Kansas RSK Value	Unit	Range of Detections	Molecular Weight	Boiling Point °C	Henry's Law Constant ($atm \cdot m^3/mol$)	Log K (oc)	K_d	Retardation Factor R_1	Retardation Factor R_2	Log K (ow)	Solubility in Organics	Solubility in Water (mg/L at 20 °C)	Specific Gravity (at 20/4 °C)
Tetrachloroethene	0.005	mg//L	<0.001 - 0.103	165.8	121	0.0177	2.42	0.66	4.95	4.01	2.67	Slightly soluble in ether, ethanol, chloroform, and benzene	206	1.623
Trichloroethene	0.005	mg//L	<0.001 - 0.0168	131.4	87.2	0.0091	1.81	0.16	1.97	1.74	2.53	Soluble in acetone, ethanol, chloroform, and ether	1,100	1.464
1,1-Dichlorothene	0.007	mg//L	<0.001 - 0.0051	96.9	37.0	0.021	1.81	0.16	1.97	1.74	2.13	Slightly soluble in ethanol, ether, acetone, benzene, and chloroform	400	1.218
cis-1,2-Dichlorothene	0.07	mg//L	<0.001 - 0.133	96.9	60.3	0.0034	1.60	0.10	1.60	1.45	1.86	Slightly soluble in ethanol, ether, acetone, benzene, and chloroform	3,500	1.284
Vinyl Chloride	0.002	mg//L	<0.001 - 0.0029	62.5	-13.4	2.78	0.39	0.01	1.04	1.03	0.6	Soluble in ethanol, carbon tetrachloride, and ether	1,100 mg/L at 25 °C	0.911

Notes:

Fraction organic carbon	0.25%	
Soil Bulk Density - Layer 1	1.50	g/cc
Soil Bulk Density - Layer 2	1.60	g/cc
Soil Porosity - Layer 1	0.25	
Soil Porosity - Layer 2	0.35	

Prepared by: mgm
Checked by: bds1

Table 2
Groundwater Monitoring
Analytical Data - Detects Only
Through April 2014
Brenntag Southwest, Inc. Facility
Wichita, Kansas

Well	Chemical Name	Tetrachloroethene	Trichloroethene	1,1-Dichloroethene	cis-1,2-Dichloroethene	Vinyl chloride
	RSK for Residential Groundwater Pathway	0.005 mg/L	0.005 mg/L	0.007 mg/L	0.070 mg/L	0.002 mg/L
MW-1d	2/7/2008		0.0020		0.0156	
MW-1d	5/6/2008		0.0014		0.0091	
MW-1d	8/29/2008		0.0031		0.0230	
MW-1d	12/22/2008		0.0018		0.0185	
MW-1d	3/19/2009		0.0016		0.0307	
MW-1d	6/19/2009		0.0022	0.0018	0.0623	0.00170
MW-1d	9/18/2009		0.00189		0.0386	0.00133
MW-1d	12/23/2009		0.0018	0.0013	0.0460	0.00074
MW-1d	3/11/2010		0.00055		0.0103	
MW-1d	6/28/2010		0.00068		0.0111	
MW-1d	9/10/2010		0.00079		0.0140	
MW-1d	12/16/2010		0.0016	0.00062	0.0265	0.00068
MW-1d	4/4/2011		0.0011	0.00025	0.0114	
MW-1d	6/7/2011				0.0105	
MW-1d	9/15/2011		0.0018	0.00044	0.0165	0.00035
MW-1d	12/15/2011		0.0018	0.00032	0.0133	
MW-1d	3/14/2012		0.0015	0.00032	0.0139	
MW-1d	6/26/2012		0.0017		0.0131	
MW-1d	10/3/2012		0.0021	0.00038	0.0163	
MW-1d	4/23/2013		0.0017	0.00043	0.0185	
MW-1d	10/25/2013		0.0017	0.00046	0.0137	
MW-1d	4/8/2014		0.0011		0.0047	
MW-1d	10/21/2014		0.0010		0.0036	
MW-1s	2/7/2008		0.0020		0.0022	
MW-1s	5/6/2008		0.0025		0.0063	
MW-1s	8/29/2008		0.0010			
MW-1s	12/22/2008		0.0011			
MW-1s	3/19/2009		0.0019		0.0081	
MW-1s	6/19/2009				0.0025	
MW-1s	9/18/2009					
MW-1s	12/23/2009		0.00075		0.0014	
MW-1s	3/11/2010		0.00097		0.0032	
MW-1s	6/28/2010		0.00056		0.00047	
MW-1s	9/10/2010		0.00051		0.00061	
MW-1s	12/16/2010		0.00054		0.00059	
MW-1s	4/4/2011		0.00110		0.0032	
MW-1s	6/7/2011		0.00065		0.0010	
MW-1s	9/15/2011		0.00098		0.0011	
MW-1s	12/15/2011		0.00140		0.0005	
MW-1s	3/14/2012		0.00260		0.0012	
MW-1s	6/26/2012		0.00370		0.0015	
MW-1s	10/3/2012		0.00320		0.0016	
MW-1s	4/23/2013		0.00250		0.0020	
MW-1s	10/25/2013		0.00300		0.0014	
MW-1s	4/8/2014		0.00090		0.0011	
MW-1s	10/21/2014		0.00082			
MW-2d	2/7/2008	0.0038	**0.0073**		0.0265	
MW-2d	5/6/2008	0.0018	**0.0120**		0.0110	
MW-2d	8/29/2008		**0.0151**		0.0414	
MW-2d	12/22/2008		**0.0112**		0.0174	
MW-2d	3/19/2009		**0.0060**		0.0400	
MW-2d	6/19/2009		0.0042		0.0425	
MW-2d	9/18/2009		0.00522	0.00105	0.0382	0.00124
MW-2d	12/23/2009		0.0048	0.00110	0.0443	0.00100
MW-2d	3/11/2010		**0.0051**	0.00049	0.0231	0.00057
MW-2d	6/28/2010		**0.0071**		0.0110	
MW-2d	9/10/2010		**0.0072**		0.0145	
MW-2d	12/16/2010		0.0048	0.00035	0.0138	
MW-2d	4/4/2011		0.0039	0.00082	0.0317	0.00090
MW-2d	6/7/2011		0.0036	0.00074	0.0323	0.00078
MW-2d	9/15/2011		0.0037	0.00100	0.0436	0.00110
MW-2d	12/15/2011		0.0035	0.00078	0.0334	0.00047
MW-2d	3/14/2012		0.0025	0.00078	0.0339	0.00079
MW-2d	6/26/2012		0.0020	0.00110	0.0472	0.00093
MW-2d	10/3/2012		0.0021	0.00110	0.0419	0.00093
MW-2d	4/23/2013		0.0014	0.00099	0.0466	0.00120
MW-2d	10/25/2013		**0.0050**	0.00038	0.0246	0.00093
MW-2d	4/8/2014		**0.0025**	0.00035	0.0163	0.00074
MW-2d	10/21/2014		0.0014	0.00058	0.0246	0.00160
MW-2s	2/7/2008	**0.1030**	**0.0098**		0.0530	
MW-2s	5/6/2008	**0.0284**	0.0033		0.0053	
MW-2s	8/29/2008	**0.0192**	0.0037		0.0027	
MW-2s	12/22/2008	**0.0289**	0.0029		0.0099	
MW-2s	3/19/2009	**0.0194**	0.0011			
MW-2s	6/19/2009	**0.0181**	0.0010			
MW-2s	9/18/2009	**0.00646**				
MW-2s	12/23/2009	**0.0070**	0.00058		0.00042	
MW-2s	3/11/2010	0.0041	0.00033			
MW-2s	6/28/2010	0.0045	0.00047		0.00052	
MW-2s	9/10/2010	**0.0064**	0.0013		0.0022	
MW-2s	12/16/2010	**0.0073**	0.00089		0.0018	
MW-2s	4/4/2011	**0.0079**	0.0013		0.0026	
MW-2s	6/7/2011	**0.0053**	0.0016		0.0023	
MW-2s	9/15/2011	**0.0217**	**0.0158**		0.0242	

All results in mg/L.
J - estimated concentration.

