Remedial Action Plan

Nebraska Solvents Company
1200 Highway 30 East, Grand Island, Nebraska

NDEQ VCP RAPMA #36-336-4923

Foth IE Project I.D.: 00FG2678.00

Prepared For Union Pacific Railroad
Omaha, Nebraska

November 2010

Foth

November 12, 2010

Ms. Laurie Brunner
Environmental Specialist
1200 N Street, Suite 400
P.O. Box 98922
Lincoln, NE 68509-8922

Dear Ms. Brunner:

RE: REMEDIAL ACTION PLAN, NEBRASKA SOLVENTS COMPANY
1200 HIGHWAY 30 EAST, GRAND ISLAND, NEBRASKA
IIS 54629, RAPMA 36-336-4923

Please find enclosed the Remedial Action Plan for the Nebraska Solvents Company site located at 1200 Highway 30 East, Grand Island, Nebraska. This document is being submitted pursuant to the Voluntary Cleanup Program Application and Memorandum of Agreement (#36-336-4923) entered into by Union Pacific Railroad and Nebraska Department of Environmental Quality on October 25, 2007.

We look forward to receiving your comments and our continued progress on this project.

Sincerely,

Foth Infrastructure & Environment, LLC

Michael G. Mason
Lead Civil Engineer

Robert M. Kick, P.G.
Senior Project Manager

cc: Jeffrey McDermott, P.E. – Union Pacific Railroad
Thomas Buell – Nebraska Department of Environmental Quality
Mike Felix – Nebraska Department of Environmental Quality

Remedial Action Plan

Distribution

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1	Grand Island Public Library for Public File
3	Mr. Jeffrey McDermott, P.E. – UP (1 working copy / 2 electronic only copies)

Remedial Action Plan

NDEQ VCP RAPMA #36-336-4923

Foth IE Project ID: 00FG2678.00

Prepared for
Union Pacific Railroad
1400 Douglas Street, Stop 1030
Omaha, NE 68179

Prepared by
Foth Infrastructure & Environment, LLC

November 2010

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Executive Summary

This Remedial Action Plan was prepared by Union Pacific Railroad (UP) to document remedial investigations and to propose remedial actions to be undertaken at the Nebraska Solvents Company (Site) located at 1200 Highway 30 East in Grand Island, Nebraska (Figure 1-1). These and future activities have been conducted under the Nebraska Department of Environmental Quality (NDEQ) Voluntary Cleanup Program (VCP) process to support the VCP Application and Memorandum of Agreement (#36-336-4923) entered into by UP and NDEQ on October 25, 2007.

Information used to delineate the extent of impact and to evaluate potential human and ecological exposure pathways included:

- Direct push technology soil and groundwater data collected during six sampling events at 248 locations;
- Direct push technology electroconductivity logging and membrane interface probe data collection at 52 locations;
- Groundwater samples collected from 62 wells with up to 12 quarterly monitoring events for some of these wells as of December 2009;
- Hydraulic tests in 19 wells;
- Soil vapor samples at 45 locations; and
- Investigation derived waste soil samples.

Based on current conditions, the following exposure pathways are considered to be potentially complete:

- On-Site Construction Worker:
  - Inhalation of chemicals of interest (COIs) from groundwater and soil to outdoor air.
  - Dermal contact with COIs in groundwater and soil.
  - Ingestion of COIs in groundwater and soil.
- Off-Site Construction Worker:
  - Inhalation of COIs from groundwater to outdoor air.

- Dermal contact with COIs in groundwater.
- Ingestion of COIs in groundwater.

- Off-Site Residents and Non-residents:
  - Ingestion of COIs in groundwater. This route of exposure as been mitigated through provision of an alternative water supply (bottled water or carbon filtration systems), where accepted by property owners, at residences where VOCs in well water have been detected.
  - Inhalation and dermal contact with COIs in groundwater. This route of exposure has been mitigated through provision of carbon filtration systems, where accepted by property owners. In addition, the NDEQ Department of Health and Human Services currently recommends that treated water be used for residential purposes, other than ingestion, if the PCE concentration exceeds 21 ug/l based on inhalation and dermal contact routes of exposure. PCE in residential groundwater wells has not exceeded this concentration, based on current testing results.
  - Vapor intrusion of COIs from groundwater to indoor air of commercial buildings. This potential route of exposure is considered relevant to areas west of Stuhr Road where shallow groundwater is impacted. The vapor intrusion pathway is considered to be less of a concern east of Stuhr Road as impacted groundwater occurs at progressively deeper depths with distance from the Site.

The following future hypothetical exposure pathway is considered to be complete.

- Off-Site Residents and Non-residents (Future):
  - Ingestion of COIs in groundwater.
  - Inhalation and dermal contact with COIs in groundwater.
  - Vapor intrusion of COIs from groundwater to indoor air of commercial buildings. This potential route of exposure is considered relevant to areas west of Stuhr Road where shallow groundwater is impacted. The vapor intrusion pathway is considered to be less of a concern east of Stuhr Road as impacted groundwater occurs at progressively deeper depths with distance from the Site.

Current land use at and near the former Nebraska Solvent Leased Property is limited to commercial and industrial uses. Reasonably ascertainable future land use at and near the Site will also be limited to commercial and industrial uses; however specific land or building uses have not been determined at the time of this report.

Signs of ecological impact such as stressed vegetation were not evident on or near the Site. Aquatic and/or terrestrial receptors on and off-site were not identified.

The following points summarize the hydrogeologic conceptual model for the study area, as presented in Figures 7-1 and 7-2:

- Historical releases of tetrachloroethene (PCE) and aromatic hydrocarbons have impacted shallow soil and groundwater at the Site. Non-aqueous phase liquid (NAPL) has not been observed at the source area.

- Over time COIs have been transported east and then east-northeast from the Site by groundwater.

- Near the source area, aromatic hydrocarbons and chlorinated hydrocarbons are evident in groundwater; however the relative concentration of the original chemical and degradation products changes with distance from the source area indicating degradation through natural processes. Within 0.25 mile downgradient of the source area (to Stuhr Road) the COIs are primarily PCE, dichloroethene (cis-DCE), and vinyl chloride (VC). From 0.25 to 1.25 mile east of the source area (Stuhr Road to Shady Bend Road) the primary COI is cis-DCE with lower concentrations of PCE. The primary COI from 1.25 to 3.5 miles from the source area (Shady Bend Road to Beck Road) is PCE.

- Advective chemical transport has occurred through porous sand overlying low permeability silts. As the plume moves eastward away from the Site, it also migrates to greater depths due to precipitation recharge.

- The groundwater flow rate in the near source area is approximately 300 feet/year and in the middle and more distal plume areas is approximately 100 ft/year. The apparent decrease in velocity is related to the lower hydraulic conductivity of the aquifer material and a slightly flatter hydraulic gradient. The COIs likely move at a slower rate due to chemical adsorption to aquifer materials.

- The area of impacted groundwater is bounded vertically by a thick layer of consolidated silt overlying the shale bedrock. The narrow lateral extent of the plume may be related to the occurrence of historic river channel sands which facilitate groundwater flow. The distal extent of groundwater impact extends to approximately Beck Road, located approximately 3.5 miles east of the source area.

- Agricultural irrigation wells and private domestic wells exist within the groundwater plume. These wells represent potential exposure pathways. Agricultural wells may also impact groundwater flow and act to attenuate impacted groundwater through withdrawal.

As an interim remedial action, bottled water was offered and provided to any resident whose water supply showed a detection of PCE (and also trichloroethene or TCE) above the method detection limit which was a fraction of microgram per liter (µg/L) or part per billion. The maximum contaminant level for both PCE and TCE is 5 µg/L. In addition, in-home water treatment systems using activated carbon were offered to all residents on bottled water. Figure 9-1 shows the extent of impacted residential properties as of December 31, 2009. Quarterly monitoring of the treated water (for homes with carbon systems) or untreated water (for homes with bottled water or those who have not chosen a remedy) is conducted and results are provided to residents in an explanatory letter. Additionally, private wells adjacent to impacted properties are monitored quarterly.

A groundwater monitoring program was also initiated including quarterly sampling and analysis of groundwater wells (Figure 2-5).

The following remedial action objectives have been developed for the Site consistent with Remedial Action Class 1 (RAC-1) protocols for groundwater resources that currently or may potentially be used as drinking water, as given below.

1. Source control to minimize further degradation of the groundwater;

2. Cleanup of readily removable contaminants, including impacted soil and soil vapor;

3. Cleanup of dissolved groundwater contamination;

4. Restoration of the aquifer to MCLs within a reasonable timeframe;

5. Prevention of further contaminant migration in the groundwater;

6. Provision of alternative water supplies to affected residences; and

7. Use of institutional controls to minimize the potential for human exposure to contamination and to protect the integrity of the remedial action.

Specific cleanup levels for soil and groundwater will be consistent with Nebraska Title 118. Soil remedial goals (RGs) were developed by Nebraska Department of Environmental Quality for both direct contact exposure pathways (residential and industrial land use) and the migration to groundwater pathway. Groundwater RGs are based on the direct contact exposure pathway based on cancer or non-cancer criteria. Soil and groundwater RGs for the respective COIs are listed in Table 1-2.

The proposed remedial action for the Site will consist of the following actions.

Source Area Soil – Shallow unimpacted soil extending from approximately land surface to three feet below land surface (bls) will be excavated, stockpiled, and tested for future reuse as backfill. Impacted soil from approximately three to seven feet bls will be excavated and disposed off-site. This soil is composed of silt and clay. Underlying sands will not be excavated.

Groundwater in the shallow saturated sand in the Source Area and Near Source Area are impacted with chlorinated and aromatic hydrocarbons to a depth of approximately 20 feet bls. These areas will be injected with a chemical oxidizing agent (modified Fenton's reagent or similar) to reduce the mass of dissolved chemical present in the Source and Near Source Area.

Soil Vapor – A soil vapor assessment was performed to evaluate the potential for vapor intrusion from groundwater into indoor air which consisted of 45 soil gas samples from three areas above the groundwater plume including the near-source area, the midgradient plume area, and the downgradient plume area. Fifteen soil gas samples were collected and analyzed from each area.

Land use in the near-source area is primarily commercial and industrial, while the land use in the midgradient and downgradient areas is primarily residential. Soil gas sampling analytical results were evaluated using the USEPA version of the Johnson & Ettinger model which was adjusted to account for site-specific information, scenario type, and current toxicity values.

In the source and near-source areas, ethylbenzene at 3 of 15 locations was the only chemical that exceeded an industrial soil gas screening level. The locations showing exceedances were on UP owned property. Off-site locations in the near source area did not show exceedances of industrial soil gas screening levels. The on-site detections will be addressed through planned remedial activities, including soil excavation and groundwater treatment.

In the midgradient plume area and at only one location, ethylbenzene was the only chemical that exceeded a residential soil gas screening level. Based on results from other test locations and knowledge of the groundwater composition, this one detection appears to be an isolated occurrence and likely is not related to the Nebraska Solvents Company plume. All other tested chemicals in the midgradient plume area and all tested chemicals in the downgradient plume area were below site-specific screening levels that are protective of the residential vapor intrusion pathway.

Source Area Groundwater – Review of the spatial distribution of COIs in groundwater near the source area (i.e., west of Stuhr Road) as well as the concentration of COIs at specific monitoring well locations over time indicates that significant chemical degradation is occurring under existing conditions. Injection of a chemical oxidizing agent such as modified Fenton's reagent or similar will be performed in both the Source Area and an area immediately downgradient to promote more rapid degradation. After completion of the Source Area soil removal and chemical injection program, a study to evaluate monitored natural attenuation as a long-term remedial option (MNA study) will be conducted to more fully understand degradation reactions, rates, and likely endpoints. These results will be provided to NDEQ at a future time.

Mid to Downgradient Plume Groundwater – The vast majority of the groundwater plume (extending from approximately Museum Drive to Beck Road) is impacted by PCE at concentrations that exceed the MCL, however by a limited amount. A two-pronged remediation approach is proposed consisting of: (1) ongoing monitoring to further evaluate and document monitored natural attenuation as a viable long-term remedial alternative; and (2) the extension of a municipal water source to eliminate any unacceptable exposure to residents. This water supply would replace the use of bottled water and in-home water treatment systems using activated carbon.

Leading Edge Groundwater – Ongoing groundwater monitoring results are being used to evaluate overall and leading edge plume stability. Typically, eight quarters of data are required for this evaluation. As of December 2009, only five quarters of data area available. Therefore, it is proposed that additional monitoring be conducted to more fully understand the plume dynamics, and especially the stability of the leading edge. These results and the possible need for supplemental remedial actions will be evaluated and provided to NDEQ at a future time.

List of Abbreviations, Acronyms, and Symbols

1,1,1-TCA	1,1,1-Trichloroethane
1,2,4-TMB	1,2,4-Trimethylbenzene
1,3,5-TMB	1,3,5-Trimethylbenzene
ARARs	Applicable or relevant and appropriate requirements
ASTs	Above-ground storage tanks
BGS	Below Ground Surface, Inc.
bls	Below land surface
CA	Chloroethane
CAA	Clean Air Act
cis-DCE	cis-1,2,-Dichloroethene
City	Grand Island, NE
COIs	Chemicals of Interest
cm/sec	Centimeters per second
CSM	Conceptual Site Model
CWA	Clean Water Act
DCA	1,1-Dichloroethane
DoI	Department of the Interior
DPT	Direct-push technology
EC	Electroconductivity
ECCS	Environmental Chemistry Consulting Services, Inc
ELCD	Electrolytic Conductivity Detector
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
Foth IE	Foth Infrastructure & Environment, LLC
ft	Feet
ft bls	Feet below land surface
HASP	Health and Safety Plan
HCL	Hydrochloric acid
HRS	Hazardous Ranking System
IDW	Investigational derived waste
MCLs	Maximum contaminant levels
MIP	Membrane Interface Probe
$\mu g/m^3$	Micrograms per cubic meter
mS/cm	MilliSiemens per centimeter
MS/MSD	Matrix spike/ matrix spike duplicate
MSDS	Material safety data sheet
NAPL	Non-aqueous phase liquid
NDEQ	Nebraska Department of Environmental Quality
NSC	Nebraska Solvents Company
OSHA	Occupational Safety and Health Act
PA/SI	Preliminary Assessment/Site Inspection
PCE	Tetrachloroethene
PDB	Passive diffusion bag
PID	Photoionization detector

QA/QC	Quality assurance/quality control
RCRA	Resource Conservation and Recovery Act
RGs	Remediation Goals
RI	Remedial Investigation
RPD	Relative percent difference
sf	Square foot
Site	1200 Highway 30 East, Grand Island, NE
SOP	Standard operating procedure
SVOCs	Semi-volatile organic compounds
TCE	Trichloroethene
TCLP	Toxic Characteristic Leaching Procedure
Tetra Tech	Tetra Tech EM Inc.
TOC	Total organic carbon
trans-1,2-DCE	trans-1,2-Dichloroethene
TSCA	Toxic Substance Control Act
UP	Union Pacific Railroad
USTs	Underground storage tanks
VC	Vinyl Chloride
VCP	Voluntary Cleanup Program
VOA	Volatile organic analysis
VOC	Volatile organic compounds

1 Background Information

1.1 Site Information

The city of Grand Island is located in eastern Hall County, Nebraska. The Nebraska Solvents Company Site is approximately ¼ mile west of the intersection of Stuhr Road and Highway 30 East, near the eastern city boundary, at 1200 Highway 30 East (Figure 1-1). The land-based description of the Site is the northeast quarter of Section 15, Township 11 North, Range 9 West. The geographic coordinates are approximately 40.9300°N latitude and 98.3255°W longitude.

Union Pacific Railroad (UP) owns the land and leased the Site to Nebraska Solvents Company (NSC) from 1966 to 1988. During that period, NSC operated a chemical storage and distribution facility. The building is currently vacant, but was most recently subleased to Palleton of Nebraska, whose operations included construction and rehabilitation of wooden pallets using mechanical fasteners. The land is currently leased to Mr. Frank Huntley.

The UP railyard property adjoins the Site to the north and west. To the east is a mixed-use area developed for commercial and industrial activity. Adjacent east of the Site is Quality Pallet, Inc., a pallet manufacturing and rehabilitating shop located at 224 Willow Street. East of the Site (across Willow Street) is the Trucks 'N' More used car lot at 215 Willow Street. North of Trucks 'N' More is Sloggett's Body and Paint. To the south is U.S. Highway 30 with undeveloped agricultural property beyond. The nearest residential neighborhoods are located about 1,750 feet to 2,750 feet east of the Site. The Site and nearby businesses are shown on Figure 1-2. Figure 1-3 illustrates the three primary areas of investigation: Near Source Area (including the lease property east to Stuhr Road), Mid-Gradient Area (Stuhr Road east to Shady Bend Road) and Down-Gradient Area (Shady Bend Road east and northeast to Beck Road).

1.2 Physical Setting

1.2.1 Surface Features

The subject property consists of a 540 feet by 140 feet (1.7 acre) parcel of land. Site improvements include a 9,720 square foot, single story, building of metal construction on a concrete slab with a loading dock on the east side. A gravel parking lot occupies the southern portion of the property and the eastern adjacent property. The area north of the building to the property boundary is lightly vegetated with grass and small trees. A portion of the grassy area north of the building is enclosed by a chain link fence. The topography is generally flat. A storm water retention pond is located on the northern portion of the property and on the adjacent railyard. The southern and eastern boundaries of the pond adjacent to the Site have vegetated berms which prevent surface runoff from the Site from entering the pond.

A water well located at the southeast corner of the building served as the water source for sanitary and process water. The water well was abandoned in accordance with NDEQ regulations in April 2009. Waste water at the site is managed by a septic system.

1.2.2 Climate and Meteorology

The yearly average high temperature for Grand Island is 61.9°F and the low temperature is 38.7°F. The average high and low temperatures for the months of April through September are 78.1°F and 54.0°F, respectively. The average high and low temperatures for the months of

October through March are 45°F and 22.5°F, respectively. The average annual precipitation is 25.9 inches. The yearly average of snowfall is 32.5 inches. The average wind speed and direction for the month of August is 10.5 miles per hour (mph) from the south to southeast. During the winter months the wind direction shifts from the north to northwest with average speeds of 12.0 mph. The yearly average humidity for the region is 45 percent (NRCS–NWCC 2007). A summary of monthly climate data is provided as Table 1-1.

1.2.3 Vegetation

Site vegetation consists of grass and small trees. Likewise, nearby commercial and industrial properties have minimal vegetative cover. No sensitive environments are known locally or regionally with respect to the Site.

1.2.4 Topography and Hydrology

The subject property is generally flat. A storm water retention pond is located on the northern portion of the property and on the adjacent railyard. The southern and eastern boundaries of the pond adjacent to the Site have vegetated berms which prevent surface runoff from the Site from entering the pond. Regional topography slopes gradually to the east and surface water generally flows to the east. The Wood River lies south of the subject property and flows to the east-northeast into the Platte River.

1.2.5 Soils and Geology

Bedrock in the study area consists of either the Niobrara Formation or the Pierre Shale. The Niobrara consists of a shaley chalk or chalky shale and the Pierre Shale is fossiliferous marine shale. Both formations represent a regional confining unit (Joeckel 2008). The bedrock surface dips to the south and controls the thickness of overlying sediment. In the immediate study area, the depth to bedrock is reported to be approximately 150 feet (Condon 2005). The bedrock to the southeast exhibits lower elevations where sediment has accumulated to greater thickness, up to approximately 250 feet south of the Platte River in Hamilton County.

The sediment column overlying the bedrock consists of Late Pliocene to Early Pleistocene silts and silty clays which extend throughout the region including the study area. These fine grained sediments are alluvial and/or eolian in origin and occupy the approximate lower half of the sediment column overlying bedrock. The silt horizon is thicker to the north (including the study area) and thinner to the south near the Platte River. The Ogallala Aquifer, which is stratigraphically equivalent to the silt horizon, is absent beneath the study area, though erosional remnants are present further west (Joeckel 2008).

Medium to coarse sand and fine to coarse gravel overlay the silt horizon. These thick, coarse-grained fluvial sediments are laterally extensive in the subsurface under the present Platte River Valley and adjacent areas. These sands and gravels constitute the High Plains aquifer from which water is obtained for various uses (Joeckel 2008).

Soil near the Site mostly consists of the O'Neill-Meadin Association, Wann-Leshara-Cass Association, Platte-Sarpy Association, and Gibbon Series, all of which consist mainly of sandy loam with varying amounts of fine to coarse grain sediment (USDA 1962).

The O'Neill-Meadin Association is dark brownish-gray to very dark grayish-brown sandy loam with a few areas of loam (USDA 1962). The Wann-Leshara-Cass Association consists of loam or sandy loam surface soils with sandy loam subsoils. Leshara soils are deep silty soils that form under somewhat poor drainage and are calcareous at the surface. The Platte-Sarpy Association ranges from silty clay loam to sandy loam. The Gibbon series consists of silt loam or silty clay loam but also includes very fine sandy loam, loam, and clay loam (NRCS-USDA 2007).

1.2.6 Hydrogeology

Three aquifer systems are present beneath the study area and include from shallow to deep: The Surficial or High Plains aquifer system; The Great Plains aquifer system; and the Western Interior Plains aquifer system (USGS 1997).

The Surficial aquifer system consists of shallow, unconsolidated sand and gravel that occur in stream-valleys. Much of the sand and gravel has been reworked from older glacial drift deposits. Examples include the Platte River and to a lesser extent the Wood River, both south of the study area. They consist of narrow bands of sediments which fill or partly fill the valleys of meandering to braided streams. Where these streams cross the High Plains aquifer, the stream-valley aquifers are hydraulically connected to and are considered to be part of the underlying High Plains aquifer. The stream-valley aquifers are in direct hydraulic connection with the streams and both receive water from and discharge water to the streams, as conditions allow. The aquifers are considered unconfined and are recharged by precipitation (USGS 1997).

Both residential and commercial irrigation water wells are completed within the Surficial aquifer system. Residential wells are generally shallow and likely are pumped at low rates. Commercial wells are completed to depths up to approximately 100 feet and are pumped at rates up to approximately 1,200 gpm. The location of commercial irrigation wells that are registered with the Nebraska Department of Natural Resources (NDNR) are shown on Figure 2-5. The locations are approximate to the accuracy of NDNR records. Non-registered commercial irrigation wells may also be present within the study area; however the location, design, capacity, and status of any such wells is unknown.

The High Plains aquifer consists of several recognized geologic units most notably the Ogallala Formation. In the study area, the Ogallala was eroded away and occurs further to the west (Condon 2005). The High Plains aquifer is considered the most prolific aquifer in Nebraska and in 1990 accounted for about 84% of groundwater withdrawals (USGS 1997).

Wells completed in the stream-valley and High Plains aquifers commonly yield 100 to 1,500 gallons per minute. Transmissivity values determined from aquifer tests conducted in the region range from 500 to 53,000 ft^2/day (USGS 1997). No karst conditions exist in the study area.

Based on the test holes installed by the Conservation and Survey Division of the Nebraska Geological Survey within the study area, the Niobrara Formation and/or Pierre Shale make up the confining unit of the Surficial or High Plains aquifer. As mentioned in section 1.2.5, the Niobrara Formation consists of a shaley chalk or chalky shale. Depths to the Niobrara Formation within the study area range from 150 feet to 230 feet bls (Joeckel 2008). The Pierre Shale is encountered in the northern portions of the study area at depths of 200 feet bls. Overlying the Niobrara Formation and Pierre Shale are well compacted silt and clayey silt and are generally encountered at 90 feet bls. Due to the significantly lower hydraulic conductivity and porosity exhibited by the silt and clayey silt compared to the overlying coarse sands, the silt and clayey silt acts as an aquitard within the study area.

The Great Plains aquifer is the second significant aquifer that underlies the study area. The depth to the top of this aquifer is approximately 1,000 feet. The thickness is from approximately 400 to 600 feet in the study area. However, the water quality is described as “saline water or brine” with concentrations in the study area ranging from 5,000 to 10,000 milligrams per liter (mg/L) (Miller and Appel 1997).

The Western Interior aquifer is the third significant aquifer that underlies the study area. The depth to the top of this aquifer is approximately 1,500 feet. The thickness is from approximately 500 to 1,000 feet in the study area. However, the Western Interior aquifer contains no fresh water and is highly mineralized (Miller and Appel 1997).

Groundwater flow across the study area is to the east based on water elevations in groundwater monitoring wells and follows regional topography which slopes to the east. The approximate depth to groundwater based on first occurrence is about 7 to 8 ft below land surface (bls) with water levels in wells locally showing shallower depths. The saturated thickness of permeable sand ranges from approximately 70 to 100 feet.

1.3 Historical Operations and Site Conditions

The U.S. Government transferred ownership of the Site property to UP for purposes of constructing a trans-continental railroad in 1875. The Site was leased by UP to NSC from 1966 to 1988 with operations at the Site beginning in 1973. Property deed, title and lease documentation are included in Appendix A. During NSC operations as a solvent distributor, various industrial compounds including solvents and fuels were stored and distributed. Available records indicate that the following chemicals were sold, including: toluene, xylene, isopropyl alcohol, methanol, tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane, methylene chloride, acetone, and methyl ethyl ketone. All solvents managed at the site were reportedly of virgin source. According to Mr. Alderson, Owner and President of Nebraska Solvents Company, his company served as a transporter for waste generated by his customers for which he was issued a RCRA identification number (NED035036169) (Tetratech 2005). Based on available records, detailed descriptions of the quantities and management of products and wastes are not available.

The Site housed 20 above-ground storage tanks (ASTs) and an unknown number of 55-gallon drums that contained various solvents. The tanks were located in the enclosed yard on the northern portion of the property. Facility assets apparently were sold to Mr. William H. Roberts of Denver, Colorado around 1986, and the property was leased to him by UP. Mr. Roberts reportedly sold the ASTs to Tropicana Energy Co. on an unknown date for use at an ethanol-gasoline blending and distributing facility (Nebraska Solvents Company 1990b). The tanks were removed in 1993 to 1994 by Poland Oil, who noted that the tanks were in good condition and the underlying ground showed no apparent evidence of a leak. During operation and removal of the tanks there was no evidence or report of a release.

The Site also housed two underground storage tanks (USTs) during operation under NSC. One contained diesel fuel (1,000 gallon capacity) and the other gasoline (2,000 gallon capacity). The location of these tanks during their operation is unknown. The tanks were removed between 1984 and 1987 and were reported to have been corroded, but did not show evidence of a release.

The most recent tenant, Palleton of Nebraska, used the Site for construction and rehabilitation of wooden pallets and also operated a truck wash-out facility for semi trailers. The truck washing operation had been discontinued prior to the start of this investigation and further details were unavailable.

A site map showing known locations of previous site features related to the NSC operations is provided as Figure 1-4. To the extent such information is available, the figure includes the location of any septic tank/leach field, loading docks (both truck and railcar), drum storage areas, underground storage tank locations, and above-ground storage tank locations. Copies of available historical aerial photographs are provided in the report by Tetra-Tech EM Inc (2005) which can be found in Appendix G (Attachment 4 of the TetraTech report). Other aerial photographs obtained by UP are included in Appendix F of this report.

1.4 Current Operations and Site Conditions

The former Nebraska Solvents Company lease property is currently vacant and includes a 9,720 square foot (sf), single story building of metal construction on a concrete slab with a loading dock on the east side. A gravel parking lot occupies the southern portion of the property and the eastern adjacent property.

The Union Pacific Railroad Grand Island, Nebraska railyard is located to the north and west of the Lease Property and is contiguous with it. North and east of the Lease Property, and north of Seedling Mile Road is Lannco LLC which provides railroad ties for the rail industry. Immediately adjacent and east of the Site on the west side of Willow Street is Midland Holding, Inc. (224 Willow Street), currently leased to Quality Pallet. On the east side of Willow Street are Sloggett Body and Paint (229 Willow Street) and Trucks'n'More (215 Willow Street).

Further east from the Willow Street businesses and at the western intersection of Highway 30 East and Seedling Mile Road is the Kensington Station gasoline fueling station. Adjacent to and west of Kensington Station is a mobile home park including three trailer homes. Agricultural land is generally present east and south of Highway 30 however residential developments are present in two areas including: (1) north and south of Seedling Mile Road between Museum Drive and Shadey Bend Road; and (2) further east generally between Gunbarrel Road and Beck Road and between Fort Kearney Road and Capital Drive.

1.5 Previously Reported Investigations

1.5.1 Summary of Previous Reports

Information regarding investigations prior to those conducted by UP is summarized in this section and includes primarily the work of Tetra Tech EM Inc (2005). NDEQ files were also reviewed for additional information, however few records of limited value were identified. Detailed descriptions of historical site operations, including the types, quantities, and management of products and wastes, are not available. Likewise the chronology and description of releases of hazardous materials is unknown. Mr. Alderson, the respondent to the USEPA 104(e) information request, stated that no officers of Nebraska Solvents Company were aware of any intentional or accidental releases.

Data from investigations prior to UP involvement, were generally limited in scope and applicability and have been superseded by UP-directed investigations which have been considerably more extensive and comprehensive. In some cases the results of prior studies were incorrect and therefore are not useful to describe the Site. For example, the groundwater flow direction was incorrectly given by TetraTech as southeast. Current study results are derived from hundreds of soil and groundwater samples and multiple rounds of groundwater data from over sixty (60) monitoring wells.

The following information was taken from the 2005 Tetra Tech Combined Preliminary Assessment / Site Inspection Report with minor editing for clarification:

In 1988, NSC retained Benjamin & Associates Engineers and Surveyors, Grand Island, Nebraska, to collect soil samples at the Site property. Soil samples were collected at 3 borings from approximate depths of 5 to 11 ft bls. An odor was noted in boring number 3. Samples were analyzed for volatile organic compounds (VOC) by A & L Mid West Laboratories, Inc., Omaha, Nebraska. The only compound reportedly detected in any of the samples analyzed was methylene chloride (0.5 µg/g or 500 µg/kg). Notably, detection limits were 500 µg/kg for all compounds analyzed by A&L Mid West Laboratories, Inc. Apparently, the results from this investigation were never reported to Environmental Protection Agency (EPA). Mr. Ed Benjamin, of Benjamin and Associates, reported the results of this investigation to NDEQ in 1995 pursuant to an inquiry by Mr. Jeff Raymond of NDEQ (Benjamin & Associates 1995).

During the Cleburn Street Well site investigations (conducted in the early 1990s), EPA sent a Section 104(e) letter to the owner and President of NSC, Mr. Clifford Alderson (incorrectly spelled as Mr. Clifford Anderson in the original letter) (EPA 1990). EPA later concluded that, based on the groundwater flow direction and the distance between the NSC Site and the Cleburn Street Well site, that the NSC Site was likely not responsible for contamination associated with the Cleburn Street Well site (EPA, 2004a).

However, information in the Section 104(e) reply provided by Mr. Richard Alderson, Vice-President and General Manager of Nebraska Solvents Company, indicated potential for a release of hazardous substances from the Site. The facility used twenty ASTs (thirteen 12,000-gallon tanks, one 10,000-gallon tank, and six 5,000-gallon tanks) to store industrial chemicals on the Site. The tanks were located within the fenced portion of the property. The tanks were apparently connected via piping to loading pumps located just north of the building. Solvents were also reportedly stored in 55-gallon drums in the building. The following is the list of solvents reportedly stored and sold by the facility during its operating history: toluene, xylene, isopropyl alcohol, methanol, tetrachloroethene (PCE), trichloroethene (TCE), 1,1,1-trichloroethane, methylene chloride, acetone, and methyl ethyl ketone. All solvents managed at the Site were reportedly of virgin source (manufactured by Vulcan Chemical Company) (NSC 1990a).

The NSC reportedly never generated hazardous waste on the Site property. Further, Mr. Alderson indicated he was unaware of any release of hazardous substance to the ground on the

Site property. (Mr. Alderson did not mention the results of the Benjamin & Associates Engineers and Surveyors investigation of the Site in 1988.) Mr. Alderson indicated that NSC served as a transporter for waste generated by his customers (NSC 1990b). The facility had notified NDEQ of this in January 1981 and was subsequently issued a Resource Conservation and Recovery Act (RCRA) identification number (NED035036169).

In addition to the solvent storage tanks, Mr. Alderson reported operation of the two USTs on the Site. These tanks had capacities of 1,000 and 2,000 gallons, respectively. They had been installed in 1975 and used to store diesel fuel and gasoline (NSC 1990a). File records indicate different removal dates (1984 and 1987). The original location of the USTs on the Site is unknown.

The May 19, 1995, letter from Mr. Ed Benjamin to Jeff Raymond of NDEQ cited above indicated that the solvent storage tanks on the property had been removed in the winter of 1993-1994 by Poland Oil. Mr. Bob Poland, Poland Oil, was reportedly involved in the removal of the tanks and stated they were in good condition and that the ground beneath them showed no discoloration or evidence of leakage (Benjamin & Associates 1995).

Tetra Tech EM Inc. (Tetra Tech) was requested by NDEQ in 2004 to conduct a combined preliminary assessment/site inspection (PA/SI) at the Site. The purpose of this investigation was to collect information concerning groundwater contamination at the Site sufficient to assess the threat posed to human health and the environment and to identify the source of contaminants in groundwater to determine the need for action at the Site. The scope of the investigation included a review of available file information, a comprehensive target survey, a site reconnaissance, limited sampling activities, and generation of a Hazardous Ranking System (HRS) scoring memorandum.

Analyses of soil samples during the PA/SI investigation collected from the locations of the former ASTs indicated high concentrations of aromatic hydrocarbons and chlorinated solvents. Private well samples were collected in the housing subdivisions located approximately one mile down gradient of the Site. Of the 82 private wells sampled, 26 had reportable concentrations of one or more VOCs. The primary constituents detected were PCE and cis-1,2-dichloroethene (cis-1,2-DCE). The subdivision is served by the Grand Island public water supply, however some of these wells are used as lawn and garden irrigation wells. Groundwater samples collected from temporary wells on the former Site included aromatic hydrocarbon compounds toluene, ethylbenzene, and xylenes and the chlorinated solvents PCE, TCE, and cis-1,2-DCE and trans-1,2-dichloroethene (trans-1,2-DCE) as the primary constituents (Tetra Tech 2005).

1.5.2 Data Quality and Temporal Variability

Review of laboratory data validation reports indicates that data quality objectives have been met, as measured through the use of trip blanks and duplicate samples and is adequate to evaluate Site conditions. In addition, data collected over time has provided insight into trends which further validate the consistency and completeness of data, for example groundwater level and water quality results. Laboratory data validation reports are provided in Appendix V.

UP has reviewed water quality and level data from monitoring wells to evaluate temporal variations as summarized below:

- Water quality data show that the overall extent of groundwater impact has been defined and that the extent is relatively constant. The rate of change in plume geometry and composition is very low.

- Water chemistry in the source area and near source area (together the plume area generally west of Stuhr Road) is more dynamic than in areas further downgradient. In these areas, a greater range of COIs are present at higher concentrations including both aromatic and chlorinated hydrocarbons. In some cases the higher concentrations of COIs result in elevated detection limits which may mask the presence of other COIs present at lower concentrations. The concentration of some COIs in the source area and near source area have systematically decreased which UP attributes to degradation stimulated by the mixture of aromatic and chlorinated hydrocarbons. Further description of these changes is presented in Section 5 of this report.

- Fewer COIs occur in groundwater in the area generally east and downgradient of Stuhr Road than to the west and with lower concentrations. Tetrachloroethylene is the predominant COI, with limited detections of other VOCs. While some variability is observed it is generally consistent with normal laboratory variability. Where the quarterly sampling of closely spaced residential wells is being conducted to monitor the below RG groundwater plume edge, limited expansion is observed, however at a very slow rate.

- Water level data shows seasonal variations with the highest water levels typically occurring during the spring quarter and the lowest levels in the winter quarter. This trend is consistent with weather patterns in which high groundwater levels are related to snow melt and spring rains and low groundwater levels are related to lack of recharge due to frozen conditions. Groundwater level fluctuation is generally similar across the study area likely due to the predominately agricultural land use of the region and ranges from approximately 2 to 3 feet.

- Additional water level variability may be locally induced by the pumping of groundwater, especially by commercial irrigation wells. To help evaluate this effect, UP placed data loggers in two groundwater monitoring wells that are located 300 ft (MW-NSC-23C) and 600 feet (MW-NSC-24C) from irrigation well G101835. This irrigation well is generally located south of East Capital Drive and west of Gunbarrel Road. Review of water level fluctuations indicates that both wells show similar water level trends during non-pumping time periods and from precipitation. During July, August and early September, pumping is indicated by pronounced intermittent drawdown in these two wells. The drawdown in well MW-NSC-23C is approximately 2.5 feet and the drawdown in well MW-NSC-24C is approximately 0.5 feet. The pumping rate is unknown, but assuming that it is equal to the pump rating (1,000 gpm), the hydraulic conductivity of the aquifer would be 325 ft/day The withdrawal of groundwater by irrigation wells has the potential to cause localized impacts on the extent of the groundwater plume; however those effects have not been quantified.

- Temporal variability in groundwater organics concentrations can be observed in source area well MW-NSC-02A.

- For the 2007-2009 quarterly samplings, concentrations of benzene, ethylbenzene, toluene, and xylenes (BTEX) were consistently higher in March and June than in September and December. This difference occurred within each individual year, and across all three years for every BTEX compound. Differences between the highest and lowest concentrations are more than an order of magnitude for all analytes.

- This variability could be the result of greater influence from organics present in the upper sand layer during spring periods of higher infiltration and higher water levels. Temporal variability will be evaluated further during the MNA study discussed in Section 9.

- Temporal variability could not be observed for chlorinated solvents in MW-NSC-02A. Elevated concentrations of BTEX in these wells resulted in elevated chlorinated solvent detection limits. No solvents were detected above the elevated detection limits.

1.6 Potential Chemicals of Interest

Chemicals of interest (COIs) are compounds that have been detected at concentrations exceeding the VCP Remediation Goals (RGs) Look-up Tables (NDEQ 2005) in soil and groundwater. Soil screening levels were evaluated for both direct contact exposure pathways (residential and industrial land use) and the migration to groundwater pathway. Soil vapor screening levels were developed based on EPA protocols. Site-specific COIs and the corresponding soil and groundwater screening levels are summarized in Table 1-2.

1.7 Data Gaps

No data gaps are known for this Site with respect to plume delineation; however ongoing groundwater monitoring will be conducted to assess plume stability and natural attenuation. UP also proposes to conduct limited additional soil investigations in the source area and near source area to finalize the proposed remedial design. On July 9, 2010, UP submitted a work plan to NDEQ for this additional work which has been approved and has now been completed.

As requested by NDEQ, UP will also prepare work plans to conduct a Monitored Natural Attenuation (MNA) Study to evaluate if MNA will likely achieve aquifer restoration within a reasonable timeframe as required by Nebraska Title 118. The potential occurrence of 1,4-dioxane in groundwater will also be addressed in this Study. Plans for this work will be submitted to NDEQ subsequent to approval of this RAP.

2 Field Investigation

2.1 Investigation Objectives

Full delineation of the lateral and vertical extent of groundwater impact to MCLs or risk-based standards in absence of MCLs is required by Nebraska Title 118 – Groundwater Quality Standards and Use Classification. The extent of soil impact is required to be delineated to either the residential direct exposure pathway or the soil migration to groundwater pathway, whichever is more conservative.

The specific objectives of the VCP investigation include the following:

- Delineate and characterize the lateral and vertical extent of impacted environmental media.
- Characterize the environmental setting, including geology, hydrogeology, and hydrology, and physical characteristics pertaining to contaminant fate and transport.
- Characterize the physiochemical properties of the COIs, their mobility and persistence in the environment, and fate and transport mechanisms.
- Identify potential human and environmental receptors that may be threatened or affected by the Site.
- Identify potential additional sources of VOCs loading to the groundwater plume.
- Collect data to support the evaluation and design of potential remedial actions.

2.2 Data Quality Objectives

Data collected in this investigation is suitable for use in site characterization and delineation. “Level II” data is a data package including summaries of surrogates, blanks and spiked samples, and is of adequate quality to support project needs. Data collected during the sampling events discussed in this VCP Investigation were evaluated by the data quality indicators below.

- **Precision:** Precision measures the reproducibility of measurements under a given set of conditions. Precision was assessed by calculating relative percent difference (RPD) for laboratory and field duplicate sample analyses. Acceptance criteria are 35 percent RPD for water samples and 50 percent for soil samples. If these criteria are not met, qualifiers were assigned to field duplicate sample results based upon the data quality manager’s judgment. Laboratory precision was evaluated through analysis of laboratory duplicates and matrix spike duplicates against the published SW-846 method or laboratory standard operating procedure (SOP).
- **Bias:** Bias measures the systematic or persistent distortion of a measurement process. Bias due to matrix interference was assessed through the analysis of matrix spike and matrix spike duplicate samples. Validation acceptance criteria were based upon laboratory-specific control limits.