Bolded results exceed RSK value.

Table 2
Groundwater Monitoring
Analytical Data - Detects Only
Through April 2014
Brenntag Southwest, Inc. Facility
Wichita, Kansas

Well	Chemical Name	Tetrachloroethene	Trichloroethene	1,1-Dichloroethene	cis-1,2-Dichloroethene	Vinyl chloride
	RSK for Residential Groundwater Pathway	0.005 mg/L	0.005 mg/L	0.007 mg/L	0.070 mg/L	0.002 mg/L
MW-2s	12/15/2011	**0.0575**	**0.0082**		0.0311	
MW-2s	3/14/2012	**0.0454**	0.0048		0.0198	
MW-2s	6/26/2012	**0.0464**	**0.0052**		0.0160	
MW-2s	10/3/2012	**0.0116**	0.0034		0.0039	
MW-2s	4/23/2013	**0.0121**	0.0033		0.0051	
MW-2s	10/25/2013	**0.0051**	0.0041		0.0014	
MW-2s	4/8/2014	0.0024	0.0019		0.00038	
MW-2s	10/21/2014	0.00068	0.0024		0.00048	
MW-3d	2/7/2008	**0.0060**	0.0047		0.0172	
MW-3d	5/6/2008	0.0012	**0.0116**	0.0018	0.0615	0.0018
MW-3d	8/29/2008		**0.0095**	0.0016	0.0611	0.0017
MW-3d	12/22/2008		**0.0069**	0.0017	**0.0708**	**0.0022**
MW-3d	3/19/2009		**0.0065**	0.0024	**0.110**	**0.0029**
MW-3d	6/19/2009		**0.0061**	0.0021	**0.113**	**0.0027**
MW-3d	9/18/2009		0.0034		0.0314	0.00104
MW-3d	12/23/2009		0.0040	0.0021	**0.0946**	**0.0028**
MW-3d	3/11/2010		0.0023	0.00055	0.0301	0.00096
MW-3d	6/28/2010		0.0036	0.0011	0.0498	0.0014
MW-3d	9/10/2010		0.0037	0.0012	0.0544	0.0018
MW-3d	12/16/2010		0.0027	0.0012	0.0521	0.0015
MW-3d	4/4/2011	0.00026	0.0026	0.00059	0.0291	
MW-3d	6/7/2011		0.0029	0.0011	0.0564	0.0012
MW-3d	9/15/2011		0.0034	0.0014	0.0526	0.0016
MW-3d	12/15/2011		0.0028	0.0011	0.0448	0.0012
MW-3d	3/14/2012		0.0025	0.00048	0.0217	
MW-3d	6/26/2012		0.0020	0.0015	**0.0714**	**0.0020**
MW-3d	10/3/2012		0.0029	0.00084	0.0362	0.0007
MW-3d	4/23/2013		0.0017	0.0011	0.0600	0.0014
MW-3d	10/25/2013		0.0029	0.0014	0.0535	0.0011
MW-3d	4/8/2014		0.0013	0.0016	0.0627	0.0019
MW-3d	10/21/2014		0.0015	0.00095	0.0429	
MW-3s	2/7/2008	**0.0501**	**0.0165**		0.0053	
MW-3s	5/6/2008	**0.0193**	**0.0156**		0.0074	
MW-3s	8/29/2008	**0.0119**	**0.0168**		0.0058	
MW-3s	12/22/2008	**0.0110**	**0.0140**		0.0028	
MW-3s	3/19/2009	**0.0165**	**0.0120**		0.0015	
MW-3s	6/19/2009	**0.0072**	**0.0071**		0.0010	
MW-3s	9/18/2009	0.00383	0.00478			
MW-3s	12/23/2009	**0.0170**	0.0049		0.00028	
MW-3s	3/11/2010	**0.0158**	0.0044			
MW-3s	6/28/2010	**0.0111**	0.0056		0.0013	
MW-3s	9/10/2010	**0.0319**	**0.0068**		0.0016	
MW-3s	12/16/2010	**0.0146**	0.0041		0.00054	
MW-3s	4/4/2011	**0.0149**	**0.0063**		0.0024	
MW-3s	6/7/2011	**0.0162**	**0.0065**		0.0037	
MW-3s	9/15/2011	**0.0243**	**0.0080**		0.0060	
MW-3s	12/15/2011	**0.0283**	**0.0072**		0.0051	
MW-3s	3/14/2012	**0.0267**	**0.0055**		0.0026	
MW-3s	6/26/2012	**0.0121**	**0.0054**		0.0014	
MW-3s	10/3/2012	**0.0233**	0.0049		0.0026	
MW-3s	4/23/2013	**0.0379**	0.0031		0.0023	
MW-3s	10/25/2013	**0.0113**	0.0019		0.0016	
MW-3s	4/8/2014	**0.0217**	0.0014		0.00087	
MW-3s	10/21/2014	**0.0193**	0.0020		0.00044	
MW-4d	4/4/2011	0.00069	0.0020	0.00510	0.0201	0.00044
MW-4d	6/7/2011		0.0032	0.00085	0.0354	0.00100
MW-4d	9/15/2011	0.00026	0.0032	0.00085	0.0315	0.00077
MW-4d	12/15/2011		0.0027	0.00064	0.0226	0.00049
MW-4d	3/14/2012	0.00059	0.0023	0.00051	0.0179	
MW-4d	6/26/2012		0.0028		0.0201	
MW-4d	10/3/2012		0.0029	0.00059	0.0192	
MW-4d	4/23/2013	0.00040	0.0023	0.00045	0.0143	
MW-4d	10/25/2013		0.0024	0.00065	0.0181	
MW-4d	4/8/2014		0.0017		0.0136	
MW-4d	10/21/2014		0.0019		0.0111	
MW-4s	6/7/2011	0.0045	0.00081		0.00081	
MW-4s	9/15/2011	0.0049	0.00110		0.00091	
MW-4s	12/15/2011	0.0013	0.00058		0.00079	
MW-4s	3/14/2012	0.0011	0.00070		0.00100	
MW-4s	6/26/2012	0.0032	0.00066		0.00082	
MW-4s	10/3/2012	0.0011	0.00080		0.00150	
MW-4s	4/23/2013	0.0026	0.00064		0.00053	
MW-4s	10/25/2013	0.0026	0.00040		0.00046	
MW-4s	4/8/2014	0.0011	0.00044			
MW-4s	10/21/2014	0.0010				

Prepared by: mgm
Checked by: bds1

All results in mg/L.
J - estimated concentration.

Bolded results exceed RSK value.

Table 3
Remedial Technologies Screening Matrix
Brenntag Southwest, Inc. Facility
Wichita, Kansas

Treatment Technology	Status	Effectiveness	Implementability	Cost
Air Sparging	Eliminate	Effective at decreasing concentrations of VOCs in groundwater.	**Requires construction of infrastructure is operating facility below concrete slab that is part of the interim action remedy.** Underground injection permit required.	Moderate
Enhanced Bioremediation	Retain	Enhances anaerobic reduction process. May require repeat applications.	Feasible injection by wells/points. Little maintenance required. Underground injection permits required.	Moderate
Chemical Oxidation	Retain	May be effective in degrading high concentrations of chlorinated VOCs in source areas, high removal in many porous medias with the exception of bedrock. Effectiveness is less reliable for clay soils, but this can be overcome by multiple injections at higher pressures.	Little maintenance required. Underground injection permits required.	Moderate
Environmental Use Control	Retain	Effective at decreasing exposure to shallow impacted groundwater. High VOCs remain for 40 years or more due to very slow natural attenuation rate.	Already implemented at the property, but likely not a stand alone solution	Low
Monitored Natural Attenuation	Retain	Small risk of exposure. Rate of MNA alone may be sufficient to prevent plume migration.	No complex system necessary.	Moderate
Pump-and-Treat	Eliminate	**Longer cleanup times to flush multiple volumes of groundwater. No existing treatment equipment at site.**	Pump and treat will remove some VOC from groundwater and prevent migration. Relatively easily constructed. Extensive utilities may complicate installation. Water discharge approval/permits required.	**High**
In-Situ Thermal Treatment	Eliminate	**Very aggressive method in high concentrations of chlorinated VOCs in source areas**, high removal has been shown in many types of media, high volumes of groundwater equate to higher energy costs.	More recent technology experience has improved performance. Impacted depth beneath 10 or more feet of unimpacted soil may favor a well-point sytem.	**High**
Vacuum Enhanced Recovery	Eliminate	Removes high concentration groundwater from central plume area relatively quickly by both soil venting and groundwater removal. Can initiate volatilization from shallow soils and collect VOCs from multiple phases (air and water). **Site groundwater COC concentrations are already low.**	Vacuum lines can be installed in existing wells. **Equipment and on-site treatment system are not available.**	Low
Zero-Valent Iron Passive Reactive Barrier (PRB)	Eliminate	Proven an effective method of preventing plume migration and degrading CVOCs on many government sites. **Lifespan of barrier is 10 to 15 years, but treatment period is indeterminent.**	Underground injection permit required.	**High**