- **Accuracy:** Accuracy measures the closeness of an individual measurement or the average of a number of measurements to the true value. Sampling accuracy was assessed by evaluating the results of equipment rinse blanks and trip blanks. Analytical accuracy was assessed through the analysis of laboratory control spike and matrix spike samples. Validation acceptance criteria were based upon laboratory-specific control limits.

- **Representativeness:** Representativeness is a qualitative parameter that expresses the degree to which sample data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, or an environmental condition. Representativeness criteria were satisfied by making certain that sampling locations were selected properly and a sufficient number of samples were collected.

- **Comparability:** Comparability is ensured by using the same sampling techniques, analytical methods, and analytical detection limits during all phases of the investigation. This project utilizes standardized sampling techniques and analytical methods.

- **Completeness:** Completeness is defined as the percentage of measurements made that are judged to be valid measurements. The completeness goal is 100 percent. However, the existing data may still be relied upon to make qualified decisions if this goal is not reached.

- **Sensitivity:** Sensitivity is the capability of a method or instrument to discriminate between different levels of the variable being measured. With the exception of dilutions or other extenuating circumstances, laboratory reporting limits for the majority of COIs should meet NDEQ VCP RGs for groundwater and soil.

All laboratory analytical reports were reviewed for compliance with data quality objectives. Data verification reports are provided for all direct-push technology (DPT) soil and groundwater, monitoring well, and private well laboratory analytical reports in Appendix V. Data verification was not performed on data packages comprised solely of investigational derived waste (IDW) or geotechnical data.

2.3 Sampling and Analysis Procedures

This section provides a description of field and research activities performed as part of the remedial investigation. Field activities were performed in accordance with the NDEQ VCP Guidance.

Field activities completed as part of the VCP Investigation include:

- Upgradient railyard groundwater investigation;
- Onsite soil and groundwater investigation;
- Downgradient groundwater investigation; and
- Public and private water well search and groundwater sampling.

The investigation approach utilized Direct Push Technology (DPT) to characterize the subsurface geology through electroconductivity (EC) logging and to collect samples of soil and groundwater. Site maps identifying the investigation target areas and data collection locations for

DPT EC logging, soil sampling, and groundwater sampling are provided in Figures 2-1, 2-2, and 2-4, respectively. A soil and groundwater sampling summary is provided in Table 2-1. Sample collection depths by investigation area are also included in Table 2-1. Descriptions of field activities are provided in the following sections.

2.3.1 Electrical Conductivity Subsurface Investigation

Thirty-one EC borings were advanced to refusal in the investigation area during implementation of the VCP Investigation. EC boring locations are shown in Figure 2-1. The EC profiles show heterogeneous alluvial deposits characterized by thick sand layers with silt and clay beds and lenses. Several logs show silt and clay as the predominant lithology in the eastern section of the study area. In the western part of the study area, thick sands with a basal silt/clay layer are observed. Refusal on the silt/clay ranges from approximately 78 to 103 ft bls across the study area.

EC borings SBD-01EC through SBD-03EC were advanced during the April 2006 investigation. Borings SBD-04EC through SBD-07EC were advanced during the August 2006 investigation. Borings SBD-08EC through SBD-10EC were advanced during the November 2006 investigation. The remaining borings SBD-11EC through SBD-31EC were advanced during the March 2008 investigation. EC logs are provided in Appendix K.

2.3.2 Soil Investigation

This section provides a description of field activities performed as part of the VCP Investigation soil investigation.

2.3.2.1 Direct-Push Soil Sampling

Subsurface soil sampling was conducted to evaluate nature and extent of on-Site impacted soil. Eight soil borings were advanced using DPT to a depth of approximately eight feet, sufficient to intersect the water table. Boring locations are shown on Figure 2-2. Sample locations from the initial Tetra Tech investigation sample locations are also shown. Sampling results from these borings were used to verify and supplement results from previous investigations.

Continuous 1.5-inch diameter soil cores were collected, described for lithology, and scanned with a photoionization detector (PID). The PID was calibrated daily. Soil boring logs are presented in Appendix M. One discrete soil sample per core was collected from the interval exhibiting the highest PID reading, which also generally correlated with the interval immediately above the water table. DPT core barrel tubes were decontaminated using a soapy water wash and a potable water rinse between each boring and a new acetate liner was used for each sample interval.

Soil samples were collected from the acetate liners and placed directly into sample containers using laboratory prepared method SW-846 5035 soil sampling kits. Containers were sealed and sample bottles were labeled with location name, date and time, sampler name, preservative, and analysis to be performed. Samples were submitted with a complete chain of custody in an ice-filled cooler to the Pace Analytical Laboratories in Overland Park, Kansas, by express courier. Sample container, preservation, and holding time requirements were met. Soil samples were analyzed for volatile organic compounds (VOCs) using analytical method SW-846 8260. Complete laboratory analytical reports and data verification reports are provided in Appendix V.

2.3.2.2 Geotechnical Soil Sampling

Geotechnical soil samples were collected for the purpose of quantifying soil properties for representative soil types. On December 4, 2006, samples were collected at well location MW-NSC-02C in the former tank area of the Site; and on December 6, 2006, samples were collected at well location MW-NSC-07C along Stuhr Road. A total of six samples were collected at depth intervals that represented discrete lithologies which were analyzed for Atterberg limits, moisture content, organic content, and grain size distribution. Atterberg limits were determined by method ASTM D-5084. Moisture and organic content were analyzed by method ASTM D-422. Grain size analysis and classification was performed by method ASTM C136. The geotechnical soil sampling results are summarized in Table 3-1. Geotechnical soil sampling results are provided in Appendix L.

2.3.3 Groundwater Investigation

This section provides a description of field activities performed as part of the VCP Investigation groundwater investigation.

2.3.3.1 Direct-Push Groundwater Profiling

DPT was used to obtain groundwater samples to determine the plume extent and to resolve macro-scale water quality variations within the plume. DPT groundwater samples were collected during field events in April, June, August and November 2006. Additional field events were performed in March, June, and December 2008.

Groundwater sample locations are shown on Figure 2-4 and are located in these general areas:

- Upgradient within the UP Railyard;
- On and immediately around the Site;
- East of the property along Willow Street and a portion of the Old Lincoln Highway (Seeding Mile Road west of Highway 30);
- South and east of the former NSC property along Highway 30;
- Along Stuhr Road (approximately ¼ mile east of the Site);
- Along Seedling Mile Access Road and the eastern edge of a sod farm (approximately ½ mile east of the Site);
- Along Voss Road, Museum Drive and East Swift Road (approximately ¾ mile east of the Site);
- Along Wainwright Street and Andrew Avenue (approximately 1 mile east of the Site);
- Along Seedling Mile Road between Wainwright Street and Shady Bend Road;

- Along Shady Bend Road and Wetzel Road (approximately 1¼ miles east of the Site);
- Along various farm access roads between 1¼ and 2 miles east of the Site;
- Along Gunbarrel Road (approximately 2¼ miles east of the Site);
- Along East Capital Avenue between 2¼ and 3 miles east of the Site;
- South of East Capital Avenue and north of Fort Kearney Road between 2½ and 3 miles east of the Site; and
- Along farm access roads and Beck Road between 3 and 3½ miles east of the Site.

Groundwater samples were collected from 233 DPT locations at selected intervals from the water table to refusal to produce a total of 684 groundwater samples. The sampling depth intervals were selected at each location based on previous laboratory results and EC logging results for the area.

Samples were collected from a screen-point sampler using dedicated single-use polyethylene tubing with a check valve. The tubing was sufficiently filled by hand oscillation after which the tubing was withdrawn from the screen-point sampler and then drained from the bottom of the tubing into new, laboratory-supplied hydrochloric acid (HCL) preserved, 40-mL sample vials. Approximately one to two liters of water was purged from each screen-point sampling point to eliminate the most turbid water from sample collection and to purge groundwater from the screen point prior to sampling. Screen point samplers and probe rods were decontaminated between sampling locations.

To facilitate decision-making during drilling, samples collected at 30 feet bls within the NSC tank yard and all samples collected along Willow Street and Highway 30 were analyzed on-site by a mobile laboratory supplied by Below Ground Surface, Inc. (BGS) from Lawrence, Kansas. During the April 2006 event, approximately one third of the samples analyzed on-site were submitted to Pace Analytical Laboratory in Lenexa, Kansas for VOC analysis by USEPA Method SW-846 8260B. All samples collected during the June, August and November 2006 events were submitted to Pace Analytical Laboratory in Lenexa, Kansas. The standard analytical turnaround time was two weeks. All samples collected during the March 2008 event were analyzed on-site by BGS using a modified method 8021 analysis. Samples collected during the June 2008 event were analyzed on-site by Environmental Chemistry Consulting Services, Inc. (ECCS) using method 8260B. Sampling depths are summarized in Table 2-1 for each location.

DPT groundwater sample locations were also collected on railroad property to the west-northwest of the NSC property as shown on Figure 2-4. Sample locations were selected to address the following areas:

- Upgradient of the NSC property (center portion of north railyard boundary); and
- Downgradient of the former roundhouse facility (southwest portion of the railyard).

Groundwater samples collected upgradient and downgradient of the former roundhouse were analyzed for VOCs using method SW-846 8260B and PAHs using method SW-846 8270C.

Groundwater samples collected from upgradient of the NSC property were analyzed for VOCs using method SW-846 8260B.

Downgradient groundwater samples were collected using the same methods and analysis utilizing data from each prior sampling event to determine locations and sampling depths for subsequent investigation.

DPT samples were collected on UP property or on City of Grand Island (City), Hall County or Merrick County rights-of-way where possible. Authorization was received from the City, County or private land owners prior to the installation of DPT borings. Utility clearances were performed at all locations to avoid utilities during drilling.

During DPT drilling, the estimated depth to refusal (thick silt/clay layer) was recorded, when encountered, to facilitate evaluations of the refusal surface.

Reference lines for cross sections of the sampling transects are provided on Figure 2-4. Table 2-2 is provided as a figure and table reference with respect to the area of investigation and sampling area.

2.3.3.2 Monitored Natural Attenuation Sampling

Between November 10 and 12, 2008, 15 wells were sampled for select parameters to assess the potential for natural attenuation to occur in the aquifer. The wells sampled were selected to provide an understanding of the aquifer throughout the entire study area and were: MW-NSC-02A, -06A, -07A, -08A, -20B, -21A, -21C, -21E, -22B, -27A, -27C, -27D, -32C, -32E, and -36B.

Prior to sample collection, all wells were purged via the low-flow method with a peristaltic pump and a flow-through cell with a multi-parameter meter. Wells were purged until the parameters (temperature, conductivity, dissolved oxygen, and pH) were stabilized in accordance with SOP 220A: *Low-Flow Sampling for Non-Volatile Analysis* (included in Appendix H). Future MNA sampling will utilize a low-flow submersible pump to minimize drawdown on the aquifer, minimize disturbance of the sample, and to easily monitor parameter stabilization. Low-flow procedures using a submersible pump can also be used for VOC sampling, however in this study UP has collected and will collect groundwater samples for VOC analysis using passive diffusion bags (PDBs).

Upon stabilization, groundwater was collected in laboratory-supplied containers. Samples were packed on ice in coolers and submitted to TestAmerica in Cedar Falls, IA for analysis. All samples were submitted for the following analysis:

- Total Alkalinity as $CaCO_3$ (SM2320B)
- Bromide (SW 9056)
- Chloride (SM 4500 CL)
- Hardness (SM 2340C)
- Nitrite as N (SM 4500 NO_2)
- Nitrate as N (SM 4500 NO_3)
- Iron and Manganese (SW 6010B)
- Methane, Ethane, Ethene (RSK 175)
- Sulfide (9034S)
- Sulfate (SW 9056)
- Total Organic Carbon (SW9060)

In addition to the above laboratory parameters, all samples were field analyzed for Iron using a Lamotte Smart Colorimeter and the reagent Phenanthroline.

2.3.3.3 DPT Source Area Investigation

Twenty-one (21) membrane interface probe (MIP) borings and 16 DPT soil-borings were advanced in the source area from December 1 to 5, 2008. The purpose of this work was to further delineate source area soils in the vadose and saturated zones that may be contributing to the dissolved groundwater plume to support remedy design and selection. The MIP locations (MIP-01 to MIP-21) and soil borings (SB-13 to SB-28) are shown on Figure 2-2.

Between December 1 and 3, 2008, MIP technology was utilized by The Forrester Group and BGS to identify the lateral and vertical extent of hydrocarbons and VOCs, based on MIP detector response. Borings were advanced to depths ranging from 30 to 70 feet bls and positioned on a 40-foot by 40-foot grid.

The MIP was equipped with three detectors: a PID for detection of aromatic hydrocarbons, an Electrolytic Conductivity Detector (ELCD) for detection of chlorinated compounds; and a flame-ionization detector (FID) for detection of straight-chain hydrocarbons. The MIP was also equipped with an EC sensor that recorded the change in conductivity values which were used to identify lithology types during the advancement of the probe.

Of the 3 detectors used during the MIP work, the FID exhibited the greatest response and therefore was the most useful in assessing the presence of hydrocarbons and VOCs in the MIP boring. The FID response indicated high levels of hydrocarbons at the Site. Responses from the FID and PID provided similar profiles and often mirrored each other, indicating that impacts related to hydrocarbons were greater than the chlorinated compounds impacts.

On December 4, 2008 a total of 15 geotechnical soil samples were collected from SB-09, SB-10, SB-11, and SB-12. Samples were collected at depth intervals that represented changes in lithology. Four samples were collected from each of the sample locations SB-09, SB-10, and SB-11 and three were collected from SB-12. All geotechnical samples were submitted to GSI in Grand Island, NE and analyzed for grain size and wet and dry density. The methods used for these analyses were ASTM C136 and ASTM C117, respectively.

The results of the geotechnical analysis confirmed the field observations and the EC logs of 4 distinct lithologies (two sand layers and two clay layers.) The geotechnical results are provided as Appendix L.

On December 4, 2008, a total of 4 soil samples were collected from borings SB-09 and SB-11 at the same depth intervals as the soil samples collected for the geotechnical analysis and were sent to Carus Corporation (Carus) in LaSalle, Illinois. The soil samples representing each primary soil type at the Site were analyzed by method ASTM D7262-07 Test Method A for permanganate natural oxidant demand (PNOD). The PNOD measurement is used to estimate the concentration of permanganate that would be consumed by the natural reducing agents in soil over a given time period.

On December 4 and 5, 2008, 16 soil borings, SB-13 through SB-28, were advanced using DPT. The borings were set on a 40-foot by 40-foot grid across the source area. All borings were advanced to a total depth ranging from 7 to 16 feet bls. The samples were collected from depth intervals which coincided with elevated peaks in the MIP responses. A total of 23 soil samples and one duplicate sample were collected form the 16 soil borings. The overall sampling interval for the borings ranged from 2.8 to 20.0 feet bls.

A total of 24 groundwater samples were analyzed from the 16 DPT soil borings. The groundwater sampling depths ranged from 6 to 18 feet. Groundwater samples were collected at the groundwater table in all 16 DTP soil borings, and at depths were the MIP results indicated peak responses in soil borings SB-17, and SB-23 to SB-28. One field duplicate was also analyzed.

Groundwater samples were analyzed for VOCs, semi-volatile organic compounds (SVOCs), and hydrocarbons. Based on groundwater results, high concentrations of BTEX related compounds were present in all groundwater samples with the exception of SB-15, SB-27, and SB-28. VOCs were present in all groundwater samples with results exceeding groundwater protection standards.

All soil samples were collected by sampling method 5035 utilizing laboratory-supplied field preservation kits and an additional soil sample was collected and placed into a soil jar. All soil and groundwater samples were placed in coolers, packed on ice, and shipped to TestAmerica in Cedar Falls, Iowa for VOC analysis by method SW8260B and TOC analysis via method SW846 9060M.

2.3.3.4 Source Area Well Abandonment and Investigation

On April 15, 2009 Thiele Geotech Inc. and The Forrester Group began decommissioning the domestic water well located at the southeast corner of the building that served as the water source for sanitary and process water. The well contained a 21-inch long Roberts' submersible pump that was positioned approximately 33 ft bls. The total depth of the well measured to 75 ft bls with heavy sedimentation present at the base. The well was backfilled to the land surface using a tremmie pipe and bentonite grout. After the bentonite grout had settled a backhoe was used to excavate an area of 5 feet by 5 feet to a depth of 5 feet with the abandoned well in the center. Approximately 2 feet of concrete was placed in the pit on top of the abandonment well. The remaining 3 feet was filled with backfill. The well was abandoned in accordance with Nebraska Departments of Natural Resources (DNR) and Health and Human Services (HHS) requirements.

Two historic sump pits are present on the Site and were investigated on April 15, 2009. One sump pit is located on the northeast corner of the building and the second is located approximately 100 feet north of the building. Prior to investigation activities, the stagnant water in the pits was pumped out until only a limited amount of sediment remained. A majority of the sediment was removed by a mini-excavator and placed on plastic sheeting adjacent to the sump pit allowing observation of the floor of the pit for any evidence of pipes or drains. After the inspection sediment that was placed on plastic was replaced in the pits and the grates were put back in place. Water from the sumps was thin-spread on the north portion of the Site.

The sump pits were determined to be approximately 5 feet long by 2 feet wide and 3 feet deep. The walls are constructed of concrete blocks and the floors of the pits are poured or pre-fabricated concrete slabs. No drains or pipes were observed in either of the sump pits. The sumps appeared to be in good condition. A discussion of soil and water disposal activities for this event is provided in Section 2.5.1 of this report.

Three soil borings (SB-29, SB-30, and SB-31) were installed on April 15, 2009 as shown on Figure 2-2. Soil borings were split-spoon sampled to approximately 20 ft bls. The observed lithologies were consistent with the previous soil borings SB-1 to SB-28. One sample was collected from the 3 to 7 ft bls (silty/sandy clay) interval of each boring for TCLP analysis based on prior MIP results indicating some level of impact in that depth interval. A discussion of soil and water disposal activities for this event is provided in Section 2.5.1 of this report.

One composite sample was also collected from all the borings at the 7 to 20 ft bls (sandy) interval for chemical oxygen demand (COD) and total iron. In addition to the soil samples, two groundwater samples were collected from MW-NSC-02A. One groundwater sample was analyzed for COD and total iron and the other groundwater sample was field-filtered and analyzed for total iron. These soil and groundwater samples were analyzed to help evaluate dosing requirements for in-situ chemical oxidation.

All samples were submitted to TestAmerica in Cedar Falls, IA for analysis. TCLP analysis was performed by method 1311/8260B and the COD and iron by methods SM 5220B and SW 6010B, respectively. Analytical data reports are included in AppendixV.

2.3.3.5 Monitoring Well Installation and Sampling

Groundwater monitoring wells were installed to allow groundwater sampling over time. Specific objectives of long-term groundwater monitoring program included the following:

- Obtain high quality, defensible data regarding physical and chemical attributes of groundwater within the study area;
- Characterize study area stratigraphy and hydrogeology, including potentiometric surface, groundwater flow paths, and aquifer characteristics; and
- Define plume extent and assess plume status (steady-state versus increasing or decreasing).

2.3.3.6 Well Installation

Sixty-two (62) two-inch diameter monitoring wells were installed using a hollow-stem auger drill rig at both on- and off-site locations during four events which occurred in December 2006, March 2008, June 2008, and December 2008. Well design and well locations were determined based on DPT groundwater data. All monitoring wells were constructed with 5-feet of screen. Well locations are shown on Figure 2-5.

Three wells are installed onsite. Two wells are installed upgradient in the UP railyard. Fifty-seven (57) offsite wells are installed on the City- or County-owned street rights-of-way from Willow Street through East Capital Avenue. Authorization was received from the City and/or

Merrick County prior to well installation. Utility clearances were performed at each location. Augers were decontaminated between borings.

Monitoring wells were installed in groups to monitor VOC-impacted depth intervals of the aquifer, as well as non-impacted portions of the aquifer above and below the impacted zones where applicable. Additional monitoring wells were installed to define the lateral extent of VOC-impacts at similar depths to nearby wells designed to monitor the core of the impacts.

The riser and well screen consisted of threaded Schedule 40 PVC and the screen slot size was 0.010 inches. A sediment trap was installed at the base of the well screen. The annular space was filled with a 12-20 silica sand filter pack. The sand pack extended approximately 2 to 3 feet above the top of the well screen. A bentonite plug 3 to 5 feet thick was installed above the filter-pack and hydrated with potable water. All remaining annular space was filled with bentonite grout. At each location, a flush-mounted completion, including a steel well housing and concrete pad meeting NDEQ requirements, was installed to minimize interference with traffic or residents. A locking Envirocap™ was installed on the top of the riser pipe to provide well security. Monitoring well construction details are summarized in Table 3-2.

Monitoring well completion logs are included in Appendix N.

2.3.3.7 Monitoring Well Development

After well completion, a waiting period of at least 24 hours passed prior to well development. Development was performed to remove fines from the filter-pack and to promote the free-flow of natural formation water into the well.

A minimum of five well volumes was purged from each well during development. Using the development pump as a surge block, the well was repeatedly surged in order to promote the movement of fines from the filter pack. Surging and well development continued until turbidity measured less than 10 nephelometric turbidity units. The development pump was decontaminated between wells.

2.3.3.8 Deployment and Retrieval of PDB Systems

The passive diffusion bag (PDB) sampling system has been employed to obtain groundwater VOC samples from discrete depth intervals which are representative of groundwater flow conditions. PDB sampling was implemented after well development was completed. A PDB sampler is a low density polyethylene bag filled with de-ionized water. The PDB sampler is suspended from a tether within the screened interval of the well. The PDB is constructed of a semi-permeable membrane and filled with deionized water. VOCs in groundwater diffuse across the membrane until constituent concentrations within the bag reach equilibrium with concentrations in the surrounding groundwater. PDB sampling is a time-weighted average, with an emphasis on the period of time generally ranging from 1 to 4 days prior to sampling (ITRC 2004). At the time of sampling, the PDB sampler is retrieved and water is transferred to three 40-milliliter (ml) glass VOA vials containing hydrochloric (HCl) acid preservative for laboratory analysis.

The wells were capped with a locking Envirocap™ that has a clip for attaching the PDB tether. The PDB samplers, each holding 350 mL of water, were attached to the tether so they will be suspended opposite the well screen. PDB tether lengths are summarized in Table 3-2. A reusable stainless steel weight is attached to the bottom of the tether to keep the PDB in place. PDB samplers were deployed no less than two weeks prior to sampling and generally were deployed quarterly in anticipation of the next sampling event. After sampling, the emptied PDB are disposed as solid waste.

According to the *User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells* (Vroblesky 2001) there is no specified maximum time for retrieval of the PDBs. Vroblersky reported that PDBs were left in place at one site in VOC contaminated groundwater for one year without loss of bag integrity. At the NSC Site, sampling is conducted quarterly. This report includes data for up to 12 quarters of sampling, depending on when each well was installed.

2.3.3.9 Monitoring Well Sampling

Prior to sampling, static water level measurements were taken using a decontaminated electronic water-level probe.

Sampling events occurred on the following dates:

- March 8, 2007;
- June 19, 2007;
- September 17, 2007;
- December 5, 2007;
- March 6, 2008;
- June 23, 2008;
- September 22 to 23, 2008;
- December 8 to 10, 2008;
- March 23 to 24, 2009;
- June 24 to 25, 2009;
- September 14 to 15, 2009; and
- December 7 to 9, 2009.

Samples are identified by well name followed by the date (e.g. MW-NSC-01A-YYMMDD). Sample identification procedures were modified starting with the December 2007 event (e.g. WG-1550-MW-01A- YYMMDD) to include a site identification number to facilitate more robust data management. Samples were packed with ice and a completed chain-of-custody in a cooler and submitted to the analytical laboratory by overnight courier.

Samples were submitted to Pace Analytical Services from April 2006 to February 2007 and to TestAmerica Laboratory in Cedar Falls, Iowa from March 2007 to the present. Samples were analyzed within holding times for VOCs by USEPA Method SW-846 8260B. Complete laboratory analytical reports and data verification reports are provided in Appendix V.

2.3.3.10 Slug Testing

Slug tests are *in-situ* aquifer characterization tests designed to estimate hydraulic conductivity and other aquifer parameters for the aquifer immediately surrounding the test well. Hydraulic conductivity along with hydraulic gradient and porosity can be used to estimate groundwater flow rates.

Generally to perform the test, a “slug” of water or a solid cylinder is injected or withdrawn from the test well to induce the rapid change in water level. A pneumatic slug was used in tests at the Site. A pneumatic slug injects a volume of air above the water table in the test well. As the air column pressurizes, the water table is depressed until the pressure is instantaneously released and water levels begin to return to equilibrium. Water levels are measured using a pressure transducer and recorded on a data logger.

Slug tests offer several advantages. Tests can be performed quickly at relatively low cost, as compared to pumping tests; estimates of aquifer parameters are made *in-situ* and thus represent a larger volume of the aquifer than permeameter tests conducted on core samples; investigation derived wastes are minimized (especially compared to a pumping test); and in the case of pneumatic slug tests, only a pressure transducer is required to be placed in the well thereby simplifying the test.

However, slug tests have a number of limitations. The storage coefficient (storativity) cannot be determined by a slug test. Additionally, due to the small-scale volume change in water table levels, the area of influence of a slug test is limited to the area immediately surrounding the test well. Thus, slug tests at various locations are necessary to characterize aquifer variations across the study area.

The specific objectives of the slug tests included collection of bulk hydraulic properties for the aquifer and determination of horizontal hydraulic conductivity, and groundwater velocity.

2.3.3.11 Test Setup and Methodology

The pneumatic slug test assembly consists of a valve, water displacement gauge, pressure transducer access port, and air chamber, which couples to the well head. A hand-held pump is used to pressurize the well until the desired air pressure (measured in inches of water) is achieved. The well is then depressurized via the valve signaling the beginning of the test.

All water level measurements were recorded by a downhole data logger for the duration of the test. An In-Situ LevelTROLL® 700 recorded data on a linear timescale with high-frequency data collection (0.25-second interval). The transducer was placed at approximately one-half meter from the static water level (Butler *et al.* 2003) in order to reduce recording errors noted by McElwee (2001) and Zurbuchen *et al.* (2002). Water level data were recorded continually via an In-Situ Rugged Reader® hand-held computer connected to the LevelTROLL®. During the pressurization phase of the test, real-time water levels indicated when the desired displacement was reached, and the air chamber was depressurized. The duration of each test varied from a few seconds to one minute, based on the time it took for water levels to stabilize following initial displacement. Three to five tests, each using different water level displacement values, were conducted at each test well.

Slug tests were performed in nine monitoring wells on June 20, 2007 and 10 wells on November 13, 2008. Slug test results are provided in Appendix O.

2.3.4 Quality Assurance/Quality Control

Quality control samples collected during field activities are listed below. A copy of the site-specific Quality Assurance Project Plan (QAPP) used for this project is included as Appendix J.

- **Trip blanks** provided by the laboratory were returned to the laboratory with VOC samples at a frequency of one per cooler.
- **Field blanks** were collected at a frequency of one per 10 primary samples.
- **Field duplicates** were collected for all methods analyzed at a frequency of one per 10 primary samples. If any field duplicates are inadvertently not collected, they were collected during a subsequent field event.
- **Matrix spikes/matrix spike duplicates** were performed by the laboratory at a frequency of one per 20 primary samples. Extra volume was collected in the field for these samples and they were designated as MS/MSD samples on the chain of custody. If any MS/MSD samples were inadvertently not collected, they were collected during a subsequent field event.
- **Equipment rinsate blanks** were collected at a frequency of one per 10 primary samples. However, equipment rinse blanks were not collected for pre-cleaned, single use equipment, such as bailers or tubing, if used. These samples were collected by pouring distilled water over decontaminated equipment and catching the rinsate in a 40-mL sample vial.

2.4 Health and Safety

All field activities conducted during the VCP Investigation field work was conducted under a site specific Health and Safety Plan (HASP).

2.5 Investigation-Derived Waste

Drill cuttings, purge/development water, decontamination water, sampling residuals, and other IDW generated during the VCP Investigation field work were containerized upon generation, tested as appropriate and disposed as described in this section.

2.5.1 Investigation Derived Solid Waste Management

Soil cuttings were produced during soil borings and the installation of monitoring wells. Cuttings were gathered and placed in covered 55-gallon drums or in lined and covered twenty cubic yard roll-off containers, for example, during the multi-well installation events. All containers were appropriately labeled to identify contents, generation date, contact information and characterization actions being taken. Composite soil samples were collected at a minimum rate of one sample per monitoring well, regardless of the volume of cuttings, and was characterized for disposal using Toxic Characteristic Leaching Procedure (TCLP) VOC methods. Total VOC analytical results were also compared to the Residential Direct Contact Exposure Pathway concentrations from the VCP RG Lookup Tables. Soil from monitoring well installation was disposed as special waste at the local landfill facility in Grand Island. Soil from on-site soil sampling that did not exceed applicable VCP RGs was thin-spread on the site surface per the

VCP guidance. A summary of IDW management and IDW laboratory analytical reports are provided in Appendix V.

Single use sampling equipment, personal protective equipment (PPE), and DPT acetate liners were decontaminated if grossly impacted, containerized in trash bags and disposed as routine solid waste.

With regard to the investigation of the two on-site sumps (discussed in Section 2.3.3.4), generator knowledge was used to determine that water and sediment in the sumps was not a concern. A preliminary investigation of the sumps determined that they were constructed within the upper 3 feet of the soil column. Soil investigations, conducted prior to evaluating the sumps, showed that the soil to an approximate depth of 3 feet (and greater at some on-site locations) is not impacted. Based on this, gravel and sediment in the sumps were assumed to have originated from surface gravel and soil at the site and therefore was not impacted. Also, water levels in the sumps were approximately two feet above water levels in the source area monitoring wells, further indicating that the sump was not connected to groundwater and therefore the water was stormwater run-in. Thus the water in the sump was reasoned to not be impacted and was thin-spread onsite. Gravel and sediment were returned to the sump because off-site disposal was believed to not be necessary.

With regard to soil cuttings from boring SB-29, which exceeded TCLP limits for tetrachloroethylene of 0.7 mg/l for PCE (discussed in Section 2.3.3.4), these cuttings were inadvertently thin-spread on site within the former tank yard prior to receipt of the analytical data. Based on MIP data, soil showing some level of impact extended from approximately 3 to 7 feet below land surface, some of which was sampled and sent to the laboratory for analysis. Due to the volatile nature of the site COIs, PCE likely volatilized to the atmosphere. The former tank yard will be excavated as part of the remedial action. Soil not planned for disposal during the excavation remedy will be tested prior to reuse as backfill on site. In the unlikely case that PCE leached to groundwater, remedial actions for groundwater are also planned. This work plan deviation has been addressed with NDEQ.

2.5.2 Investigation Derived Water Management

Wastewater generated during the VCP investigation was stored in 55-gallon drums pending the receipt of analyses that were used to determine proper disposal. Accumulated water was sampled for VOCs at a minimum rate of 1 sample per 5 drums or 300 gallons. Samples were analyzed using USEPA Method SW-846 8260B. Analytical results were compared to the Residential Direct Contact Exposure Pathway concentrations from the VCP RG Lookup Tables. Water not exceeding MCLs for COIs was thin-spread over the site per the VCP guidance. Water exceeding MCLs generated during the initial investigation event was resampled after additional IDW water was added during the following investigation. The results for the filled drum were below VCP RG and the water was disposed in the source area. IDW water from well installation activities was sampled and disposed off-site by the well installation subcontractor after receipt of the analytical data.

A summary of IDW management and IDW laboratory reports are provided in Appendix V.

3 Physical Site Characterization

This report section presents investigation results.

3.1 Surface Water

Topography within the region of the study area is flat lying with a gradual slope to the south and east.

The study area is located within the Wood River drainage basin. Surface water from the former leased property and from the larger study area flows overland though various ditches. A tributary to the Wood River is located approximately 1.8 miles south of the former leased property along East Swift Road and joins with the Wood River east of the East Swift Road and Shady Bend Road intersection. The Wood River parallels Fort Kearney Road. In the study area, the flow of groundwater is generally parallel to and in the same direction as the flow of water in the Wood River. The Wood River discharges to the Platte River approximately 6 miles northeast of the former leased property.

A storm water retention pond is located on the northern portion of the property and on the adjacent railyard. The southern and eastern boundaries of the pond adjacent to the Site have vegetated berms which prevent surface runoff from the Site from entering the pond. Likewise an elevated track right-of-way on the west side of the site provides a topographic barrier to surface water flow both onto and from the former leased property.

3.2 Soils and Geology

3.2.1 Geology

Geologic deposits of the study area through which groundwater and dissolved constituents may flow consist of stacked vertical sequences of unconsolidated fluvial or river dominated sediments ranging up to approximately 100 feet thick. Fluvial sequences consist of upward fining sequences generally composed of sand and locally gravel and grading upwards to finer sands, silt, and locally clay. These sediments were deposited by braided rivers transporting sediment eastward from the Rocky Mountains through the Tertiary and Quaternary periods. Thin soil composed of organic-rich silt and sand caps most of the study area.

The sediment types present across the study area were investigated using EC logging which measures the response of sediment types to an applied electrical current. Clays conduct electricity most efficiently and so exhibit a greater EC response. Conversely, sands are poor conductors and so exhibit a limited response. Silts produce an intermediate response. Thirty-one (31) EC logs were collected across the study area from land surface to refusal typically at depths ranging from approximately 69 to 103 feet. Sediment cores were also obtained and described to develop a correlation between sediment type and EC logging response. Soil boring locations are shown in Figure 2-2. EC logs are provided in Appendix K and soil boring logs are provided in Appendix M. Geologic cross-sections are provided in Figures 3.1 through 3.5.

Sand-rich sediments dominate the geologic materials present in the study area. Silts are locally abundant; however clay lithologies are relatively limited in occurrence and extent. The limited extent of clay is consistent with regional studies and is reportedly related to extensive river reworking of sediments over time. Review of the EC logs provides insight into the distribution of sediment types, as summarized below and on Figure 7-2.

- In the on-site area formerly comprising the tank yard, apparent fill material is present to an approximate depth of 3 feet. Specific information documenting the placement of fill in the former AST area north of the Site building is not available; however the material texture is sand rather than topsoil silt and clay found elsewhere.

- In the source area and near source area from the Leased Property to Stuhr Road, sediment types consist of silt and silty clay to a depth of about 15 feet overlying sand to about 65 feet. Interbedded silty sand and silty clay extend to refusal at about 95 feet. In this area, groundwater impacts are limited to the upper part of the water column to depths of 30 feet. These lithologies are evident in EC logs 1, 2, 3 and 17.

- Downgradient of the near source area, between Hwy 30 and Shady Bend Road and south of Seedling Mile Road, lithologies are more silt- and clay-rich. Sand-rich textures generally extend from the land surface to approximately 30 to 40 feet. Below this horizon, silty sand and silty clay are present to about 70 feet with more sand-rich textures to refusal at about 80 feet. These lithologies are generally evident in EC logs 15, 16, 18, and 19. Impacted groundwater is generally present in this area to depths of about 50 feet.

- From Shady Bend Road to North Gunbarrel Road and from Hwy 30 to Seedling Mile Road, two sediment profiles exist. Generally to the north, sediments are dominated by sand and silty sand, as evident in EC logs 26, 20, 28, 11, and 12. In the southern part of this area, sand and silty sand with silty-clay interbeds extend from about 25 to 30 feet, as evident in EC logs 8, 9, and 29. Impacted groundwater is generally present in this area to depths of about 20 to 60 feet.

- From North Gunbarrel Road to Beck Road and from Fort Kearney Road to about East Capital Avenue, sediments are dominated by sand and silty sand, as evident in EC logs 22, 23, and 24. Sand with local silt and/or clay interbeds are locally present, as evident in EC logs 27 and 30. Impacted groundwater is generally present in this area to depths of about 40 to 80 feet.

These sediment types are consistent with the observed pattern of groundwater flow and the extent of impacted groundwater. Groundwater is flowing predominantly through sand-rich sediments. More silt- and/or clay-rich sediment, for example between Stuhr Road and Shady Bend Road and south of Seedling Mile Road, represents lower permeability channel margin sediments which restrict groundwater flow. Even within the sediment profile dominated by sand, for example between Shady Bend Road and Beck Road, interbedded layers of silty sand and/or silty-clay may occur. These are interpreted to be overbank deposits, which locally were not re-eroded by shifting braided river channels. However, the limited vertical and lateral extent of these interbeds means that they do not represent any significant hydraulic barrier to the flow of groundwater or dissolved chemical constituents. This inference is validated by the distribution of impacted groundwater which has extended below and beyond these interbeds.

The type and distribution of sediments in the study area are typical of braided river sedimentary systems where coarse sand is deposited in response to seasonal influx of stormwater runoff, meltwater, and sediment load. The resulting deposits cover large areas in thin deposits which stack over time. Portions of the study area containing coarser and thicker sands are interpreted to represent channel deposits of the ancestral Platte and Wood Rivers. While time-correlative sand, silt and clay were deposited across the river system, sediments were reworked and finer sediments were winnowed leaving a relatively thick accumulation of sand. Fine grained deposits appear as discrete lenses of limited extent.

3.2.2 Soil Geotechnical Characteristics

Geotechnical analytical results from samples collected from MW-NSC-02 and MW-NSC-07 during well installation are provided in Appendix L and are summarized in Table 3-1. Clay-rich soils, including two samples (MW-NSC-02 2’-4’ and MW-NSC-02 4’-6’) from 2 to 6 feet bls, were characterized as sandy lean clay. Sand-rich sediments, including four samples (MW-NSC-02 6’-8’, MW-NSC-07 12’-24’, MW-NSC-07 32’-34’, and MW-NSC-07 45’-47’) from 8 to 47 ft bls, were characterized as poorly graded sand. Organic content was approximately 0.1 percent and moisture content averaged 11 percent.

The Source Area Investigation MIP EC log evaluation confirmed 5 distinct soil layers or Horizons on the site, as follows:

- Fill: Unimpacted loose sandy fill material from ground surface to 2.8 feet bls;
- Horizon A: Clay layer - 2.8 to 6.9 feet bls;
- Horizon B: Upper Sand layer - 6.9 to 10.2 feet bls;
- Horizon C: Clay lens - 10.2 to 11.4 feet bls; and
- Horizon D: Bulk sand layer - 11.4 to 70 feet bls.

3.3 Hydrogeology

A shallow aquifer exists in alluvial deposits to a depth of up to approximately 100 feet overlying regionally extensive silt. The depth to groundwater varies spatially and seasonally from 1 to 8 ft bls and flows generally to the east and northeast. The aquifer is considered to be unconfined.

This subsection summarizes the groundwater potentiometric surface results during the VCP Investigation.

3.3.1 Groundwater Surface

The potentiometric surface is the imaginary surface representing the total head of groundwater and is indicated by the level to which water will rise in a well. The potentiometric surface in the overall Study Area is unconfined and so is represented by the water table, which is generally between 1 and 8 ft bls. In the source area, a low permeability clay is present from about 3 to 7 ft bls. The water table generally occurs within the clay as indicated by the water level in wells MW-NSC-02 and MW-NSC-07.

The groundwater flow direction in the vicinity of the Site is to the east with a general east-northeasterly direction east of Shady Bend Road. Review of groundwater surface contour maps indicates that the hydraulic gradient is relatively uniform (Figures 3-6 through 3-9). For water elevation data from the June 2009 groundwater sampling event, the hydraulic gradient was calculated between well locations 2 and 10, 20 and 28, and 26 and 33. The source and near source area hydraulic gradient is slightly steeper (0.0016 ft/ft) than that determined for the remainder of the plume (0.0011 ft/ft). Table 3-3 summarizes groundwater elevations from each quarter of groundwater monitoring. Figures 3-6 through 3-9 illustrate the seasonal potentiometric surface contours during 2009.

Groundwater levels are highest in the spring due to snowmelt and precipitation recharge and lowest in the fall to winter due to frozen conditions. Seasonal groundwater fluctuations range from are approximately 2 to 3.5 feet as a function of precipitation and snow melt.

Water levels between co-located wells completed in different depth intervals are similar indicating that strong vertical hydraulic gradients are not present. This is further evidence that aquifer conditions are unconfined.

3.3.2 Slug Test Results

Following the completion of the slug tests, groundwater level data were corrected for atmospheric pressure effects and compiled in graphical plots and tables detailing displacement and recovery versus time. Hydraulic properties were calculated and the assumptions and limitations of the test parameters were evaluated. Finally, the Conceptual Site Model (CSM) was revised to reflect conditions determined from the test results.

3.3.2.1 AQTESOLV Analysis

The aquifer modeling software AQTESOLV was utilized for groundwater level data analysis. A model of hydraulic conditions was developed and is presented in Appendix O.