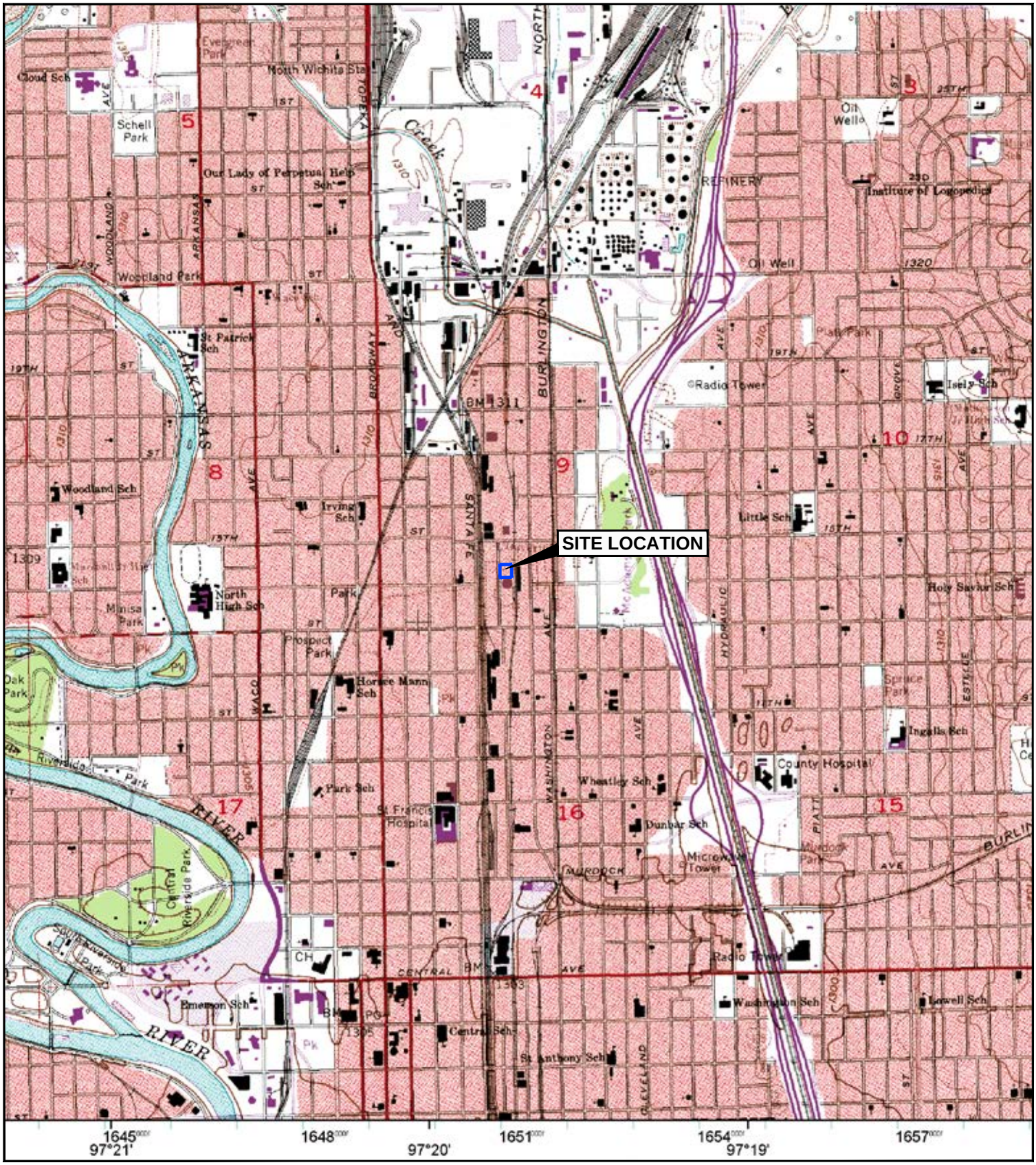
Notes:
O&M - operation and maintanence
Technologies to consider come from the Remediation Technologies Screening Matrix developed by the EPA.
Only Technologies with a target contaminant of halgenated volatile organic compounds were considered.
Bold indicates reason for elimination of technology from further consideration.

Prepared by: mgm
Checked by: bds1

Table 4
Detailed Remedial Action Options Screening Matrix
Brenntag Southwest, Inc. Facility
Wichita, Kansas

Evaluation Criteria Description	Remedial Action Option 1 Monitored Natural Attenuation Environmental Use Controls	Remedial Action Option 2 Enhanced Bioremediation Groundwater Monitoring Environmental Use Controls	Remedial Action Option 3 Chemical Oxidation Groundwater Monitoring Environmental Use Controls
1. Overall Protection	Remedial action objectives may be met.	Remedial action objectives are met.	Remedial action objectives are met.
2. Compliance with ARAR's	Meets ARARs.	Meets ARARs.	Meets ARARs.
3. Long-Term Effectiveness and Permanence			
- Magnitude of Residual Risk	Very slow attenuation rate leaving 75% of mass after 10 years.	Short term active remedy could result in 10% or less of VOCs remaining after 1 to 2 years.	Short term active remedy could result in 10% or less of VOCs remaining after 1 to 2 years.
- Adequacy and Reliability of Controls	**Requires groundwater monitoring to determine effectiveness. Near stable concentrations at MW-3s may indicate need for more active remedy.**	Requires groundwater monitoring to determine effectiveness.	Requires groundwater monitoring to determine effectiveness.
-Active source area remediation	Active source area has already been addressed during the 2007 Interim Action.	Active source area has already been addressed during the 2007 Interim Action.	Active source area has already been addressed during the 2007 Interim Action.
4. Short-Term Effectiveness			
- Time to achieve remedial action objectives.	**Indeterminent based on current groundwater concentrations of PCE at MW-3s. Nine years of additional sampling and analysis included in the cost estimate.**	**4 years**	**4 years**
- Protection of site remediation workers during remedial action.	Implementation would require ongoing sampling and analysis of impacted groundwater.	Implementation would require limited handling of impacted material and treatment chemicals.	Implementation would require limited handling of impacted material and treatment chemicals.
- Protection of community during remedial action.	Risk to community not increased by implementation.	Risk to community not increased by implementation.	Risk to community not increased by implementation.
- Protection of environment during remedial action.	**None.**	Impact reduced through compliance with injection permit.	Impact reduced through compliance with injection permit.
5. Implementability			
- Technical	Common technology. No additional equipment and materials required.	Bench-scale or pilot-scale treatability tests to determine treatment efficiencies and rates. A number of biological enhancement chemicals and bioaugmentation products are available.	Bench-scale or pilot-scale treatability tests to determine treatment efficiencies and rates. A number of chemical oxidation chemicals and products are available.
- Permits	None.	Underground Injection permits required.	Underground Injection permits required.
6. Cost	$251,000	$491,000	$470,000

Figures



NOTES:

1. Coordinate System: KS83-SF
2. Datum: NAD83
3. Location: 37 42 37N, 97 19 44W

Foth

N

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

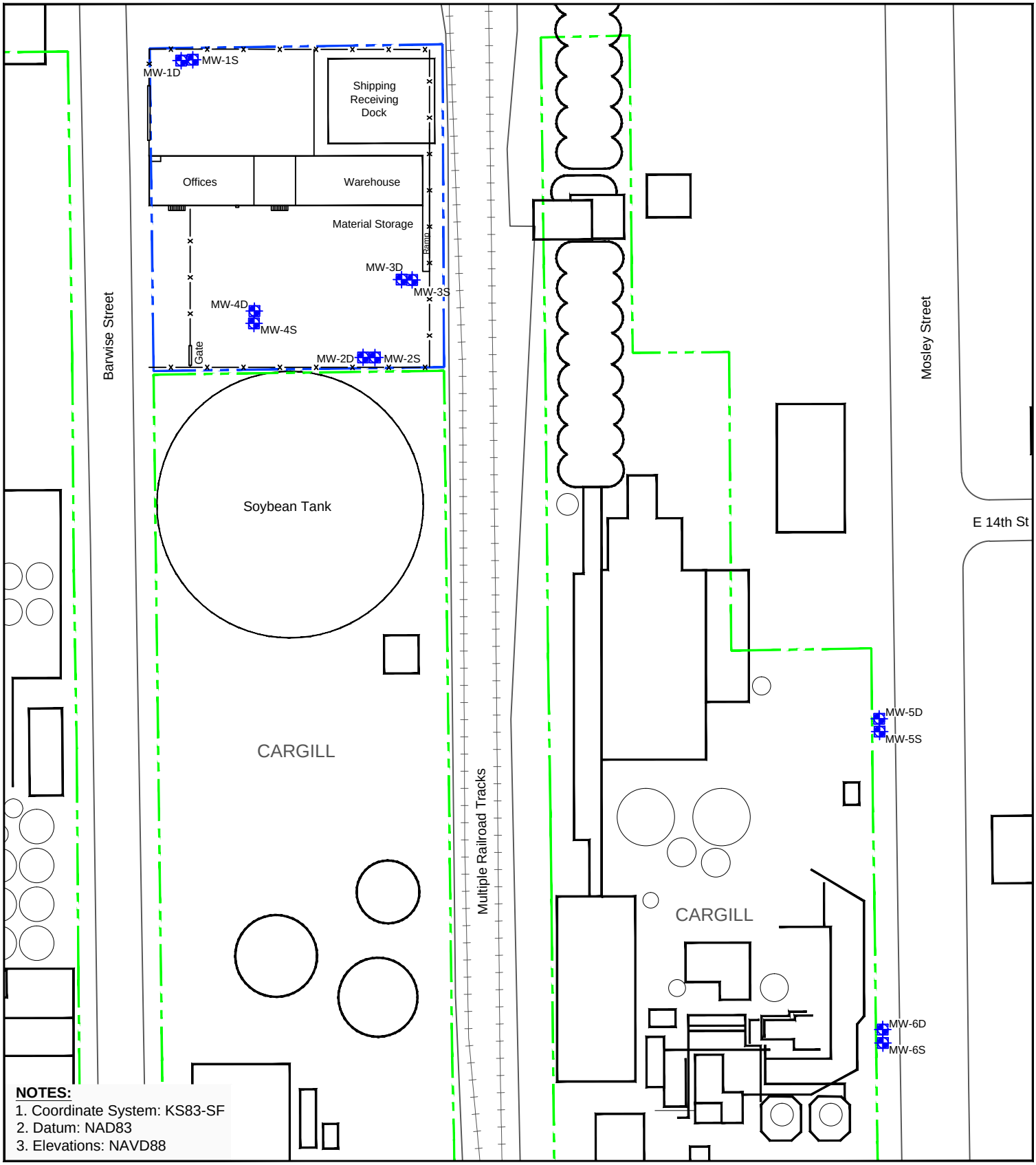
0 1,000 2,000 Feet

BRENNTAG SOUTHWEST

FIGURE 1
SITE LOCATION MAP
CORRECTIVE ACTION STUDY
1520 N. BARWISE STREET
WICHITA, KANSAS

Date: FEBRUARY 2015	Revision:	
Drawn By: ADM	Checked By: MGM	Scope: 12B477

Feb 27, 2015 - 7:31am ADM1 X:\SP\IE\2012\12B477\GIS\dwg\CAS Report Figures\12B477_CAS_F1 SiteLocation.dwg



NOTES:
1. Coordinate System: KS83-SF
2. Datum: NAD83
3. Elevations: NAVD88

LEGEND:
- Monitoring Well Location
- Fence
- Brenntag Property Boundary
- Cargill Property Boundary

Foth

N

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

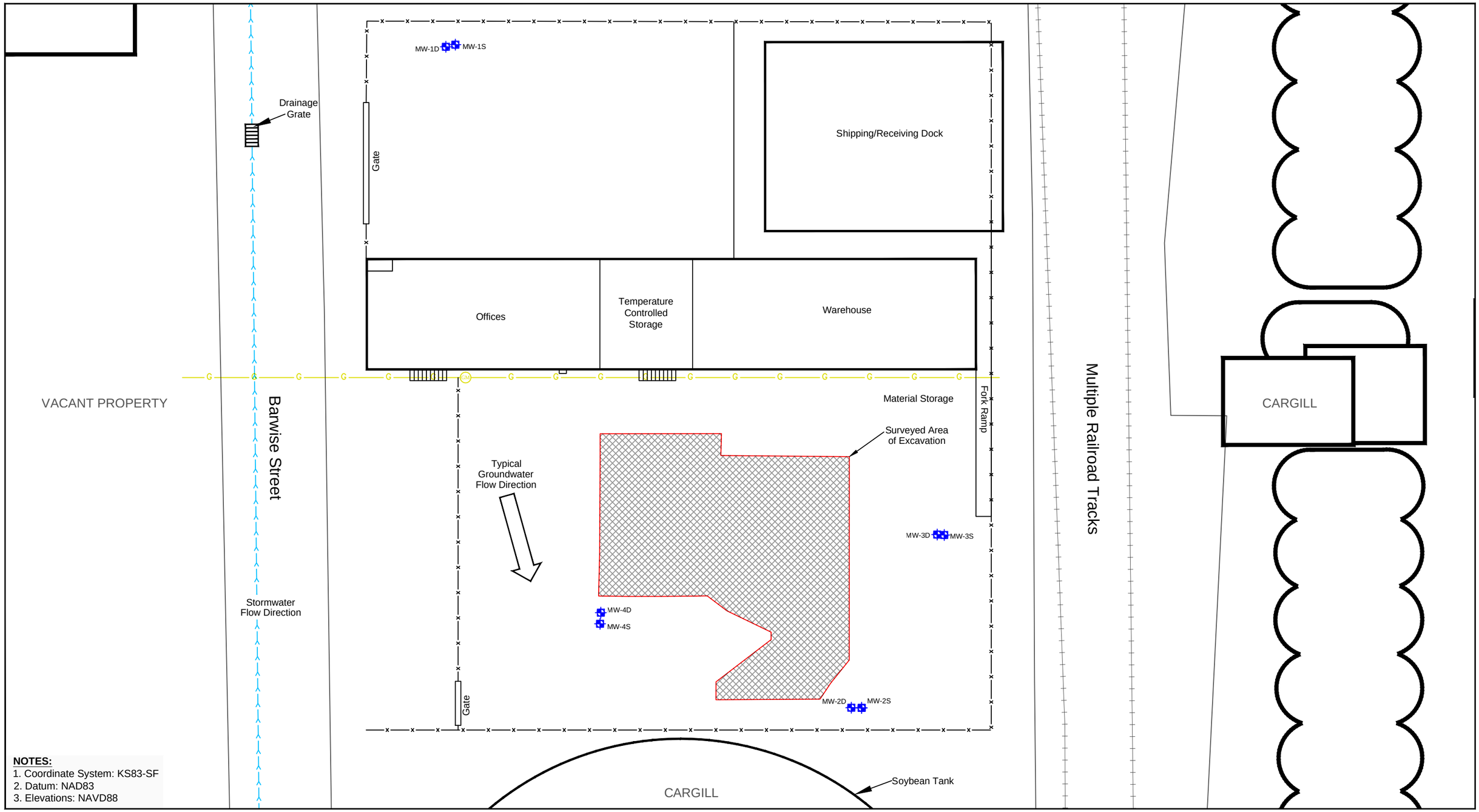
0 40 80 Feet

BRENNTAG SOUTHWEST

FIGURE 2
SITE LAYOUT MAP
CORRECTIVE ACTION STUDY
1520 N. BARWISE STREET
WICHITA, KANSAS

Date: FEBRUARY 2015	Revision:	
Drawn By: ADM	Checked By: MGM	Scope: 12B477

Feb 27, 2015 - 7:33am ADM1 X:\SP\IE\2012\12B477\GIS\dwg\CAS Report Figures\12B477_CAS_F2 SiteLayout.dwg



NOTES:
1. Coordinate System: KS83-SF
2. Datum: NAD83
3. Elevations: NAVD88

LEGEND:
- Monitoring Well Location
- Fence
- Gas Line
- Storm Sewer
- Surveyed Area of Excavation

Foth

N

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

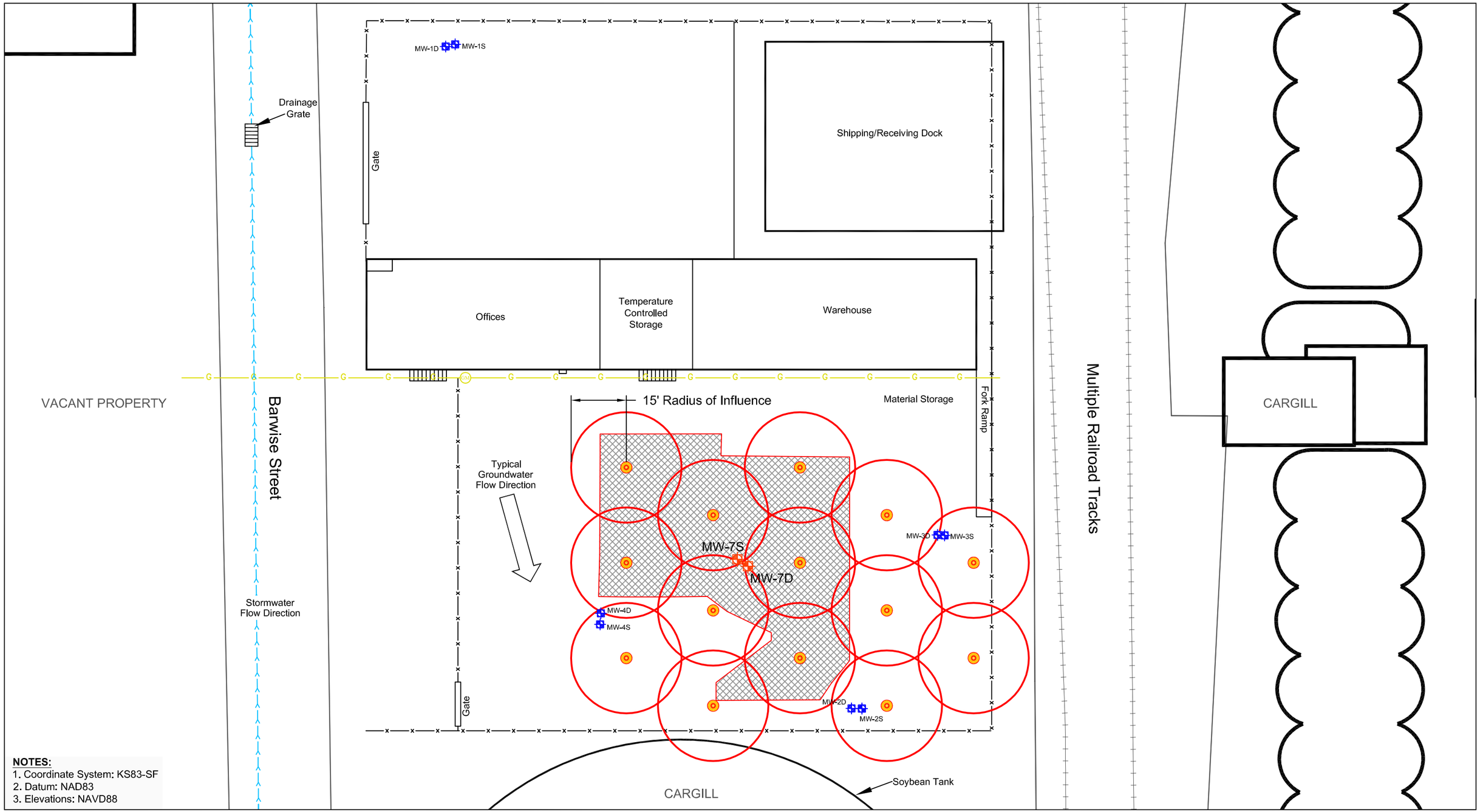
0 25 Feet

BRENNTAG SOUTHWEST

FIGURE 3
INTERIM REMEDIAL MEASURE
FOR SOIL EXCAVATION AREA (2007)
CORRECTIVE ACTION STUDY
1520 N. BARWISE STREET
WICHITA, KANSAS

Date: FEBRUARY 2015	Revision:	
Drawn By: ADM	Checked By: MGM	Scope: 12B477

Mar 02, 2015 - 5:00am ADM1 X:\SP\IE\2012\12B477\GIS\dwg\CAS Report Figures\12B477_CAS_F3 ExcavFootprint.dwg



NOTES:
1. Coordinate System: KS83-SF
2. Datum: NAD83
3. Elevations: NAVD88

LEGEND:
- Monitoring Well Location
- Fence
- Gas Line
- Storm Sewer
- Surveyed Area of Excavation
- New 2" Injection Well
- New 2" Monitoring Well

Foth

N

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

0 25 Feet

BRENNTAG SOUTHWEST

FIGURE 4
INJECTION REMEDY PLAN
CORRECTIVE ACTION STUDY
1520 N. BARWISE STREET
WICHITA, KANSAS

Date: FEBRUARY 2015	Revision:	
Drawn By: ADM	Checked By: MGM	Scope: 12B477

Feb 27, 2015 - 7:05am ADM1 X:\SP\IE\2012\12B477\GIS\dwg\CAS Report Figures\12B477_CAS_F4 InjectionRemedy.dwg

Appendix A

Mass Balance

Groundwater Mass

Well	PCE lbs	TCE lbs	1,1-DCE lbs	cis-DCE lbs	VC lbs	GW Mass lbs	GW Mass %	Area sq ft	Soil Volume % of Total
Below Exc. - shallow	0.009	0.001	0.000	0.000	0.000	0.010	5.5%	53.1%	11.7%
MW-2s	0.000	0.000	0.000	0.000	0.000	0.000	0.1%	8.3%	1.9%
MW-3s	0.004	0.000	0.000	0.000	0.000	0.004	2.4%	21.9%	5.1%
MW-4s	0.000	0.000	0.000	0.000	0.000	0.000	0.1%	16.7%	3.2%
Below Exc. - deep	0.000	0.004	0.002	0.096	0.004	0.106	58.4%	-	41.5%
MW-2d	0.000	0.000	0.000	0.009	0.001	0.010	5.5%	-	6.5%
MW-3d	0.000	0.001	0.001	0.039	0.000	0.042	23.0%	-	17.0%
MW-4d	0.000	0.001	0.000	0.008	0.000	0.009	5.0%	-	13.0%
Totals	0.013	0.009	0.003	0.152	0.004	0.181	100.0%	100.0%	100.0%
	7.0%	5.0%	1.8%	84.0%	2.3%	100.0%			