The test data were processed prior to modeling. Raw data showed a period of water level fluctuation due to the oscillation of groundwater during the pre-test pressurization phase that preceded rapid (instantaneous) depressurization and recovery in a high conductivity aquifer. During the data filtering process, the water level indicating the initial displacement was identified, and all preceding water level fluctuations (resultant of pressurization) were deleted. The initial displacement values for each test were set to time equals zero for direct input into AQTESOLV.

The groundwater level data were curve-matched to type curves derived from the Butler (1998) solutions for estimating hydraulic conductivity. Butler (1998) extended the Hvorslev (1951) solution for a single-well slug test in a homogeneous, anisotropic confined aquifer to include inertial effects in the test well. The Butler solution predicts the theoretical change in water level in the test well. The solution accounts for oscillatory water-level response sometimes observed in aquifers of high hydraulic conductivity.

The groundwater level data were reviewed in AQTESOLV using the Butler (1998) solution to develop initial estimates for hydraulic conductivity (K) and transmissivity (T). The solution type curves were matched to test data using visual methods and manual adjustment of the effective water column length (Le). Following manual and visual adjustment, each curve was automatically matched for the best fit.

Several parameters and assumptions were required to evaluate the data:

- Aquifer thickness (b) – Aquifer thickness was estimated from direct-push borings advanced during previous phases of investigation near the test well locations. Estimated aquifer thickness for each well is presented in Appendix O.
- Homogeneity of aquifer materials – The aquifer was assumed to consist of homogenous sediment throughout the test area.
- Horizontal and vertical anisotropy – the aquifer was assumed to be isotropic, that is, aquifer parameters are considered the same regardless of direction.

Following the completion of AQTESOLV analysis, the hydraulic conductivity estimates for each test iteration were averaged for each test well. K-values ranged from 31 to 360 ft/day. These values are generally typical of poorly to moderately graded clean sand (Freeze & Cherry, 1979). Hydraulic conductivity values for each test are presented in Appendix O.

The depth of groundwater impact was used to select the test wells and the corresponding hydraulic properties that best represent the portion of the aquifer impacted by COIs.

- Test wells in the A and B horizons were used to characterize the source area and near source area, generally from Willow Street to Stuhr Road. The average hydraulic conductivity was determined to be 160 ft/day; the hydraulic gradient was 0.0016 ft/ft; and the porosity was 0.3 (30%), representative of a moderately graded sand.

- Test wells in the B and C horizons were used to characterize the mid plume area, generally from Stuhr Road to Gunbarrel Road. The average hydraulic conductivity was determined to be 63 ft/day; the hydraulic gradient was 0.0011 ft/ft; and porosity was 0.25 (25%), representative of a poorly graded sand.

- Test wells in the C and E horizons were used to characterize the downgradient plume area, generally from Gunbarrel Road to Beck Road. The average hydraulic conductivity was determined to be 54 ft/day; the hydraulic gradient was 0.0011 ft/ft; and porosity was 0.25 (25%), representative of a poorly graded sand.

The groundwater flow rate, or seepage velocity, was estimated using Darcy's Law, as presented below:

$$V_s = \frac{q}{n} = \frac{Q/A}{n} = \frac{K\, dh/dl}{n}$$

where

V_s = seepage velocity
q = Q/A = specific discharge or discharge per unit area of cross-sectional flow
n = porosity (in decimal form)
Q = discharge
A = the area of cross-sectional flow
K = hydraulic conductivity
dh/dl = hydraulic gradient

The seepage velocity for each area was calculated as follows:

- Source and Near-Source Area seepage velocity: 302 ft/year
- Midplume Area seepage velocity: 103 ft/year
- Downgradient Area seepage velocity: 89 ft/year

Following the calculation of bulk aquifer properties, the data were applied to the CSM to better reflect actual aquifer conditions. The CSM and aquifer properties will be used to evaluate future corrective actions at the site.

AQTESOLV data reports and seepage velocity calculation sheets are compiled and presented in Appendix O.

The MNA Study discussed in Section 9 will evaluate the feasibility of conducting additional pumping tests using irrigation well G-101835 and nearby monitoring wells to further refine the CSM.

4 Nature and Extent of Contamination

This section of the report describes the nature and extent of chemical impacts to soil, soil vapor, and groundwater.

4.1 Source Area Soil

The extent of soil impact is primarily within the area of the lease property and north of the Site building. Limited further delineation will be conducted along the adjoining properties to the east prior to soil remediation activities. The Site housed 20 ASTs and an unknown number of 55-gallon drums that contained various solvents. The ASTs and drums were located in the enclosed yard on the northern portion of the property (Figure 2-2). There are no reports of a historic release for this property (EPA, 1990a).

Eight soil samples were collected from 8 borings generally ranging from six to nine ft bls in the former AST area (Figure 2-2). COI concentrations exceeded VCP RGs for the Migration to Groundwater pathway. All detections of COIs above laboratory reporting limits are summarized in Table 4-1. The estimated extent of impacted soils is depicted in Figure 4-1. These represent impacted soils from all soil horizons and will be addressed through the various remedies proposed in Section 9. Figures 4-3 and 4-4 depict the relative areas of impact in the source area.

COIs detected in soil include:

- PCE was detected in SB-08-08 at a concentration of 23,500 µg/kg.
- Cis-1,2-DCE was detected in SB-08-08 at a concentration of 31,700 µg/kg.
- 1,1,1-TCA was detected in SB-04-08 at a concentration of 74,400 ug/kg.
- Ethylbenzene was detected in five samples at concentrations ranging from 8,580 (SB-01-08) to 918,000 µg/kg (SB-05-08).
- Toluene was detected in five samples at concentrations ranging from 9,270 (SB-01-08) to 1,260,000 µg/kg (SB-05-08).
- Xylenes (total) were detected in six samples at concentrations ranging from 2,350 (SB-08-08) to 5,980,000 µg/kg (SB-05-08).
- 1,2,4-Trimethylbenzene was detected in two samples at concentrations ranging from 2,740 ug/kg (SB-08-08) to 27,000 µg/kg (SB-04-08).

Soil analytical results from the Source Area Characterization in December 2008 included samples collected from borings SB-17, SB-22, and SB-25 which exhibited the highest detections of chlorinated and aromatic hydrocarbons. All 16 borings had one or more COI detected at concentrations exceeding the screening criteria. Analytical data reports and the verification reports are included in Appendix V. The highest concentrations of hydrocarbons and VOCs where exhibited by SB-17 at the 4 to 6 feet bls interval and are as follows:

- Benzene: 532 µg/kg;

- Ethylbenzene: 2,690,000 µg/kg;
- Toluene: 836,000 µg/kg;
- Xylene: 1,550,000 µg/kg;
- PCE: 14,300 µg/kg;
- TCE: 228 µg/kg;
- 1,1-DCE: 97.7 µg/kg; and
- cis-1,2-DCE: 670 µg/kg.

The extent of soil impact has been defined within the area of the lease property and north of the Site building. Limited further delineation will be conducted along the adjoining properties to the east prior to soil remediation activities.

The vast majority of impacted soil is within the upper 7 feet with impacts potentially as deep as 11 feet based on PID readings.

The analytical results from Carus concluded that the PNOD ranges between 0.2 and 31.9 g/kg, and the average for all 8 samples analyzed was 14 g/kg. As expected in the two clay layers (Horizons A and C) a higher PNOD (average, 24.6 g/kg) was exhibited than the two sand layers (Horizons B and D) (average, 3.45 g/kg). PNOD values less than 20 g/kg favor the use of permanganate oxidant. The data exhibit an average PNOD for the source area clay layers greater than 20 g/kg and therefore would not be favorable to use a permanganate oxidant.

4.2 Soil Vapor

A screening soil vapor assessment was performed by UP in 2009 to evaluate the potential for vapor intrusion from groundwater into indoor air. The location of the 45 soil vapor samples, collected from near-source, midgradient plume, and downgradient plume areas, are shown on Figure 2-3. Land use in the near-source area is primarily commercial and industrial, while the land use in the midgradient and downgradient areas is primarily residential. Groundwater sampling results indicate elevated detections of COIs in the source and near source area and much lower levels, primarily PCE, are present in the midplume and downgradient plume areas.

A summary table of soil gas results for detected constituents, in units of $\mu g/m^3$, is provided in Table 4-2. The estimated extent of soil vapor exceeding screening levels is shown in Figure 4-2. A Soil Vapor Sampling Risk Evaluation is presented in Appendix R.

UP will prepare a work plan to collect additional groundwater sampling data, especially between Willow Street and Stuhr Road, which can be utilized to quantify the potential for vapor intrusion in this area.

4.2.1 Investigation

On January 27 and 28, 2009, 45 soil gas sampling points were installed across the extent of impacted groundwater associated with the site. This work was conducted in January to assure that a frost cap would exist, which would limit the escape of soil gas to the atmosphere. Fifteen soil gas probes were installed in each area of the site: the near source area; the midplume area; and the downgradient plume area. Soil gas probes were installed to a depth of 3.5 feet due to the shallow water table. On January 29 and 30, soil gas samples were collected in SUMMA canisters using a 30-minute flow controller. Background, duplicate, and field quality assurance samples were also collected. All samples were submitted to TestAmerica in Cedar Falls, Iowa for analysis of chlorinated and aromatic hydrocarbons.

Soil gas sampling procedures are more fully described in Appendix I of this report. Soil gas laboratory reports are provided in Appendix V of this report.

4.2.2 Analysis of Soil Gas Data

Soil gas sampling results were evaluated to develop site-specific soil gas screening levels to evaluate vapor intrusion into: (1) industrial buildings in the source area and near-source area; and (2) off-site residential buildings in the mid-plume and downgradient plume areas. Shallow groundwater impacts identified in the source area include the following chemicals: benzene, cis-1,2-dichloroethylene (cis-1,2-DCE), 1,1-dichloroethane (1,1-DCA), ethylbenzene, tetrachloroethylene (PCE), toluene, trichloroethylene (TCE), and vinyl chloride (VC).

The USEPA advanced version of the Johnson and Ettinger (J&E) vapor intrusion model for soil gas (SG-ADV; Version 3.1; 02/04) was used to calculate screening levels for the Site. The J&E model was adjusted to include site-specific information, scenario type, and current toxicity values (Appendix R).

4.2.2.1 Calculation of Site-Specific Industrial Soil Gas Screening Levels

Site-specific industrial soil gas screening levels were calculated for the source and near-source area based on the industrial land use in this area. Site-specific information included the depth of soil gas sampling points and soil type. The J&E model was adjusted to account for an industrial exposure scenario assuming an industrial exposure of 250 days per year for 8 hours per day over a 25 year period. The air changes per hour parameter was adjusted from 0.25 to 0.83 air changes per hour to represent a commercial building in accordance with American Society for Testing and Materials (ASTM) guidance (2004).

The J&E model was also adjusted to account for updated toxicity information. At the time the J&E model was developed, both 1,1-DCA and ethylbenzene were considered to be noncarcinogens. Since then, USEPA has changed the carcinogenicity status of both chemicals and consider them human carcinogens. While Nebraska Voluntary Cleanup Program Guidance (2008) stills considers 1,1-DCA and ethylbenzene to be noncarcinogens, the Nebraska Department of Environmental Quality (NDEQ) is in the process of updating their existing toxicity values and will follow current recommendations presented in the USEPA Regional Screening Table. Therefore, the J&E model was updated to be consistent with current toxicity values for 1,1-DCA and ethylbenzene.

Industrial soil gas screening levels for potential carcinogens are based on a target excess lifetime cancer risk of 1E-05. Industrial soil gas screening levels for all other chemicals were evaluated based on a hazard quotient of 1 for noncancer effects.

The following results were derived from these calculations.

- Ethylbenzene exceeds the calculated industrial screening level for the vapor intrusion pathway in three out of the 15 soil gas samples collected in the source and near-source area, including locations SG-02, SG-03, and SG-04, on the Nebraska Solvent Company leased property.

- No other sample exceeded the industrial soil gas screening level for any chemical of potential concern analyzed.

4.2.2.2 Calculation of Site-Specific Residential Soil Gas Screening Levels

Site-specific residential soil gas screening levels were calculated for the midplume area and the downgradient plume area. Site-specific information included the depth of soil gas sampling points and soil type.

The air changes per hour parameter was adjusted from 0.25 to 0.5 air changes per hour to represent a residential building in accordance with American Society for Testing and Materials (ASTM) guidance (2004). This exchange rate is consistent with those used by the USEPA and the California Department of Toxic Substances Control.

The J&E model was also adjusted to account for updated toxicity information, as described above.

Target indoor air concentrations for a residential scenario were taken from the most recent USEPA Regional Screening Table (USEPA, 2010) assuming an exposure scenario of 350 days per year for 24 hours per day over a 70 year lifetime. Residential soil gas screening levels for potential carcinogens are based on a target excess lifetime cancer risk of 1E-06. Residential soil gas screening levels for all other chemicals were based on a hazard quotient of 0.25 for noncancer effects.

The following results were derived from these calculations.

- Ethylbenzene exceeds the calculated residential screening level for the vapor intrusion pathway in only one out of the 30 soil gas samples (at location SG-20) collected in the midgradient and downgradient plume areas.

- At location SG-20, toluene was also detected but did not exceed the residential screening level for the vapor intrusion pathway. However, both ethylbenzene and toluene were found to be present at concentrations three to four orders of magnitude above other sample locations in the midgradient plume area. Thus detections at SG-20 appear anomalous and likely are not related to the Nebraska Solvents Company Site.

- The maximum detected concentration of all other chemicals of potential concern are below the calculated residential screening level for the vapor intrusion pathway.

- Soil vapor results for the midplume and downgradient plume areas are consistent with the known extent of groundwater impact which occurs at greater depths below the water table with distance from the source area. Thus shallow groundwater in the midplume and downgradient plume areas is not impacted and therefore does not represent a vapor source.

4.3 Surface Water and Sediments

A storm water retention pond is located north of the fenced portion of the lease property. The southern and eastern boundaries of the pond adjacent to the Site have vegetated berms which prevent surface runoff from the Site from entering the pond. Based on DPT groundwater data, this pond is outside the area of groundwater impact.

4.4 Groundwater

The extent of groundwater impact exceeding MCLs has been defined; however the nature of impact and chemical concentrations varies with geographic area. Summaries of analytical results above the laboratory reporting limits are shown in Tables 4-3 to 4-17. DPT groundwater sampling locations and results are shown in Figure 2-4 and monitoring well locations are shown in Figure 2-5. Cross sections of sample results are depicted in Figures 4-5 to 4-14. Reference lines for these cross sections are provided on Figure 2-4. Chemical concentration maps from the June 2009 groundwater monitoring event are included in Figure 4-15. The extent of groundwater impact is depicted on geological cross-sections in Figures 4-16 through 4-20. Reference lines for these cross-sections are shown on Figure 2-1. Table 2-2 references the Tables and Figures by area of investigation. A network of groundwater monitoring wells was installed in phases as impacted groundwater was defined during the DPT investigations. A summary of detections is provided in Tables 4-20 for Near Source Area wells, 4-21 for Mid-Gradient Area wells and 4-22 for Down-Gradient Area wells.

4.4.1 Source Area Groundwater

Groundwater samples were collected at various locations and depths in the source area (on UP property) to evaluate the vertical extent of VOC impact to groundwater, as summarized below.

- The deepest detection was found to occur at a depth of 30 feet bls in only one location. Deeper samples collected from that location and from nearby locations did not exceed residential VCP RGs. Thus the maximum vertical extent of groundwater impact in the source area is estimated to be 30 feet bls.
- A clean upgradient boundary was also defined at the adjacent UP railyard property.
- The lateral extent of groundwater impact is between Highway 30 and Seedling Mile Road.
- The following compounds in groundwater, representing a mix of aromatic and chlorinated hydrocarbons, exceeded VCP RGs: 1,1-DCE, cis-DCE, VC, dichloroethane, chloroethane, benzene, ethylbenzene, toluene, xylenes, and both 1,2,4- and 1,3,5-trimethylbenzene.

4.4.2 Near-Source Groundwater

- This area, generally from Willow Street to Stuhr Road, exhibits shallow groundwater impacts ranging from approximately 10 to 30 feet bls, some of which exceed the MCL.
- Significant detections of aromatic hydrocarbons were not observed beyond Willow Street.

- Along Stuhr Road only cis-DCE and VC are detected at concentrations exceeding MCLs.

- The lateral extent of groundwater impact is approximately 500 feet wide extending south from Seedling Mile Road.

4.4.3 Mid-Plume Groundwater

- This area generally from Stuhr Road to Shady Bend Road indicates that the area of impacted groundwater is moving deeper. At Shady Bend Road, detections above the MCL range in depth from approximately 20 feet bls to 80 feet bls.

- At Shady Bend Road , the lateral extent of groundwater impact is approximately 900 feet wide extending north from Seedling Mile Road.

- At Shady Bend Road only PCE and cis-DCE are present at concentrations above the MCLs. Other chlorinated hydrocarbons found at Shady Bend Road at levels not exceeding the MCLs included 1,1-DCE, 1,1,1-TCA and 1,1-DCA.

4.4.4 Downgradient Groundwater

- This area from Shady Bend Road to Beck Road indicates a progressive deepening of the groundwater plume. For example at Gunbarrel Road, the plume extends from approximately 40 feet bls to 80 feet bls and at the terminus of the plume from approximately 60 feet bls to 80 feet bls.

- The direction of the groundwater plume turns from an easterly direction to a northeasterly direction around Shady Bend Road and the lateral extent of groundwater impact is generally bounded by Seedling Mile Road / Fort Kearney Road on the south.

- PCE is the only COI present above the MCL at concentrations ranging up to 19.3 ug/L. PCE daughter products, including cis-DCE and 1,1-DCA are present at levels not exceeding the MCLs.

- Current data indicate that the groundwater PCE plume terminates near Beck Road, north of East Capital Avenue. The maximum concentration of PCE detected in samples along the western side of Beck Road was 1.4 ug/L at 60 feet bls.

4.4.5 Preliminary Groundwater MNA Characterization

Between November 10 and 12, 2008, 15 wells were sampled for select parameters to assess the potential for natural attenuation to occur in the aquifer. The wells sampled were selected to provide a preliminary understanding of the aquifer throughout the entire study area and were: MW-NSC-02A, -06A, -07A, -08A, -20B, -21A, -21C, -21E, -22B, -27A, -27C, -27D, -32C, -32E, and -36B. Samples were analyzed for: Total Alkalinity as $CaCO_3$; Bromide; Chloride; Hardness; Nitrite as N; Nitrate as N; Iron and Manganese; Methane; Ethane; Ethene; Sulfate; Sulfide; and Total Organic Carbon. Samples were also field analyzed for temperature, conductivity, dissolved oxygen, pH, and iron. Field parameters collected during the event are summarized in Table 4-18. Analytical data results from the preliminary monitored natural attenuation sampling are presented in Table 4-19.

The following points summarize the key findings for the November 2008 sampling event:

- Water temperature exhibited limited stratification with warmer temperatures present in the upper 25 feet (13.09 to 14.73 degrees C and averaging 13.89 degrees C). Below that depth, temperatures are variable but slightly cooler (11.82 to 13.7 degrees C and averaging 12.53 degrees C).

- Conductivity ranged from 0.389 to 1.037 mS/cm with an average of 0.713 mS/cm. Overall conductivity appears to decrease with depth.

- Dissolved oxygen was present above a concentration of 1 ppm in shallow wells, generally less than 25 feet deep and deeper wells generally exhibit lower dissolved oxygen. Several shallow wells exhibited low DO that would not be expected including MW-07A and MW-08A which at a depth of 14.75 feet had dissolved oxygen of 0.39 and 0.83 ppm, respectively. These results indicate that the shallow part of the aquifer is naturally aerobic except where it may be impacted by COIs. In general, oxygen appears to be consumed as water moves to greater depths within the aquifer.

- Values of pH range from 6.42 to 7.26 and average 6.81 indicating overall neutral groundwater conditions. In general there is a slight rise in pH with increasing depth possibly indicating the buffering of more acidic rainwater and soil acids.

- Alkalinity ranged in concentration from 186 to 413 mg/L and averaged 262 mg/L. The range of alkalinity values appear to be wider for samples within the upper 25 feet of the aquifer than below that depth.

- Hardness ranged from 235 to 629 mg/L and averaged 478 mg/L and, except for one sample (MW-21E with 235 mg/L at a depth of 94.25 feet), showed little variation.

- Manganese and iron were each detected in 14 of the 15 wells sampled. Manganese ranged in concentration from 0.0158 to 0.807 mg/L and averaged 0.235 mg/L. Iron ranged in concentration from 0.411 to 54.9 mg/L and averaged 10.28 mg/L.