Soil Mass	PCE lbs	TCE lbs	1,1-DCE lbs	cis-DCE lbs	VC lbs	Soil Mass lbs	Soil Mass %	Area sq ft	Soil Volume % of Total
Below Exc. - shallow	0.0342	0.0010	0.0000	0.0001	0.0000	0.0354	27.5%	53.1%	11.7%
MW-2s	0.0002	0.0002	0.0000	0.0000	0.0000	0.0004	0.3%	8.3%	1.9%
MW-3s	0.0149	0.0004	0.0000	0.0001	0.0000	0.0154	11.9%	21.9%	5.1%
MW-4s	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005	0.4%	16.7%	3.2%
Below Exc. - deep	0.0000	0.0031	0.0015	0.0437	0.0002	0.0485	37.7%	-	41.5%
MW-2d	0.0000	0.0004	0.0001	0.0039	0.0000	0.0045	3.5%	-	6.5%
MW-3d	0.0000	0.0010	0.0006	0.0180	0.0000	0.0196	15.2%	-	17.0%
MW-4d	0.0000	0.0010	0.0000	0.0035	0.0000	0.0045	3.5%	-	13.0%
Totals	0.0499	0.0070	0.0023	0.0694	0.0002	0.1288	100.0%	100.0%	100.0%
	38.7%	5.4%	1.8%	53.9%	0.1%	100.0%			

Soil and Groundwater Mass	PCE lbs	TCE lbs	1,1-DCE lbs	cis-DCE lbs	VC lbs	Total VOC lbs
Shallow Subtotal	0.0625	0.0032	0.0000	0.0005	0.0000	0.0663
Deep Subtotal	0.0000	0.0129	0.0055	0.2207	0.0043	0.2435
Total	0.0625	0.0161	0.0055	0.2213	0.0043	0.3097

Soil Density	shallow	93.5	lbs/cu ft
	deep	99.7	lbs/cu ft

Concentration of COPC is below RSK value

Prepared by: mgm
Checked by: bds1

Groundwater Tetrachloroethene Mass

Well	Depth A ft amsl	Depth B ft amsl	Thickness ft	Area sq ft	Soil Volume cu ft	Porosity	Volume GW gal	GW Conc mg/L	GW Mass lbs	GW Mass %
Below Exc. - shallow	1,292.06	1,286.42	5.6	5,100	28,764	0.25	53,792	0.019	0.009	68.6%
MW-2s	1,292.49	1,286.54	6.0	800	4,760	0.25	8,902	0.001	0.000	0.4%
MW-3s	1,292.52	1,286.54	6.0	2,100	12,558	0.25	23,485	0.019	0.004	30.0%
MW-4s	1,291.16	1,286.17	5.0	1,600	7,984	0.25	14,931	0.001	0.000	1.0%
Below Exc. - deep	1,286.42	1,266.38	20.0	5,100	102,204	0.35	267,588	0.000	0.000	0.0%
MW-2d	1,286.54	1,266.44	20.1	800	16,080	0.35	42,100	0.000	0.000	0.0%
MW-3d	1,286.54	1,266.54	20.0	2,100	42,000	0.35	109,963	0.000	0.000	0.0%
MW-4d	1,286.17	1,266.15	20.0	1,600	32,032	0.35	83,865	0.000	0.000	0.0%
								Totals	0.013	100.0%

Soil Tetrachloroethene Mass

Area	Soil Volume cu ft	GW Conc mg/L	Distribution Coefficient K_d	Soil Conc mg/kg	Soil Mass lbs	VOC Mass %
Below Exc. - shallow	28,764	0.019	0.66	0.013	0.0342	68.6%
MW-2s	4,760	0.001	0.66	0.000	0.0002	0.4%
MW-3s	12,558	0.019	0.66	0.013	0.0149	30.0%
MW-4s	7,984	0.001	0.66	0.001	0.0005	1.0%
Below Exc. - deep	102,204	0.000	0.66	0.000	0.0000	0.0%
MW-2d	16,080	0.000	0.66	0.000	0.0000	0.0%
MW-3d	42,000	0.000	0.66	0.000	0.0000	0.0%
MW-4d	32,032	0.000	0.66	0.000	0.0000	0.0%
				Totals	0.0499	100.0%

Soil Density	shallow	93.5	lbs/cu ft
	deep	99.7	lbs/cu ft

Prepared by: mgm
Checked by: bds1

Groundwater Trichloroethene Mass

Well	Depth A ft amsl	Depth B ft amsl	Thickness ft	Area sq ft	Soil Volume cu ft	Porosity	Volume GW gal	GW Conc mg/L	GW Mass lbs	GW Mass %
Below Exc. - shallow	1,292.06	1,286.42	5.6	5,100	28,764	0.25	53,792	0.002	0.001	11.9%
MW-2s	1,292.49	1,286.54	6.0	800	4,760	0.25	8,902	0.002	0.000	2.0%
MW-3s	1,292.52	1,286.54	6.0	2,100	12,558	0.25	23,485	0.002	0.000	4.3%
MW-4s	1,291.16	1,286.17	5.0	1,600	7,984	0.25	14,931	0.000	0.000	0.0%
Below Exc. - deep	1,286.42	1,266.38	20.0	5,100	102,204	0.35	267,588	0.002	0.004	46.7%
MW-2d	1,286.54	1,266.44	20.1	800	16,080	0.35	42,100	0.001	0.000	5.4%
MW-3d	1,286.54	1,266.54	20.0	2,100	42,000	0.35	109,963	0.002	0.001	15.1%
MW-4d	1,286.17	1,266.15	20.0	1,600	32,032	0.35	83,865	0.002	0.001	14.6%
								Totals	0.009	100.0%

Soil Trichloroethene Mass

Area	Soil Volume cu ft	GW Conc mg/L	Distribution Coefficient K_d	Soil Conc mg/kg	Soil Mass lbs	VOC Mass %
Below Exc. - shallow	28,764	0.002	0.16	0.000	0.0010	14.7%
MW-2s	4,760	0.002	0.16	0.000	0.0002	2.4%
MW-3s	12,558	0.002	0.16	0.000	0.0004	5.4%
MW-4s	7,984	0.000	0.16	0.000	0.0000	0.0%
Below Exc. - deep	102,204	0.002	0.16	0.000	0.0031	44.2%
MW-2d	16,080	0.001	0.16	0.000	0.0004	5.1%
MW-3d	42,000	0.002	0.16	0.000	0.0010	14.3%
MW-4d	32,032	0.002	0.16	0.000	0.0010	13.8%
				Totals	0.0070	100.0%

Soil Density	shallow	93.5	lbs/cu ft
	deep	99.7	lbs/cu ft

Prepared by: mgm
Checked by: bds1

Groundwater 1,1-Dichloroethene Mass

Well	Depth A ft amsl	Depth B ft amsl	Thickness ft	Area sq ft	Soil Volume cu ft	Porosity	Volume GW gal	GW Conc mg/L	GW Mass lbs	GW Mass %
Below Exc. - shallow	1,292.06	1,286.42	5.6	5,100	28,764	0.25	53,792	0.000	0.000	0.0%
MW-2s	1,292.49	1,286.54	6.0	800	4,760	0.25	8,902	0.000	0.000	0.0%
MW-3s	1,292.52	1,286.54	6.0	2,100	12,558	0.25	23,485	0.000	0.000	0.0%
MW-4s	1,291.16	1,286.17	5.0	1,600	7,984	0.25	14,931	0.000	0.000	0.0%
Below Exc. - deep	1,286.42	1,266.38	20.0	5,100	102,204	0.35	267,588	0.001	0.002	66.4%
MW-2d	1,286.54	1,266.44	20.1	800	16,080	0.35	42,100	0.001	0.000	6.4%
MW-3d	1,286.54	1,266.54	20.0	2,100	42,000	0.35	109,963	0.001	0.001	27.3%
MW-4d	1,286.17	1,266.15	20.0	1,600	32,032	0.35	83,865	0.000	0.000	0.0%
								Totals	0.003	100.0%

Soil 1,1-Dichloroethene Mass

Area	Soil Volume cu ft	GW Conc mg/L	Distribution Coefficient K_d	Soil Conc mg/kg	Soil Mass lbs	VOC Mass %
Below Exc. - shallow	28,764	0.000	0.16	0.000	0.0000	0.0%
MW-2s	4,760	0.000	0.16	0.000	0.0000	0.0%
MW-3s	12,558	0.000	0.16	0.000	0.0000	0.0%
MW-4s	7,984	0.000	0.16	0.000	0.0000	0.0%
Below Exc. - deep	102,204	0.001	0.16	0.000	0.0015	66.4%
MW-2d	16,080	0.001	0.16	0.000	0.0001	6.4%
MW-3d	42,000	0.001	0.16	0.000	0.0006	27.3%
MW-4d	32,032	0.000	0.16	0.000	0.0000	0.0%
				Totals	0.0023	100.0%

Soil Density	shallow	93.5	lbs/cu ft
	deep	99.7	lbs/cu ft

Prepared by: mgm
Checked by: bds1

Groundwater cis-1,2-Dichloroethene Mass

Well	Depth A ft amsl	Depth B ft amsl	Thickness ft	Area sq ft	Soil Volume cu ft	Porosity	Volume GW gal	GW Conc mg/L	GW Mass lbs	GW Mass %
Below Exc. - shallow	1,292.06	1,286.42	5.6	5,100	28,764	0.25	53,792	0.000	0.000	0.1%
MW-2s	1,292.49	1,286.54	6.0	800	4,760	0.25	8,902	0.000	0.000	0.0%
MW-3s	1,292.52	1,286.54	6.0	2,100	12,558	0.25	23,485	0.000	0.000	0.1%
MW-4s	1,291.16	1,286.17	5.0	1,600	7,984	0.25	14,931	0.000	0.000	0.0%
Below Exc. - deep	1,286.42	1,266.38	20.0	5,100	102,204	0.35	267,588	0.043	0.096	63.1%
MW-2d	1,286.54	1,266.44	20.1	800	16,080	0.35	42,100	0.025	0.009	5.7%
MW-3d	1,286.54	1,266.54	20.0	2,100	42,000	0.35	109,963	0.043	0.039	25.9%
MW-4d	1,286.17	1,266.15	20.0	1,600	32,032	0.35	83,865	0.011	0.008	5.1%
								Totals	0.152	100.0%

Soil cis-1,2-Dichloroethene Mass

Area	Soil Volume cu ft	GW Conc mg/L	Distribution Coefficient K_d	Soil Conc mg/kg	Soil Mass lbs	VOC Mass %
Below Exc. - shallow	28,764	0.000	0.10	0.000	0.0001	0.2%
MW-2s	4,760	0.000	0.10	0.000	0.0000	0.0%
MW-3s	12,558	0.000	0.10	0.000	0.0001	0.1%
MW-4s	7,984	0.000	0.10	0.000	0.0000	0.0%
Below Exc. - deep	102,204	0.043	0.10	0.004	0.0437	63.0%
MW-2d	16,080	0.025	0.10	0.002	0.0039	5.7%
MW-3d	42,000	0.043	0.10	0.004	0.0180	25.9%
MW-4d	32,032	0.011	0.10	0.001	0.0035	5.1%
				Totals	0.0694	100.0%

Soil Density	shallow	93.5	lbs/cu ft
	deep	99.7	lbs/cu ft

Prepared by: mgm
Checked by: bds1

Groundwater Vinyl Chloride

Well	Depth A ft amsl	Depth B ft amsl	Thickness ft	Area sq ft	Soil Volume cu ft	Porosity	Volume GW gal	GW Conc mg/L	GW Mass lbs	GW Mass %
Below Exc. - shallow	1,292.06	1,286.42	5.6	5,100	28,764	0.25	53,792	0.000	0.000	0.0%
MW-2s	1,292.49	1,286.54	6.0	800	4,760	0.25	8,902	0.000	0.000	0.0%
MW-3s	1,292.52	1,286.54	6.0	2,100	12,558	0.25	23,485	0.000	0.000	0.0%
MW-4s	1,291.16	1,286.17	5.0	1,600	7,984	0.25	14,931	0.000	0.000	0.0%
Below Exc. - deep	1,286.42	1,266.38	20.0	5,100	102,204	0.35	267,588	0.002	0.004	86.4%
MW-2d	1,286.54	1,266.44	20.1	800	16,080	0.35	42,100	0.002	0.001	13.6%
MW-3d	1,286.54	1,266.54	20.0	2,100	42,000	0.35	109,963	0.000	0.000	0.0%
MW-4d	1,286.17	1,266.15	20.0	1,600	32,032	0.35	83,865	0.000	0.000	0.0%
								Totals	0.004	100.0%

Soil Vinyl Chloride

Area	Soil Volume cu ft	GW Conc mg/L	Distribution Coefficient K_d	Soil Conc mg/kg	Soil Mass lbs	VOC Mass %
Below Exc. - shallow	28,764	0.000	0.01	0.0000	0.0000	0.0%
MW-2s	4,760	0.000	0.01	0.0000	0.0000	0.0%
MW-3s	12,558	0.000	0.01	0.0000	0.0000	0.0%
MW-4s	7,984	0.000	0.01	0.0000	0.0000	0.0%
Below Exc. - deep	102,204	0.002	0.01	0.0000	0.0002	86.4%
MW-2d	16,080	0.002	0.01	0.0000	0.0000	13.6%
MW-3d	42,000	0.000	0.01	0.0000	0.0000	0.0%
MW-4d	32,032	0.000	0.01	0.0000	0.0000	0.0%
				Totals	0.0002	100.0%

Soil Density	shallow	93.5	lbs/cu ft
	deep	99.7	lbs/cu ft

Prepared by: mgm
Checked by: bds1

Appendix B

Cost Estimates

Cost Estimate Summary
Brenntag Southwest
1520 N. Barwise
Wichita, Kansas

ALTERNATIVE	DESCRIPTION	ACTIVE REMEDIATION TIME (years) [1]	TOTAL REMEDIATION TIME (years) [2]	CAPITAL COST		OPERATIONS, MAINTENANCE & MONITORING COST		TOTAL COST
				Installation Costs	Total Capital Cost [3]	Annual Monitoring Costs	Total OM&M	Current Worth [4]
Alternative 0	No Further Action	N/A	N/A	$0	$0	$0	$0	$0
Alternative 1	Monitored Natural Attenuation	N/A	9.0	$4,300	$6,880	$24,600	$221,400	$251,000
Alternative 2	Enhanced Bioremediation	2.0	4.0	$213,133	$298,387	$49,200	$147,600	$491,000
Alternative 3	Chemical Oxidation	2.0	4.0	$199,800	$279,720	$49,200	$147,600	$470,000

[1] Active remediation time is the time estimated to implement remedial actions for each alternative. Based upon KDHE guidance, an additional two years of monitoring is included in the cost to verify remedy effectiveness.

[2] Total remediation time is the longest of the time required to complete any element of the site remedy as noted in supplemental cost detail sheets for each alternative.groundwater

[3] Total Capital Cost includes construction costs plus design, construction oversight, and contingency costs.

[4] Total Cost - Current Worth is the total cost to complete the remedy including all Capital and OM&M Cost, not corrected for present worth, but represented as current 2015 dollars (i.e. no correction for inflation or allowance for interest accrual on any investments).

CORRECTIVE ACTION STUDY ASSUMPTIONS
Brenntag Southwest
1520 N. Barwise
Wichita, Kansas

Site:	Brenntag, Inc.
Location:	Wichita, Kansas
Phase:	Feasibility Study (-30% to +50%)
Base Year:	2015
Date:	26-Feb-15

Parameter	Assumption	Comments
Upper Portion of Aquifer (14'-20' bgs)		
Hydraulic Conductivity (ft/day)	138	CI Report
Hydraulic Gradient (ft/ft)	0.00145	CI Report
Darcy Flow (gpm)	0.47	
Porosity	0.25	CI Report
Seepage Velocity (ft/day)	0.80	
Impacted Saturated Thickness (ft)	6	CI Report
Impacted Area (sq.ft)	12,000	
Impacted Volume (cu.ft)	72,000	
Lower Portion of the Aquifer (20'-40' bgs)[1]		
Hydraulic Conductivity (ft/day)	304	CI Report
Hydraulic Gradient (ft/ft)	0.00145	CI Report
Darcy Flow (gpm)	-	
Porosity	0.35	CI Report
Seepage Velocity (ft/day)	1.26	
Impacted Saturated Thickness (ft)	-	
Impacted Area (sq.ft)	-	
Impacted Volume (cu.ft)	-	
Fence Length (ft)	205	

[1] Site groundwater from 20 to 40 feet below ground surface does not require remediation.