- Chloride ranged from 10.3 to 95.0 mg/L and averaged 51.8 mg/L. The range of chloride values appear to be wider for samples within the upper 25 feet of the aquifer than below that depth.

- Sulfate ranged from 39.6 to 221 mg/L and averaged 140 mg/L. The range of sulfate values appear to be wider for samples within the upper 25 feet of the aquifer than below that depth.

- Sulfide was detected in 3 of the 15 wells (MW-NSC-20B, -21C, and -22B) and ranged from 0.16 to 0.40 mg/L. It was not detected at a detection limit of 1.0 mg/L in the other 12 wells.

- Methane was detected in 5 of the 15 wells sampled above the detection limit of 26.0 µg/L and ranged from 63 to 3,930 ug/L. The highest detection of methane of 3,930 µg/L was exhibited in MW-NSC-02A, a source area well.

- Ethane and ethene were not detected in any of the 15 samples above a detection limit of 26.0 µg/L.

- Bromide was not detected in any of the 15 samples above a detection limit of 1.0 mg/L.

- Nitrite was detected in two wells (MW-NSC-02A and -32E) above the detection limit of 0.100 mg/L. The highest concentration was 0.635 mg/L exhibited in MW-NSC-02A, a source area well.

- Nitrate was detected in 14 of 15 wells above a detection limit of 0.10 mg/L. Nitrate ranged from 2.03 to 13.0 mg/L and averaged 7.97 mg/L.

- TOC was detected in 14 of 15 wells above a detection limit of 1.00 mg/L. TOC ranged from 1.29 to 5.88 mg/L and averaged 2.59 mg/L. The highest TOC detection was in well MW-NSC-02A, a source area well.

- Ferrous iron from field screening was detected in all 15 groundwater samples analyzed; however two samples exceeded the maximum detection limit for the Lamotte Colorimeter of 5.00 mg/L. Ferrous iron ranged from 0.01 to >5 mg/L and averaged approximately 1.71 mg/L. The field screening peaks for ferrous iron correspond with the elevated concentrations for iron found in the laboratory samples for MW-NSC-22B (39.3 mg/L) and MW-NSC-27C (54.9 mg/L).

The laboratory analytical data reports and the verification reports are provided in Appendix V.

4.4.6 Source Area Chemical Demand

Chemical analyses were performed in the source area to evaluate the natural and site-related chemical demand of source area soil to assist in the design of the chemical oxidation remedy.

The highest concentrations of the detected analytes in soil and respective borings are as follows:

- PCE: 2.31 mg/kg (SB-29);
- TCE: 0.0374 mg/kg (SB-29); and
- Benzene: 0.0188 mg/kg (SB-31).

The composite soil sample exhibited a COD concentration of 732 mg/kg and a total iron concentration of 2,530 mg/kg.

The groundwater sample that was not field-filtered exhibited a COD concentration of 102 mg/L and a total iron concentration of 2.41 mg/L. The field-filtered sample exhibited a total iron concentration of 2.28 mg/L.

Total organic carbon (TOC) was detected and measured in groundwater samples SB-13 through SB-23 and SB-26 ranging from 4.73 to 516 mg/L. TOC was detected in SB-24 at a depth of 8 feet bls, but not at a depth of 15 feet bls. SB-28 also had a detection of TOC at a depth of 8 feet bls, but not at a depth of 12 feet bls. These results indicate that there is a high amount of variability in TOC at the Site.

5 Contaminant Fate and Transport

This report section presents information regarding COI characteristics especially with regard to their transport and fate, including transformation and degradation. Site specific chemical characteristics will be further described after the proposed MNA Study has been completed. The MNA Study will provide site-specific discussion regarding the context of the chemicals of concern detected at the site and the site-specific characteristics that would influence contaminant fate and transport. Site specific characteristics that affect chemical attenuation are particularly significant to the mid and downgradient portions of the plume where COIs in groundwater exceed VCP RGs by only a limited amount.

5.1 Contaminant Characteristics

The physical and chemical properties of the primary COIs are summarized in Table 5-1.

5.2 Transformation and Degradation

Over the past two decades, numerous laboratory and field studies have demonstrated that subsurface microorganisms can degrade a variety of chlorinated solvents (U.S. EPA, 1998). Whereas fuel hydrocarbons are biodegraded through use as a primary substrate (electron donor), chlorinated aliphatic hydrocarbons may undergo biodegradation under three different circumstances, including:

1. intentional use as an electron acceptor;
2. intentional use as an electron donor; or
3. cometabolism where degradation of the chlorinated organic is fortuitous and there is no benefit to the microorganism.

At a given site, one or all of these circumstances may pertain, although at many sites the use of chlorinated aliphatic hydrocarbons as electron acceptors appears to be most important under natural conditions. In this case, biodegradation of chlorinated aliphatic hydrocarbons will be an electron-donor-limited process. Conversely, biodegradation of fuel hydrocarbons is an electron-acceptor-limited process.

In an uncontaminated aquifer, native organic carbon is used as an electron donor, and DO is used first as the prime electron acceptor. Where BTEX is present, these compounds will also be used as an electron donor. After the DO is consumed, anaerobic microorganisms typically use additional electron acceptors (as available) in the following order of preference (Figure 5-1):

Most readily consumed:	nitrate
	ferric iron oxyhydroxide
	sulfate
Least readily consumed:	carbon dioxide

Evaluation of the distribution of these electron acceptors can provide evidence of where and how chlorinated aliphatic hydrocarbon biodegradation is occurring. In addition, because chlorinated aliphatic hydrocarbons may be used as electron acceptors or electron donors (in competition with other acceptors or donors), data showing the distribution of these compounds and their daughter products can provide evidence of the mechanisms of biodegradation working at a site. As with BTEX, the driving force behind oxidation-reduction reactions resulting in chlorinated aliphatic hydrocarbon degradation is electron transfer. Although thermodynamically favorable, most of the reactions involved in chlorinated aliphatic hydrocarbon reduction and oxidation do not proceed abiotically.

Microorganisms are capable of carrying out the reactions, but they will facilitate only those oxidation-reduction reactions that have a net energy yield.

5.2.1 Mechanisms of Chlorinated Aliphatic Hydrocarbon Biodegradation

The following sections describe the biodegradation mechanisms of those compounds that are most prevalent and whose behavior is best understood. These include the PCE, TCE, DCE, and VC detected at the site.

5.2.1.1 Electron Acceptor Reactions (Reductive Dehalogenation)

The most important process for the natural biodegradation of the more highly chlorinated solvents is reductive dechlorination. During this process, the chlorinated hydrocarbon is used as an electron acceptor, not as source of carbon, and a chlorine atom is removed and replaced with a hydrogen atom. Figure 5-2 illustrates the transformation of chlorinated ethenes via reductive dechlorination. In general, reductive dechlorination occurs by sequential dechlorination from PCE to TCE to DCE to VC to ethene. Depending upon environmental conditions, this sequence may be interrupted, with other processes then acting upon the products. During reductive dechlorination, all three isomers of DCE can theoretically be produced. Under the influence of biodegradation, cis-1,2-DCE is a more common intermediate than trans-1,2- DCE, and that 1,1-DCE is the least prevalent of the three DCE isomers when they are present as daughter products. Reductive dechlorination of chlorinated solvent compounds is associated with the accumulation of daughter products and an increase in the concentration of chloride ions. Reductive dechlorination affects each of the chlorinated ethenes differently.

Of these compounds, PCE is the most susceptible to reductive dechlorination because it is the most oxidized. Conversely, VC is the least susceptible to reductive dechlorination because it is the least oxidized of these compounds. As a result, the rate of reductive dechlorination decreases as the degree of chlorination decreases. Because chlorinated aliphatic hydrocarbon compounds are used as electron acceptors during reductive dechlorination, there must be an appropriate source of carbon for microbial growth in order for this process to occur. Potential carbon sources include natural organic matter, fuel hydrocarbons (BTEX), or other anthropogenic organic compounds.

5.2.1.2 Electron Donor Reactions

Microorganisms are generally believed to be incapable of growth using PCE and TCE as a primary substrate (i.e., electron donor). However, under aerobic and some anaerobic conditions, the less oxidized chlorinated aliphatic hydrocarbons (e.g., DCE and VC) can be used as the primary substrate in biologically mediated oxidation-reduction reactions. In this type of reaction, the facilitating microorganism obtains energy and organic carbon from the degraded chlorinated aliphatic hydrocarbon.

5.2.1.3 Cometabolism

When a chlorinated aliphatic hydrocarbon is biodegraded via cometabolism, the degradation is catalyzed by an enzyme or cofactor that is fortuitously produced by the organism for other purposes. The organism receives no known benefit from the degradation of the chlorinated aliphatic hydrocarbon. Rather, the cometabolic degradation of the chlorinated aliphatic hydrocarbon may in fact be harmful to the microorganism responsible for the production of the enzyme or cofactor. Cometabolism is best documented in aerobic environments, although it potentially could occur under anaerobic conditions. It has been reported that under aerobic conditions chlorinated ethenes, with the exception of PCE, are susceptible to cometabolic degradation. During cometabolism, the chlorinated alkene is indirectly transformed by bacteria as they use BTEX or another substrate to meet their energy requirements. Therefore, the chlorinated alkene does not enhance the degradation of BTEX or other carbon sources, nor will its cometabolism interfere with the use of electron acceptors involved in the oxidation of those carbon sources.

5.2.2 Behavior of Chlorinated Solvent Plumes

Chlorinated solvent plumes can exhibit three types of behavior depending on the amount of solvent, the amount of biologically available organic carbon in the aquifer, the distribution and concentration of natural electron acceptors, and the types of electron acceptors being used. Individual plumes may exhibit all three types of behavior in different portions of the plume. The different types of plume behavior are summarized below.

5.2.2.1 Type 1 Behavior

Type 1 behavior occurs where the primary substrate is anthropogenic carbon (e.g., BTEX), and microbial degradation of this anthropogenic carbon drives reductive dechlorination. Type 1 behavior results in the rapid and extensive degradation of the more highly-chlorinated solvents such as PCE, TCE, and DCE.

5.2.2.2 Type 2 Behavior

Type 2 behavior dominates in areas that are characterized by relatively high concentrations of biologically available native organic carbon. Microbial utilization of this natural carbon source drives reductive dechlorination (i.e., it is the primary substrate for microorganism growth). Type 2 behavior generally results in slower biodegradation of the highly chlorinated solvents than Type 1 behavior, but under the right conditions (e.g., areas with high natural organic carbon contents); this type of behavior also can result in rapid degradation of these compounds.

5.2.2.3 Type 3 Behavior

Type 3 behavior dominates in areas that are characterized by inadequate concentrations of native and/or anthropogenic carbon, and concentrations of dissolved oxygen that are greater than 1.0 mg/L. Under these aerobic conditions, reductive dechlorination will not occur. The most significant natural attenuation mechanisms for PCE, TCE, and DCE will be advection, dispersion, and sorption. However, VC can be rapidly oxidized under these conditions. Type 3 behavior also occurs in groundwater that does not contain microbes capable of biodegradation of chlorinated solvents.

5.2.2.4 Mixed Behavior

As mentioned above, a single chlorinated solvent plume can exhibit all three types of behavior in different portions of the plume. The most fortuitous scenario involves a plume in which PCE, TCE, and DCE are reductively dechlorinated with accumulation of VC near the source area (Type 1 or Type 2 behavior), then VC is oxidized (Type 3 behavior), either aerobically or via iron reduction further downgradient. Vinyl chloride is oxidized to carbon dioxide in this type of plume and does not accumulate. The following sequence of reactions occurs in a plume that exhibits this type of mixed behavior.

$$\text{PCE} \rightarrow \text{TCE} \rightarrow \text{DCE} \rightarrow \text{VC} \rightarrow \text{Carbon Dioxide} + \text{Water} + \text{Chloride}$$

In general, TCE, DCE, and VC may attenuate at approximately the same rate, and thus these reactions may be confused with simple dilution. Note that no ethene is produced during this reaction. Vinyl chloride is removed from the system much faster under these conditions than it is under reducing conditions.

6 Potential Receptors

This report section presents a human and ecological exposure model to evaluate potential human and ecological exposure pathways associated with the Site COIs. Information used to evaluate potential human and ecological exposure pathways included DPT soil and groundwater data collected during six sampling events, groundwater samples collected from a partial monitoring well network over the initial 12 quarterly monitoring events, and IDW soil samples collected during the monitoring well installation in March 2008. The human and ecological exposure model is discussed and evaluated in the following sections.

6.1 Potential Human Receptors

The Site is located within a commercial / industrial area of Grand Island. Mixed residential and agricultural areas are present approximately one-quarter of a mile downgradient of the Site and extend throughout the study area. Figure 6-1 shows the current land use and zoning in the investigation areas. City water mains service residences and businesses east of the former Nebraska Solvents property to approximately ¼ mile east of Shady Bend Road.

<u>Municipal Wells</u> Municipal water is supplied to businesses and residences within a portion of the area of groundwater impact. Municipal water wells are located over four miles to the south in the City Well Field along the Platte River. No public water wells are located within the area of groundwater impact.

<u>Commercial Wells</u> Commercial wells near to and within the study are relatively few. Municipal water is available to and provided for most businesses along Highway 30 East and so commercial wells are not necessary. The closest commercial well to the Leased Property is at the Kensington Station. This well also services three mobile homes adjacent to Kensington Station. Irrigation wells are also present in agricultural areas east of the Site, some of which likely draw impacted water from the plume.

<u>Private Wells</u> Private residential wells used for irrigation are present generally north and south of Seedling Mile Road between Museum Drive and Shady Bend Road. Some of these wells show VOC impact, however this water is not used for domestic purposes. Private residential wells used both for domestic purposes and for irrigation are present further east between Gunbarrel Road and Beck Road and north of Fort Kearney Road and south of Capital Drive. Some of these wells are known to be impacted by PCE at levels above the RG.

Based on current conditions, the following exposure pathways are considered to be potentially complete:

- On-Site Construction Worker:
    - Inhalation of COIs from groundwater and soil to outdoor air.
    - Dermal contact with COIs in groundwater and soil.
    - Ingestion of COIs in groundwater and soil.
- Off-Site Construction Worker:

    - Inhalation of COIs from groundwater to outdoor air.
    - Dermal contact with COIs in groundwater.
    - Ingestion of COIs in groundwater.

- Off-Site Residents and Non-residents:

    - Ingestion of COIs in groundwater. This route of exposure as been mitigated through provision of an alternative water supply (bottled water or carbon filtration systems), where accepted by property owners, at residences where VOCs in well water have been detected.
    - Inhalation and dermal contact with COIs in groundwater. This route of exposure has been mitigated through provision of carbon filtration systems, where accepted by property owners. In addition, the NDEQ Department of Health and Human Services currently recommends that treated water be used for residential purposes, other than ingestion, if the PCE concentration exceeds 21 ug/l based on inhalation and dermal contact routes of exposure. PCE in residential groundwater wells has not exceeded this concentration, based on current testing results.
    - Vapor intrusion of COIs from groundwater to indoor air of commercial buildings. This potential route of exposure is considered relevant to areas west of Stuhr Road where shallow groundwater is impacted. The vapor intrusion pathway is considered to be less of a concern east of Stuhr Road as impacted groundwater occurs at progressively deeper depths with distance from the Site.

Since groundwater from this stratigraphic interval is used as a regional potable water source, the following future hypothetical exposure pathway is considered to be complete, in addition to those previously identified.

- Off-Site Residents and Non-residents (Future):

    - Ingestion of COIs in groundwater.
    - Inhalation and dermal contact with COIs in groundwater.
    - Vapor intrusion of COIs from groundwater to indoor air of commercial buildings. This potential route of exposure is considered relevant to areas west of Stuhr Road where shallow groundwater is impacted. The vapor intrusion pathway is considered to be less of a concern east of Stuhr Road as impacted groundwater occurs at progressively deeper depths with distance from the Site.

6.2 Potential Ecological Receptors

Land use at and near the Site is limited to commercial and industrial use properties. There are no signs of stressed vegetation on or near the Site. Aquatic and/or terrestrial receptors on and off-site were not identified.

A surface water pond is present north of the former tank yard, half of which is on the former lease property and half of which extends onto other UP property to the north. The pond, constructed by UP, was first observed in the 1993 aerial photograph, which is after the time when Nebraska Solvents Company was in operation. The pond collects stormwater runoff primarily from the UP railyard and from Lannco (308 Willow Street) located west and north of the pond. The discharge point for the pond is at its northern edge.

A surface water berm is present between the area impacted by Nebraska Solvents Company and the pond so it does not receive stormwater runoff from the impacted area. Soil and groundwater samples from the area between the Site and the pond indicate decreasing impact toward the pond, and so there is no route of exposure for impacted media to reach the pond. Review of the ECOS map shows no significant ecological receptors are present at the pond.

6.3 Potential Exposure Summary

The following comments summarize potential exposures at the Site and in downgradient affected areas:

- During investigation activities, the use of groundwater as a domestic source of drinking water was identified as a completed exposure pathway with regard to ingestion, dermal, and inhalation routes of exposure. In areas where impacted domestic water wells were identified (even if those detections were below VCP RGs), bottled water was supplied to affected residents thereby eliminating the ingestion route of exposure. In-home carbon filtration systems were subsequently installed in forty-nine homes to eliminate potential ingestion, dermal, and inhalation exposure pathways. An extension of the City water supply will represent a permanent alternative water supply to mitigate all potential exposures from the domestic use of groundwater.

- Vapor intrusion of COIs from the groundwater table to indoor air is a potential route of exposure; however is considered to be limited to current and/or future hypothetical commercial buildings at or near the Site. As the groundwater plume moves to greater depths with distance from the source area, this route of exposure is incomplete. Further investigations are planned to document the significance, if any, of this potential exposure route in the near-source area.

- Construction worker exposure to impacted on-site soil and on-site and off-site groundwater is potentially complete. Potential exposures to impacted groundwater are limited to source and near-source areas where impacted groundwater occurs at shallow depths. As the groundwater plume moves to greater depths with distance from the source area, this route of exposure is incomplete.

- The future hypothetical use of groundwater as a municipal water source represents a potential exposure route; however such use is not contemplated at this time. COIs in groundwater do not appear to be of concern to any existing municipal well field.

7 Conceptual Site Model

A hydrogeologic conceptual site model has been developed to integrate investigation results into a framework useful for understanding the principal controls on the distribution, transport, and fate of chemicals of concern in geologic media. This understanding will be used in conjunction with the human and ecological exposure model developed in Section 6 to develop remedial alternatives.

7.1 Geology

Bedrock, consisting of Cretaceous-age Niobrara Formation or Pierre Shale, underlays all of the study area. These bedrock formations consist of low permeability, shale-rich rock. Above bedrock, unconsolidated sediments consist of a lower silt layer and an upper sand layer. Water resources are developed in the upper sand layer.

On a regional basis, the top of the silt layer dips gently to the east. The depth to the top of silt in the source area is approximately 90 ft bls and increases in an easterly direction to about 103 ft bls in the field east of Shady Bend Road at location SBD-08EC. Within the study area, this surface is undulating and channelized, and exhibits a broad rise in the center of the study area where depths decrease to 75 to 85 ft bls.

The upper sand layer exhibits a heterogeneous distribution of sediments characterized by an upward fining sequence of sand with discontinuous silt interbeds. Surficial soils are loamy. Graphical representations of the EC logs are provided in Appendix K.

The type and distribution of sediments in the study area are typical of braided river sedimentary systems. Portions of the study area containing coarser and thicker sands are interpreted to represent channel deposits of the ancestral Platte River. While time-correlative sand, silt and clay were deposited across river system in response to sediment supply and water energy, sediments in the main channel were more frequently reworked and finer sediments were winnowed leaving a relatively thick accumulation of sand. Finer grained deposits consisting of fine sand, silt and locally clay represent point bar and overbank deposits were finer grained sediments were deposited from flood waters. These fine grained deposits appear as clay and silt lenses.

7.2 Hydrogeology

This subsection describes the conceptual site model hydrogeology, including a discussion of aquifer materials, and the rate and direction of groundwater flow.

7.2.1 Aquifer Materials

An unconfined aquifer is developed in sand-rich alluvial sediments present in the upper sand layer, as described above. The underlying lower silt layer acts as an aquitard. The fine grained nature of the silt is insufficient to produce economic quantities of groundwater. Underlying shale-rich bedrock is the lower bounding unit of the unconsolidated sediment system.

7.2.2 Groundwater Flow Direction and Rate

Groundwater levels generally range from about 2 to 10 feet bls. Groundwater levels are highest in the spring due to snowmelt and precipitation recharge and lowest in the fall to winter due to frozen conditions. Seasonal groundwater fluctuations range from approximately 2 to 3.5 feet. The groundwater flow direction in the vicinity of the Site is to the east with a general east-northeasterly direction east of Shady Bend Road.

Groundwater recharge is considered to originate from regional and local sources. Regionally, the study area is located near and within large agricultural areas. Precipitation infiltration from the land surface to the water table within the study area is considered to be the major source of recharge to the regional aquifer. The recharge of fresh water at the land surface over time has pushed the groundwater plume downward with distance from the source area.

The hydraulic gradient is approximately 0.001 ft/ft, however it is slightly steeper in the source and near source area (0.0016) than further down gradient (0.0011). The highest hydraulic conductivities appear to occur in the upper part of the aquifer and hydraulic conductivity decreases with depth. Since the COI plume occurs at greater depth with distance from the source area, the rate of groundwater flow varies with the hydraulic conductivity of the aquifer through which it is flowing. Thus in the upgradient area the flow rate is approximately 300 ft/yr through the upper part of the aquifer. However, in the mid to downgradient areas the flow rate is slower, about 100 ft/year, due to lower hydraulic conductivities in the mid to lower part of the aquifer. The COI flow rates are expected to be slower due to adsorption onto aquifer materials.

Water levels between co-located wells completed in different depth intervals are similar indicating that strong vertical hydraulic gradients are not present This also supports the conclusion that the aquifer is unconfined.

7.3 Contaminant Occurrence and Migration

This subsection summarizes contaminant occurrence in soil and groundwater and how and where the contaminants are expected to migrate.

7.3.1 Soil

Evidence exists that a release of chlorinated solvents and aromatic hydrocarbons occurred at the Nebraska Solvents Company lease property; however the timing and nature of the release(s) is unknown. The extent of soil impacts has been determined by on-Site investigation. Shallow soil impacts range from approximately 3 to 7 feet bls, in a silty clay horizon within the former AST area. Non-aqueous phase liquid (NAPL) has not been observed in soil.

Shallow soil from 0 to approximately 3 feet bls (and deeper in many locations) is not impacted. Though impacted soil exceeds industrial RGs, impacted soil is not exposed at the land surface and so does not represent a current route of exposure. On-Site soil vapor levels could be of concern at the Leased Property; however Site buildings are not located over impacted soil and are not occupied. Some soil sampling results exceed VCP RGs for the Migration to Groundwater pathway. These soil impacts likely represent an ongoing source for COIs to groundwater. Thus, remedial actions are planned to address impacts that exceed RGs to mitigate current and future potential exposures.

7.3.2 Groundwater

The extent of groundwater impact in the Study Area has been identified. Though COI solubilities are low, chemicals dissolved in groundwater extend from the source area in an easterly and northeasterly direction for approximately 3.5 miles. The leading edge of the plume is bounded by Beck Road to the east and generally by Seedling Mile Road and Fort Kearney Road to the south and Highway 30 to the north. The maximum width of the plume is generally less than 1,200 feet. The VOC plume extends to greater depths with distance from the source area. At the source area the plume extends from the top of the water table to approximately 20 feet bls. At the leading edge of the plume the vertical extent is approximately 40 to 80 ft bls. NAPL has not been identified in groundwater wells.

Certain areas of groundwater impacts exceed groundwater RGs for RAC-1 groundwater resources, equivalent to drinking water standards. Potential current and future exposure scenarios exist for ingestion, dermal contact, and inhalation of COIs from groundwater, with the primary exposure pathway associated with ingestion from existing or future residential or commercial water wells. Thus remedial actions are planned to address groundwater impacts that exceed potable water RGs to mitigate current and future potential exposures.

7.4 Conceptual Model Summary

The following points summarize the hydrogeologic conceptual model for the study area, as presented in Figure 7-1:

- One or more historical surface release(s) of chlorinated and aromatic hydrocarbon impacted soil and groundwater at the Site source area.
- Shallow groundwater allowed COIs from the release(s) to readily impact groundwater. NAPL has not been evident at the source area.
- Over time dissolved COIs in groundwater have been transported east and then east-northeast from the Site by groundwater.
- Near the source area, aromatic hydrocarbons and some chlorinated hydrocarbons have degraded through natural processes. This is evident from the changing relative concentrations of the parent and daughter COIs and their decreasing concentration as the groundwater moves eastward from the source area.
- Advective chemical transport has occurred through porous sand overlying low permeability silts and shale bedrock. As the plume moves eastward away from the Site, it also migrates to greater depth due to precipitation recharge.
- The extent of impacted groundwater is bounded vertically by the extent of sand. The narrow lateral extent of the plume may be related to the presence of historical river sands which channel groundwater flow.
- Agricultural irrigation wells and private domestic wells exist along the groundwater plume. These wells serve as potential external forces to influence the flow of impacted groundwater and exposure pathways.

- Current and future potential routes of exposure exist with regard to impacted soil, soil vapor, and groundwater which require remedial actions.

8 Summary and Conclusions

This section summarizes findings that support the specific objectives of the VCP investigation, including the following:

- Determination of the lateral and vertical extent of groundwater impacted by chlorinated VOCs.
- Characterization of potential additional sources of VOC loading to the groundwater plume.
- Evaluation of baseline routes of exposure and receptors.
- Collection of data to support the evaluation and design of potential response actions.
- Ongoing activities to mitigate exposures and remediate environmental impacts.

8.1 Summary

The nature and extent of VOC impact to soil and water has been defined and information has been used to develop a conceptual site model for VOC fate and transport. Potential routes of exposure have also been identified and a basis to conduct remedial actions has been established. This section summarizes key findings of the VCI Investigation.

8.1.1 Nature and Extent of Impact

Undocumented, historical releases of chemical solvents occurred in the northern area of the Site where multiple ASTs and 55-gallon drums, and two USTs were located. These releases impacted soil and groundwater. NAPL was not evident at the source area during VCP Investigation activities.

The extent of soil impact has been defined to be essentially within the area of the lease property and north of the Site building. The vast majority of impacted soil is present from 3 to 7 feet. LNAPL has not been identified.

Over time, COIs have dissolved into groundwater and have been transported eastward and northeastward from the Site. The VOC plume has migrated to greater depths with distance from the source area. Groundwater impacts are limited to sand-rich sediments overlying a layer of silt and shale bedrock. In general, groundwater impacts are defined by the areas based on distance from the source area:

- **Source Area (Lease Property):** VOC impacts are shallow and extend in soil and/or groundwater to approximately 20 ft bls. The width of the groundwater plume (north to south) in the source area is approximately 100 feet.
- **Near-Source Area (Lease Property to Stuhr Road):** VOC impacts are shallow and extend in groundwater from appproximately 10 to 30 ft bls. The plume width ranges from approximately 100 feet at the source to approximately 200 feet wide. The groundwater

plume extends eastward from the Lease Property generally parallel to and south of Seedling Mile Road.

- **Mid-Plume Area (Stuhr Road to Shadey Bend Road):** VOC impacts to groundwater range in depth from approximately 20 to 80 ft bls. The plume width ranges from approximately 200 feet at Stuhr road to approximately 500 feet at Shadey Bend Road. The plume extends eastward from about Stuhr Road to Wainwright Road and then turns to the northeast from Wainwright Road to Shadey Bend Road.

- **Down-gradient Plume Area (Shadey Bend Road to Beck Road):** VOC impacts to groundwater range in depth from about 40 to 80 ft bls. The plume width ranges from approximately 500 feet at Shadey Bend Road to about 900 feet on East Capital Drive. The plume extends northeasterly parallel to and between Seedling Mile/Fort Kearney Road and Highway 30.

Potentially completed exposure pathways exist for:

- On-Site Construction Worker with regard to impacted soil and groundwater;

- Off-Site Construction Worker with regard to impacted groundwater;

- Off-Site Residents and Non-residents with regard to impacted soil vapor and/or groundwater; and

- Off-Site Residents and Non-residents (Future) with regard to impacted soil vapor and/or groundwater.

COIs have impacted residential drinking water wells in an area generally between Gunbarrel Road and Beck Road, and Fort Kearney Road and East Capital Drive. Bottled water and in some cases water treatment systems using carbon have been supplied to residents to eliminate the use of impacted groundwater for drinking and cooking and to provide an alternate source of potable water.

Based on soil vapor sampling results, soil vapor impacts to indoor air do not appear to be a completed route of exposure; however additional work will be proposed to further evaluate potential vapor intrusion between Willow Street and Stuhr Road. East of Stuhr Road, the vapor intrusion pathway is considered to not be of concern because the groundwater plume moves deeper with distance from the source area due to the recharge of clean water from snowmelt and precipitation.

8.2 Proposed Work

Based on the VCP Investigation results, the following work is proposed to complete site characterization activities and to initiate remedial actions.

- Though the extent of groundwater impact has been defined using DPT groundwater sampling and the current monitoring well network, ongoing sampling of monitoring wells will be necessary to document plume extent and stability, especially at the leading edge.

- Periodic water samples will continue to be collected from water treatment systems that were installed in private residences to evaluate treatment performance.

- Though the extent of soil impact is defined at the leased parcel, limited off-site soil sampling will be conducted to confirm the full lateral extent of off-site soil impacts, if any. This work will be conducted as a pre-design step during remedial planning.

- Further work will be conducted to evaluate the vapor intrusion pathway between Willow Street and Stuhr Road.

- Remedial Actions are proposed to address impacted soil at the source area, impacted groundwater in the source and near source areas, and to provide a permanent alternative water supply for impacted residential land owners.

- A study to more fully evaluate the natural attenuation of COIs in groundwater will be conducted to determine if monitored natural attenuation can achieve RGs within the time limits set by Nebraska Title 118.

9 Remedial Action Work Plan

This section describes current interim remedial actions and future planned remedial actions to address soil, soil vapor, and groundwater impacts above RGs.

9.1 Interim Remedial Actions

Interim remedial actions were performed to mitigate VOC impacts to private water wells. Bottled water was offered to any resident whose water supply showed a detection of PCE (and also trichloroethene or TCE in one case) above the method detection limit which was a fraction of microgram per liter (ug/L) or part per billion. The maximum contaminant level for both PCE and TCE is 5 ug/L.

In addition, in-home water treatment systems using activated carbon were offered to all residents on bottled water. Figure 9-1 shows the distribution of impacted and periodically monitored residences as of December 31, 2009. A cross reference of the assigned well identification number and property information are included in Appendix P.

The detection limits used by UP are below the VCP RGs. However, if VOC compounds other than PCE or TCE, which are reasonably attributable to the Nebraska Solvents Company, are detected by UP in water from a residential well, then UP will offer and provide bottled water to be replaced with an in-home water treatment systems using activated carbon.

The in-home water treatment systems, designed and installed by EcoWater®, utilize a canister of activated carbon to adsorb VOCs from water. Each treatment system was plumbed to treat all water used throughout the house. Each treatment system was tested after installation and has been periodically retested. Testing results are evaluated to determine the continued effectiveness of the systems and the schedule of activated carbon replacement. Testing results are provided to residents in an explanatory letter. Telephone numbers are also provided for Foth Infrastructure and Environment, Union Pacific Railroad, The Center for Toxicology and Environmental Health, the Central District Health Department, and the NDEQ so residents may contact qualified individuals who can answer specific technology and health related questions.

Quarterly monitoring of impacted private wells and wells on properties adjacent to impacted private wells is conducted to identify any plume migration and provide interim remedies should any new impacts be identified. Private well laboratory analytical data reports and verification reports are included in Appendix V.

As described in more detail below, UP considers in-home water treatment systems using activated carbon to be a possible, but not preferred, long-term remedial alternative. This is because groundwater restoration to MCLs likely cannot be completed in a timeframe acceptable to impacted residential land owners.

9.2 Remedial Action Objectives

Both short term and long term remedial action objectives (RAOs) have been established for the site. Short term objectives are to remove a large percentage of mass in a short amount of time. The long term objectives are to meet the VCP remedial goals (RGs) for soil and groundwater.

RGs were developed by Nebraska Department of Environmental Quality for both direct contact exposure pathways (residential and industrial land use) and the migration to groundwater pathway. Soil and groundwater VCP RGs for the respective COIs are listed in Table 9-1.

The following remedial action objectives (RAOs) have been developed for the Site consistent with Remedial Action Class 1 (RAC-1) protocols for groundwater resources that currently or may potentially be used as drinking water. These RAOs address the chemicals of concern, exposure pathways, potential receptors, cleanup levels as determined by the lookup tables, locations for points of compliance, and timeframe for which the remedial actions will be completed.

9.2.1 Source Control to Minimize Further Degradation of the Groundwater

This RAO is designed to eliminate sources of contamination that may further degrade groundwater which may potentially be used as drinking water. There are no ongoing releases from former site operations and no current site operations; however, impacted soil exists on the former lease property which may represent an ongoing source of groundwater impact.

Therefore UP proposes to excavate and remove impacted soil up to a maximum depth of approximately 7 feet. In particular low permeability clay generally ranging from 3 to 7 feet below land surface and containing significant VOC mass will be excavated. Though this soil is below the water table, this excavation is believed to be feasible due to the low permeability of the clay, which for the duration of the excavation event, is unlikely to produce a significant amount of water. Clay removal will occur from one depth to the next across the entire excavation (or part thereof) until sand is reached. Water management will likely be required as the underlying sand is exposed.

In-situ chemical oxidation treatments will be used to address impacts that cannot practicably be removed through excavation. For example, UP will not conduct excavation that potentially could threaten the structural integrity of a building foundation. In addition, it would be infeasible to excavate a stringer of impacted soil at depth in an area that otherwise shows little impact. Thus chemical injections will be used to treat unexcavated areas of the lease property showing residual impact, at depths ranging from about 7 to 20 feet below land surface, based on the known extent of impact. In certain near-source areas, generally east of the lease property, chemical injections will also be used to treat groundwater in sand-rich deposits beginning at depths ranging from about 7 feet up to 20 feet below land surface, based on the known extent of impact.

Soil excavation and in-situ soil (and groundwater) chemical oxidation treatments would be initiated within a 1 year timeframe, with subsequent follow-up actions based on testing results.

Due to the presence of impacted soil (silt and clay) below the water table, the remedial action objectives for soil will meet “soil leaching to groundwater” standards using a dilution attenuation factor (DAF) of 1. This standard may be below practical quantification limits for certain compounds and, if so, the practical quantification limit will be used as the standard. DAF-1 standards are long term objectives and likely will not be met throughout the source area after active remediation (soil excavation and chemical oxidation) has been completed. UP proposes that if groundwater VCP RGs are consistently met in the source area and soil RAOs are deemed to be overly conservative or not practicable, that UP may request a modification to the soil RAOs based on site-specific empirical data.

The points of compliance for soil will extend vertically to the top of the saturated sand horizon, at an approximate depth of 7 feet, and laterally to the outer edge of soil impact attributed to the former Nebraska Solvents Company operations. MIP profiling will be conducted to evaluate the extent of residual impact, if any, and direct push soil sampling will be used to collect verification soil samples. Points of compliance for groundwater impacts will be defined by a monitoring network that includes wells in various locations and at sufficient depths to monitor the extent of groundwater impacted above groundwater VCP RGs, as acceptable to NDEQ.

9.2.2 Cleanup of Readily Removable Contaminants Including Impacted Soil and Soil Vapor

UP will remediate readily removable contaminants. This includes excavation with off-site disposal and in-situ chemical treatment of impacted vadose zone soil. Soil will be excavated and treated as described above to protect groundwater resources. Free product has not been observed.

The construction worker scenario is potentially complete. The construction worker will be protected by meeting the "soil leaching to groundwater" pathway cleanup levels for the chemicals of concern. Until such time as this RAO is met, engineering controls may be required to mitigate possible exposure.

Points of compliance will be as described above such that the vertical and lateral extent of vadose zone cleanup can be documented. Soil excavation and in-situ soil (and groundwater) chemical oxidation treatments would be initiated within a 1 year timeframe, with possible follow-up actions based on testing results.

Potential issues related to the migration of soil vapor from the subsurface to indoor air will also be addressed. Based on current testing, only a limited area on the former Nebraska Solvents Company lease property is indicated to exceed industrial screening levels. Off-site soil vapor analytical data indicate that residential screening levels were not exceeded; however additional groundwater testing and vapor intrusion modeling will be conducted to verify this initial conclusion. Potential soil vapor issues will be addressed through the excavation of impacted soil on the former leased property and through in-situ groundwater treatment using chemical oxidation technology.

Industrial cleanup standards will be applied to the former leased property and residential standards will be applied to off-site properties, unless an off-site property owner grants a non-residential land use restriction. Cleanup standards are presented in Table 9-1.

9.2.3 Cleanup of Dissolved Groundwater Contamination

UP will act to remediate groundwater impacted by COIs at concentrations exceeding VCP RGs. As discussed in further detail in Sections 9.3.3, 9.3.4 and 9.3.5 of this report, UP proposes to achieve the cleanup of dissolved groundwater impact using in-situ chemical oxidation technology in the source area and near-source area and monitored natural attenuation throughout the entire plume. The proposed MNA Study will assess the feasibility of monitored natural attenuation to address residual groundwater impacts.

Groundwater remediation will be conducted to eliminate exposure pathways associated with the use of impacted groundwater as a drinking water supply. Applicable cleanup levels are VCP RGs for the potable use of RAC-1 groundwater resources.

Points of compliance will include groundwater monitoring points at various locations and depths around and within the area of groundwater impact, as determined in cooperation with NDEQ. This may entail adding wells in certain locations to collect information regarding the effectiveness of remedial actions. UP may also request that NDEQ allow reductions to the number and frequency of wells used to monitor groundwater, if it can be shown through statistical means that data quality objectives can be met through a reduced sampling program.

Groundwater monitoring will be conducted until such time as the VCP RGs have been met, utilizing a monitoring well network acceptable to NDEQ. A compliance period of two years of semi-annual groundwater monitoring will be established following attainment of VCP RGs to verify permanence of the remedy.

The timeframe for meeting VCP RGs is unknown at this time; however the MNA Study will be conducted over the next two to three years to evaluate the feasibility of using monitored natural attenuation to meet VCP RGs within a reasonable period of time, as acceptable to NDEQ.

9.2.4 Restoration of the Aquifer to VCP RGs within a Reasonable Timeframe

UP will endeavor to develop remedial actions to restore groundwater to VCP RGs within a reasonable timeframe. Nebraska Title 118 defines a reasonable timeframe to meet VCP RGs as 20 years, though Appendix A of Title 118 also states that alternative timeframes may be established. UP will conduct studies to determine the remedial actions necessary to achieve groundwater RGs and will work with NDEQ to establish remedial timeframes consistent with Nebraska Title 118 and satisfactory to NDEQ.

9.2.5 Prevention of Further Contaminant Migration in the Groundwater

UP will employ methods to prevent further contaminant migration in groundwater including: (1) mitigation of source and near-source area groundwater impacts to prevent further migration of the most highly impacted part of the groundwater plume; and (2) limiting the advancement of the leading edge of the plume exceeding MCLs. Source and near-source groundwater will be addressed through the excavation of impacted soil on the former Leased Property and through in-situ groundwater treatments, as described in further detail in Sections 9.3.1 and 9.3.3, of this report.

The stability of the leading edge of the plume, whether it is advancing, stable, or decreasing, will be evaluated beginning with at least 8 quarters of chemical data from leading edge wells and as new data are collected. Plume stability will be evaluated using techniques to evaluate if statistically significant data trends exist. Statistical techniques, such Mann-Kendall and/or similar techniques, will be used to conduct this analysis. The “Monitoring and Remediation Optimization System” or MAROS, a computer program well suited for this analysis, was developed by the Air Force Center for Environmental Excellence (AFCEE) and provided for public use. The program is a collection of tools (including Mann-Kendall) to assess:

- Groundwater concentration trends over time;

- Sampling frequency optimization;
- Spatial moment analysis – to determine plume stability;
  - 0th moment - total dissolved mass
  - 1st moment - center of mass
  - 2nd moment - plume spread
- Well redundancy analysis; and
- Data sufficiency analysis.

UP is also planning to conduct an MNA study which will help assess the conditions under which natural attenuation causes the plume to no longer advance.

If the groundwater plume is determined to be advancing, UP will conduct evaluations leading to the development of a remedy to prevent further migration. This may include groundwater flow modeling and the development of feasible alternatives for NDEQ consideration. Subsequent to NDEQ approval, the remedial alternative will be implemented. The RAO for the selected remedy will be groundwater RGs for RAC-1 groundwater resources.