Prepared by: mgm
Checked by: bds1

Alternative 1
Monitored Natural Attenuation

COST ESTIMATE SUMMARY

Site:	Brenntag, Inc.	**Description:**	Alternative 1 consists of monitored natural attenuation (MNA) of the remaining chlorinated impacts to groundwater at the Site.
Location:	Wichita, Kansas		
Phase:	Feasibility Study (-30% to +50%)		
Base Year:	2015		
Date:	2/26/2015		

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
ART SYSTEM					
Capital Costs					
2" Well Installation (Shallow to 20 ft)	1	EA	$1,500	$1,500	Foth Experience
2" Well Installation (Deep to 40 ft)	1	EA	$1,800	$1,800	Foth Experience
Well Abandonment	2	EA	$500	$1,000	Foth Experience
Subtotal				**$4,300**	
MISCELLANEOUS					
Construction Management (10% of Subtotal)				$430	EPA, July 2000 (Industry Standard)
Contingency (35% of Subtotal)				$1,505	EPA, July 2000 (Industry Standard)
Design (15% of Subtotal)				$645	EPA, July 2000 (Industry Standard)
Subtotal				**$2,580**	
Capital				**$6,880**	
ANNUAL COSTS - OPERATIONS, MAINTENANCE AND MONITORING (OM&M)					
Groundwater Monitoring					
Semi-Annual Groundwater Sampling Labor & Equipment	2	events	$2,000	$4,000	Site-Specific Experience
Analytical (Add 15% for QA samples)	28	sample	$150	$4,200	Site-Specific Experience
Waste disposal	2	events	$200	$400	Site-Specific Experience
Foth costs (Reporting (10 hours/event), project management)	2	event	$8,000	$16,000	Site-Specific Experience
Subtotal				**$24,600**	
OM&M	**9**	**years**		**$221,400**	
Administration (10%)				**$22,828**	
		Total Current Worth		**$251,000**	

Prepared by: mgm
Checked by: bds1

Alternative 2
Enhanced Bioremediation

COST ESTIMATE SUMMARY

Site:	Brenntag, Inc.	**Description:**	Alternative 2 consists of an injection of substrate and innoculation to enhance biodegradation of chlorinated compounds in the Site groundwater.
Location:	Wichita, Kansas		
Phase:	Feasibility Study (-30% to +50%)		
Base Year:	2015		
Date:	2/26/2015		

DESCRIPTION		QTY	UNIT	UNIT COST	TOTAL	NOTES
ENHANCED BIOREMEDIATION / REDUCTIVE DECHLORINATION - DIRECT PUSH INJECTION						
Capital Costs	Injection Events					
Bioremediation Substrate	2	2,667	CY	$30	$160,000	Foth Experience
Bioaugmentation Innoculation	1	2,667	CY	$5	$13,333	Foth Experience
Chemical Mixing and Injection Contractor	2	3	days	$1,000.00	$6,000	Foth Experience
2" Well Installation (to 20 ft)		15	EA	$1,500	$22,500	Foth Experience
2" Well Installation (to 40 ft)		1	EA	$1,800	$1,800	Foth Experience
Soil Sampling and Analysis		10	EA	$150	$1,500	Foth Experience
Well Abandonment		16	EA	$500	$8,000	Foth Experience
Subtotal					**$213,133**	
MISCELLANEOUS						
Construction Management (10% of Subtotal)					$21,313	EPA, July 2000 (Industry Standard)
Contingency (15% of Subtotal)					$31,970	EPA, July 2000 (Industry Standard)
Design (15% of Subtotal)					$31,970	EPA, July 2000 (Industry Standard)
Subtotal					**$85,253**	
Capital					**$298,387**	
ANNUAL COSTS - OPERATIONS, MAINTENANCE AND MONITORING (OM&M)						
Groundwater Monitoring						
Quarterly Groundwater Sampling Labor & Equipment (10 wells)		4	events	$2,000	$8,000	Site-Specific Experience
Analytical (Add 15% for QA samples)		56	sample	$150	$8,400	Site-Specific Experience
Waste disposal		4	events	$200	$800	Site-Specific Experience
Foth costs (Reporting (10 hours/event), project management)		4	event	$8,000	$32,000	Site-Specific Experience
Subtotal		**2**	**years**		**$49,200**	
Groundwater Monitoring						
Semi-Annual Groundwater Sampling Labor & Equipment (10 wells)		2	events	$2,000	$4,000	Site-Specific Experience
Analytical (Add 15% for QA samples)		28	sample	$150	$4,200	Site-Specific Experience
Waste disposal		2	events	$200	$400	Site-Specific Experience
Foth costs (Reporting (10 hours/event), project management)		2	event	$8,000	$16,000	Site-Specific Experience
Subtotal		**2**	**years**		**$24,600**	
OM&M		**4**	**years**		**$147,600**	
Administration (10%)					**$44,599**	
		Total Current Worth			**$491,000**	

Prepared by: mgm
Checked by: bds1

Alternative 3
Chemical Oxidation

COST ESTIMATE SUMMARY

Site:	Brenntag, Inc.	**Description:**	Alternative 3 consists of in-situ chemical oxidation with Potassium Permanganate to address chlorinated compounds in the groundwater at the Site.
Location:	Wichita, Kansas		
Phase:	Feasibility Study (-30% to +50%)		
Base Year:	2015		
Date:	2/26/2015		

DESCRIPTION		QTY	UNIT	UNIT COST	TOTAL	NOTES
IN-SITU CHEMICAL OXIDATION						
Capital Costs	Injection Events					
In-Situ Chemical Oxidation (Potassium Permanganate)	2	2,667	cy	$30.00	$160,000	Foth Experience
Chemical Mixing and Injection Contractor	2	3	days	$1,000.00	$6,000	Foth Experience
2" Well Installation (to 20 ft)		15	EA	$1,500	$22,500	Foth Experience
2" Well Installation (to 40 ft)		1	EA	$1,800	$1,800	Foth Experience
Soil Sampling and Analysis		10	EA	$150	$1,500	Foth Experience
Well Abandonment		16	EA	$500	$8,000	Foth Experience
Subtotal					**$199,800**	
MISCELLANEOUS						
Construction Management (10% of Subtotal)					$19,980	EPA, July 2000 (Industry Standard)
Contingency (15% of Subtotal)					$29,970	EPA, July 2000 (Industry Standard)
Design (15% of Subtotal)					$29,970	EPA, July 2000 (Industry Standard)
Subtotal					**$79,920**	
Capital					**$279,720**	
ANNUAL COSTS - OPERATIONS, MAINTENANCE AND MONITORING (OM&M)						
Groundwater Monitoring						
Quarterly Groundwater Sampling Labor & Equipment (10 wells)		4	events	$2,000	$8,000	Site-Specific Experience
Analytical (Add 15% for QA samples)		56	sample	$150	$8,400	Site-Specific Experience
Waste disposal		4	events	$200	$800	Site-Specific Experience
Foth costs (Reporting (10 hours/event), project management)		4	event	$8,000	$32,000	Site-Specific Experience
Subtotal		**2**	**years**		**$49,200**	
Groundwater Monitoring						
Semi-Annual Groundwater Sampling Labor & Equipment (10 wells)		2	events	$2,000	$4,000	Site-Specific Experience
Analytical (Add 15% for QA samples)		28	sample	$150	$4,200	Site-Specific Experience
Waste disposal		2	events	$200	$400	Site-Specific Experience
Foth costs (Reporting (10 hours/event), project management)		2	event	$8,000	$16,000	Site-Specific Experience
Subtotal		**2**	**years**		**$24,600**	
OM&M		**4**	**years**		**$147,600**	
Administration (10%)					**$42,732**	
		Total Current Worth			**$470,000**	

Prepared by: mgm
Checked by: bds1