9.2.6 Provision of Alternative Water Supplies to Affected Residences

An alternative water supply has been and will be provided to affected residences. Bottled water and water filtration systems using activated carbon have been provided to residents where COIs have been detected in water samples from private water wells. Also, an extension to the City of Grand Island municipal water supply is proposed to provide potable water to affected residents. The water system will be designed subsequent to NDEQ approval of the RAP and public acceptance of the remedy. The proposed design will be reviewed by the City of Grand Island. Construction will begin after the design is approved.

UP proposes to offer service line connections to residents on existing lots who have been impacted and to those who may reasonably be impacted in the future with the intent to eliminate the current and future potential need for bottled water, in-home carbon treatment systems, and residential potable water monitoring. Residents who "may reasonably be impacted in the future" could include persons whose private well is near the area of groundwater impact and so VOC detections could result from the natural flow of groundwater. Therefore, a service line connection will be offered by UP to all current residential property owners generally within or immediately adjacent to the area bounded by Gunbarrel Road, Beck Road, Fort Kearney Road and East Capital Drive, as depicted on Figure 9-5 of this report. These connections will be paid by UP. Further descriptions of the alternative water provisions are included in Section 9.3.4.2 of this report.

After the municipal extension is constructed and residents are connected, UP will continue to collect and analyze groundwater samples from monitoring wells within and adjacent to the area of groundwater impact until VCP RGs are met.

9.2.7 Use of Institutional Controls to Minimize the Potential for Human Exposure to Contamination and to Protect the Integrity of the Remedial Action

Institutional controls (ICs) will be utilized to minimize the potential for human exposure and to protect the integrity of the remedial actions.

With regard to soil and groundwater impacts on the UP-owned property formerly leased by Nebraska Solvents Company, an IC will be required assuming that industrial soil cleanup standards are utilized and that groundwater will not yet meet VCP RGs, even after in-situ treatment using chemical oxidation has been implemented. This IC will be implemented following vadose zone soil excavation and in-situ soil and groundwater treatment activities.

With regard to groundwater impacts at off-site properties, an IC will be necessary to restrict the installation of potable water wells in the area of impacted groundwater until such time as the RGs for groundwater are met, as described in Section 9.2.3, above. The groundwater IC will be prepared in consultation with state, county, city, and residential stakeholders. The timeframe for implementation of this IC will be concurrent with design and installation of the municipal water system extension.

Once established, ICs will be evaluated periodically to ensure effective control of remaining impacted media.

9.3 Proposed Remedial Action

The proposed remedial action for the Site will consist of the following actions.

- Source area excavation of impacted soil;
- Source area treatment of impacted soil and groundwater using a chemical oxidant;
- Near source area treatment of impacted groundwater using a chemical oxidant;
- Monitored natural attenuation of residual chemical impacts throughout the plume length;
- Extension of the municipal water supply to provide an alternate and permanent source of potable water.
- Institutional Controls, as appropriate, to restrict land use activities to prevent potential exposure to impacted soil, soil vapor, and/or groundwater.

9.3.1 Source Area Soil

Shallow unimpacted soil extending from approximately land surface to three feet bls will be excavated, stockpiled, and tested for future reuse as backfill. Impacted soil from approximately three to seven feet bls will be excavated and disposed off-site. This soil is composed of silt and clay which contain the majority of VOC impact. Underlying sands will not be excavated.

9.3.1.1 Soil Excavation

A significant part of the proposed remedial action is shallow soil excavation within the source area within the upper 7 feet of the soil column, also designated as “Soil Horizon A”. A Waste Management Plan will be prepared to address issues with soil excavation, management, and disposal. An Area of Contamination (AOC) will also be designated.

Surficial sandy soil, which has been shown to not be impacted, will be excavated to an approximate depth of 2.8 ft bls and stockpiled on site within the AOC for future reuse. Impacted soil comprising the “Soil Horizon A”, consisting of clay-rich soil from approximately 2.8 to 6.9 ft bls, will then be excavated and staged for off-site disposal. Sidewall soil samples will be collected and analyzed on-site via a mobile laboratory to assess soil quality during excavation. The proposed excavation will remove approximately 1,357 pounds of COI mass, which accounts for approximately 70 percent of the source area mass. The horizontal excavation limits for “Soil Horizon A” are shown in the red outline on Figure 9-2. The vertical extent of excavation will be limited to the A Horizon as shown on Figure 9-3.

The estimated volume of impacted media excavated in this alternative is 1,500 cubic yards. Based on soil sampling results, it is estimated that 65 percent of the excavated impacted soil would be disposed as special waste and 35 percent would be disposed as hazardous waste. Soil excavated for offsite disposal will be loaded directly into trucks, required manifests will be prepared, and soil will be transported to a pre-approved landfill.

The bottom of the excavation will be lined with a geo-membrane fabric and one-foot of gravel to create a firm base and then backfilled. Clean site soil and fill delivered from an off-site source will be used to backfill the excavation. The backfill material will be sampled for COIs and a Standard Proctor test will also be performed. The fill will be free of coarse material such as asphalt, concrete, rock, or vegetative matter. Soil test results will be reviewed and the soil source(s) will be approved prior to the start of construction activities to prevent any delay.

Due to the small size of the Site and excavation, backfill material will not be stockpiled but will be directly off-loaded from each delivery truck into the excavated area. A skid-steer or other appropriate equipment will then distribute the fill evenly over the excavated area. Backfill material will be compacted in one-foot lifts to a 95 percent (Standard Proctor) compaction density. Each lift will be compacted with a rolling drum machine or similar equipment. Compaction test for each lift will be conducted according to ASTM method D698. The site will be leveled and made suitable for industrial use.

It is anticipated that groundwater will be encountered in the upper 3 feet of the soil column and so wastewater requiring treatment or disposal will likely be generated. Pumps and on-site water storage will be provided. The wastewater will be managed in accordance with Nebraska Title 128 and Title 132 and the Department’s “Investigation Derived Waste and Remediation Waste Considerations” guidance document and with the City of Grand Island wastewater discharge requirements and with applicable permits.

9.3.1.2 Engineering Controls

Engineering controls will be applied at the Site to (1) mitigate possible hazards during remedy implementation and (2) to provide an alternative water supply to impacted groundwater users.

Existing site fencing, construction fencing, and/or flagging will be utilized to restrict site access during the implementation of remedial actions, for example during excavation, drilling, and injection work. The Health and Safety Officer will observe site activities and cause temporary fencing to be erected to restrict public access to active work areas, as needed. At the end of each work day, fencing will be placed to prevent access to work areas. Equipment (such as excavators) will be placed to block vehicular traffic from work areas.

Alternative water supplies represent a second type of engineering control at the Site. Bottled water and water filtration systems using activated carbon have been provided to residents where impacts to private water wells have been detected. Also, an extension to the City of Grand Island municipal water supply is proposed to provide potable water to affected residents. The water system will be designed subsequent to NDEQ approval of the RAP and public acceptance of the remedy. The proposed design will be reviewed by the City of Grand Island. Construction will begin after the design is approved.

9.3.1.3 Institutional Controls

If remedial actions do not yield results leading to unrestricted land use, then UP will establish an institutional control on the former leased property prohibiting non-residential land use.

An institutional control (IC) is also proposed to restrict the installation of potable water wells in the area of impacted groundwater. Similar well installation restrictions were imposed at the Cornhusker Army Ammunitions Plant and the Parkview Superfund Site, located in and near Grand Island, as a part of remedial actions at those sites. The City of Grand Island's jurisdiction to apply an IC extends into the entire area of impacted groundwater, as currently defined.

These and other ICs, if any, will be prepared in consultation with state, county, city, and residential stakeholders.

9.3.2 Source Area Soil Vapor

Soil vapor mitigation will be performed in the source and near-source areas through the remediation of soil and the treatment of impacted groundwater. The proposed source and near-source remedial actions could be performed relatively quickly and subsequent soil vapor and/or groundwater sampling would be used to determine its effectiveness.

9.3.3 Source Area Groundwater

UP proposes to treat groundwater in the source area and near source area utilizing a phased approach. The essential tasks comprising each phase include:

1. NDEQ approval of a dosing plan;
2. chemical application;
3. a waiting period with periodic groundwater monitoring from appropriately placed groundwater monitoring wells to determine when the reagent is spent;
4. a follow-up DPT investigation to quantify the nature and extent of COIs;
5. data review to determine treatment effectiveness;
6. development of a new dosing plan to address residual COIs; and
7. reporting to NDEQ of remediation results and planned future actions.

The injection treatment plan identifies areas and dosing based on geochemical modeling using available soil and groundwater sampling results. Fenton’s reagent will be used to treat COIs in the unsaturated and/or unsaturated zone. The amount of reactant needed in any particular horizon will depend upon the COI concentrations in soil and groundwater and any natural oxidation demand. The vertical and horizontal extents of the chemical injection remedy are shown on Figures 9-3 and 9-4, respectively.

Fenton’s reagent is well suited for the COIs regardless of whether the groundwater environment is aerobic or anaerobic. However, anaerobic conditions in the source and near-source area will promote post-treatment reductive dechlorination of residual chlorinated solvents in support of a long term MNA remedy.

UP anticipates that the RAO will not be met after the first phase of injection and monitoring, and proposes to conduct up to two additional phases of groundwater treatment. Sampling conducted after the first treatment will determine the scope and timing of the second treatment, and so forth.

After source area and near source area soil excavation and groundwater treatments have been performed UP will conduct an MNA study to determine if the remaining groundwater impacts are likely to naturally attenuate within a reasonable timeframe as defined by NDEQ. A workplan for the MNA study will be provided to NDEQ after the RAP is approved.

9.3.4 Mid to Downgradient Plume Groundwater

The majority of the groundwater plume (extending from approximately Museum Drive to Beck Road) is impacted by PCE at concentrations that exceed the MCL, however by a limited amount. Given the broad lateral extent and depth of impact, a two-pronged approach is proposed consisting of (1) ongoing monitoring to further evaluate and document water quality and the impact of monitored natural attenuation as a viable long-term remedial alternative, and (2) the extension of a municipal water source to eliminate any unacceptable exposure to residents.

9.3.4.1 Monitored Natural Attenuation

As noted above, UP will conduct an MNA study to evaluate the feasibility of using monitored natural attenuation as a remedial alternative to meet VCP RGs within a timeframe acceptable to NDEQ. A work plan will be submitted to NDEQ which describes how the MNA Study will be conducted, including which wells and sampling parameters will be part of the study, and the feasibility of conducting additional pumping tests using irrigation well G-101835 and nearby monitoring wells.

The MNA Study will evaluate the following lines of evidence including:

1. Whether the plume is stable, increasing, or decreasing over time;

2. Use of geochemical indicators to document that biodegradation is occurring by comparing background geochemistry with plume geochemistry to identify the presence of electron-acceptor zones in the aquifer;

3. Documenting microbial activity; and

4. Documenting through groundwater modeling whether or not MNA can achieve remediation goals within a reasonable time frame, which is 20 years as defined in Nebraska Title 118.

In any event, groundwater monitoring will be ongoing and will be conducted in areas showing impact exceeding VCP RGs.

9.3.4.2 Water Supply Extension

While existing bottled water and residential water treatment systems using carbon provide an effective alternative water supply, UP believes that these systems would not be acceptable to residents as a long-term remedy. Therefore UP proposes to construct an extension to the City of Grand Island water supply thereby providing impacted residents with a permanent supply of potable water.

UP proposes to offer service line connections to residents on existing lots who have been impacted and to those who may reasonably be impacted in the future with the intent to eliminate the current and future potential need for bottled water, in-home carbon treatment systems, and residential potable water monitoring. Residents who “may reasonably be impacted in the future” could include persons whose private well is near the area of groundwater impact and so VOC detections could result from the natural flow of groundwater. Therefore, a service line connection will be offered by UP to all current residential property owners generally within or immediately adjacent to the area bounded by Gunbarrel Road, Beck Road, Fort Kearney Road and East Capital Drive, as depicted on Figure 9-5. These connections will be paid by UP.

Each resident will have the choice of either having their existing well abandoned by a Nebraska licensed well driller, or having their well remain in place, but be disconnected from the home potable water supply if the resident wants to maintain the wells for non-potable purposes.

Residents may refuse to be connected to the municipal water extension. Each resident who is offered a service connection may accept that offer within six (6) months of the date of the offer and UP will provide the connection at no charge to the resident. If after 6 months, the resident does not accept UP’s offer to provide a no-cost service connection then the resident may still connect to the water main extension, however at their own cost. Thereafter, the resident will also pay for bottled water and/or carbon treatment system maintenance, if desired.

Bottled water and/or in-home treatment systems will be maintained until a municipal water source is extended to impacted homes. After residential properties are connected to the extension of the city water supply, bottled water and water treatment systems supplied by UP will be removed or transferred to the home owner.

After the municipal extension is constructed and residents are connected, UP will continue to collect and analyze groundwater samples from monitoring wells within and adjacent to the area of groundwater impact until VCP RGs are met.

9.3.5 Leading Edge Groundwater

Ongoing groundwater monitoring results are being used to evaluate leading edge plume stability. At least eight quarters of data are required to evaluate groundwater plume stability using, for example, the Mann-Kendall analysis. As of December 31, 2009, only six quarters of data were available at the leading edge and these data appear inconclusive at this time. Therefore, insufficient data exists to determine whether the plume leading edge, is advancing, stable, or retreating. Further analyses will be conducted and those results will be provided to NDEQ as a part of planned quarterly reporting.

Well surveys and sampling will be conducted in this area to determine any potential future impacts to private drinking water supplies, as well as continued monitoring well sampling.

9.3.6 ARARs

Remedial actions are required to meet any Federal or State standards, requirements, criteria, or limitations that are determined to be applicable or relevant and appropriate requirements (ARARs). The proposed remedial action was evaluated based on the three general ARARs categories: chemical-specific ARARs; location-specific ARARs; and action-specific ARARs, as discussed in more detail below. Applicable ARARs for this Site are detailed in Table 9-2.

9.3.6.1 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. Soil and groundwater MCLs for the COIs were identified in Federal Standards (40 CFR 141.16) and in the VCP RGs Lookup tables and are listed in Table 1-2.

9.3.6.2 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. The proposed remedial action 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 a historic district.
- The remedial actions are not anticipated to be located in the 100-year floodplain, except for portions of the water main extension which will pass through portions of the Wood River floodplain.

9.3.6.3 Action-Specific ARARs

Action-specific ARARs are utilized to determine activity or technology based restrictions on the remedial action. These requirements may be imposed based on the chemical and disposal/treatment method employed. Several regulations were identified that may impose restrictions on the remedial action, 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), 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. All work will be performed under a site-specific written HASP. Periodic vapor monitoring will be conducted during construction activities. Also, to satisfy requirements of the Emergency Planning and Community Right-to-Know Act (EPCRA), a material safety data sheet (MSDS) for the COIs will be made available to all site personnel. Applicable permits and access agreements will be obtained from the City Engineer's Office and any private land owners.

9.3.7 Remedy Evaluation Criteria

The proposed remedy is evaluated below with regard to criteria set forth in the VCP guidance.

9.3.7.1 Protection of Human Health and the Environment

The proposed remedies are protective of human health and environment. During remediation of the source area and the near source area, engineering controls and personal protective equipment will be applied to restrict access to work areas and to reduce or eliminate potential exposure by site workers to impacted media. Additional precautions will be implemented to safely manage and apply chemical oxidants that will be injected into soil and groundwater. The half-life of the chemical to be used, a modified Fenton's reagent, is short and any residual impact to the environment will be limited.

Monitored natural attenuation will have no adverse impact to human health and the environment as this process is to document that natural processes are working to achieve remedial objectives within a timeframe acceptable to NDEQ.

Installation of the municipal water extension will require safe work practices to prevent worker injury during construction. Installation of this system will be protective of human health by providing an alternative source of drinking water. No adverse impact to the environment is expected from the construction.

9.3.7.2 Compliance with ARARs

The proposed remedial action will meet Federal, State, and local ARARS including chemical-specific ARARs; location-specific ARARs; and action-specific ARARs. Table 9-2 summarizes applicable ARARs.

9.3.7.3 Short-Term and Long-Term Effectiveness

The degree of both short-term and long-term effectiveness and permanence of the proposed remedial actions are high based on: (1) the shallow impacted soil (to approximately 7 ft bls) will be excavated and permanently removed from the Site; (2) near source area groundwater will be treated via a chemical oxidation injection program; and (3) the installation of an extension of the municipal water supply will provide a permanent alternative water supply.

The effectiveness and permanence of monitored natural attenuation for the body of the groundwater plume will be monitored and reported to NDEQ.

9.3.7.4 Implementability

The proposed remedy is readily implementable. Impacted soil is shallow and ready access exists for excavation equipment. Excavation will not be conducted in areas that might threaten the structural integrity of any building. In this case, chemical treatment will be used to complete the soil remediation.

Likewise, the site and nearby areas where chemical injection will be conducted are open and accessible to workers and equipment. Access agreements are or will be in place to conduct work at off-site locations on public and private property.

Public rights-of-way exist along which the water extension infrastructure can be installed and the City of Grand Island is prepared to grant access for system construction upon receiving an approved design.

The area of groundwater impact is within the jurisdiction zone for the City of Grand Island and so institutional controls limiting groundwater use can be put in place, as has been done for the Cornhusker Army Ammunition Plant and the Parkview Site.

9.3.7.5 Cost

The cost of remediation is not relevant to the selection of this remedy and so is not provided in this report. No public money is being used to perform this remediation.

9.3.7.6 Community Acceptance

Community acceptance of the proposed remedies will be addressed as part of the public notice and comment period.

9.4 Performance Monitoring

Groundwater monitoring will be conducted to evaluate the success of the remedy and until remedial goals are met. The well network (Figure 2-5) will be monitored through the quarterly groundwater sampling and analysis program currently in place. Groundwater samples will be analyzed for the standard 8260 VOC analytical list. Groundwater sampling will be performed in accordance with the methods detailed in Section 2.3.3.5 of this report.

The monitoring well network may be modified to improve the ability of UP to effectively and efficiently monitor the remedy. This may include the installation of new wells to better monitor the remedial actions. UP may also propose to reduce the number and/or sampling frequency of wells, based on statistical analyses demonstrating that the change will not adversely impact the validity of the sampling results. UP will propose any monitoring network changes to NDEQ for consideration.

Data will be reviewed to evaluate the nature, concentration, extent, and trends which may be evident and to evaluate the success of remedial actions. Groundwater monitoring reports will be prepared and submitted to NDEQ within 30 days after the end of each quarter. Each monitoring report will include a brief letter summarizing the work done, key conclusions, and any issues. Appendices will include: data tables showing groundwater elevations and water quality data; a groundwater contour map; groundwater sampling and field data sheets; and laboratory, chain-of-custody, and data validation reports.

9.5 Remediation Waste Management

Excavated source area soil will be stockpiled within the area of interest (AOI) and characterized as either special or hazardous waste. Soil that is deemed too wet will be staged at a drying area to allow drying.

Special waste will be loaded into dump trucks, covered, and disposed at the Butler County, Nebraska, Landfill. Required documentation and manifests will be provided as required by the Landfill. Hazardous waste, if any, will be loaded into trucks, properly covered, manifested according to applicable state and federal regulations, and disposed at the Clean Harbors facility at Lone Mountain in Waynoka, Oklahoma.

Weigh tickets, manifests, and certificates of disposal or destruction will be obtained and retained in the project files to document proper disposal.

9.6 Permitting and Regulatory Involvement

The City Engineer, Public Works, Traffic, and Water Departments will be notified prior to the initiation of construction as needed and to accomplish specific objectives. Communication with NDEQ will be maintained throughout the remedial design and implementation to facilitate ongoing regulatory approval of the work being conducted. Specific permits and access agreements, both public and private, will be obtained as needed. Applicable permits are identified in Table 9-2.

All work performed by Foth IE and any contractors will be in accordance with a Foth-approved, site-specific Health and Safety Plan. Daily health and safety meetings will be conducted to review the work planned for that day and to address any specific physical or chemical hazards that might be associated with that work.

9.7 Proposed Schedule of Remedial Activities

A proposed schedule for the remedial activities, including but not limited to timeframes for submittal of pre-design plans, vapor intrusion evaluations, and MNA studies, is presented in Appendix U. UP proposes to begin remedial actions upon receipt of agency and public approval; however interim actions may be conducted if formal regulatory approval is delayed. UP's interest in conducting any interim action will be discussed with NDEQ prior to implementation, and any required work plans will be prepared and submitted for NDEQ review and approval.

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Tables