Environment

Prepared for:
Chicago Central & Pacific Railroad
Homewood, Illinois

Prepared by:
AECOM
Minneapolis, MN
60196282.1
May 2011

CON 12-15
Doc #29575

2010 Hydrocarbon Recovery and Groundwater Monitoring Report

Former Fueling and Distribution Area
Council Bluffs Yard - Council Bluffs, Iowa
PIN Number: 2160-IAPR-100084

AECOM Environment

Prepared for:
Chicago Central & Pacific Railroad
Homewood, Illinois

Prepared by:
AECOM
Minneapolis, MN
60196282.1
May 2011

2010 Hydrocarbon Recovery and Groundwater Monitoring Report

Former Fueling and Distribution Area Council Bluffs Yard - Council Bluffs, Iowa PIN Number: 2160-IAPR-100084

Prepared By: Trevre R. Andrews, Technical Specialist

Prepared By: Curt D. Mann, P.E., CHMM, Project Manager

Reviewed By: Jonathan S. Murer, P.G., Senior Hydrogeologist

Contents

List of Appendices

List of Tables

List of Figures

Executive Summary

On behalf of the Chicago Central & Pacific Railroad (CCPR), AECOM Technical Services Inc., (AECOM) has been conducting groundwater monitoring and hydrocarbon recovery activities at the CCPR railyard in Council Bluffs, Iowa (Site). This document summarizes the results of the 2010 groundwater monitoring and hydrocarbon recovery and evaluation program (2010 Program) completed within the vicinity of the Former Fueling and Distribution Area.

The objectives of the 2010 Program were as follows:

- Further evaluate the extent, magnitude, and stability of dissolved hydrocarbons within the Former Fueling and Distribution Area
- Further evaluate the extent, magnitude, and mobility of free-phase hydrocarbons within the Former Fueling and Distribution Area
- Evaluate the status of the Site in the context of the applicable Iowa regulatory program

To meet these objectives, the following tasks were completed as part of the 2010 Program:

- Continued operation of the hydrocarbon recovery system located within the former Locomotive Fueling and Distribution Area
- One groundwater monitoring event was completed in August 2010 to evaluate the extent of dissolved hydrocarbon impacts at the Site
- Collection of monthly fluid level measurements from wells part of, and in the vicinity of, the active recovery system
- Collection of monthly fluid level measurement from monitoring wells to evaluate the migration, if any, of the free-phase hydrocarbon plume
- Completed baildown tests at wells R-3, MW-10R, MW-27, MW-28, and MW-29 during August 2010

The mechanical recovery system located within the Former Fueling and Distribution Area is a pneumatic skimming system that includes a control building to house the system components and underground piping to protect air and recovery lines. Nine Site recovery wells and converted monitoring wells are attached to the control building via the underground piping (i.e., MW-12, MW-13, MW-17, MW-18, MW-20, R-1, R-2, R-3, and R-4). Each recovery point, when operational, can be outfitted with Xitech® hydrocarbon skimming pumps to facilitate hydrocarbon removal. Recovery wells MW-12, MW-13, MW-17, MW-18, MW-20, and R-4 can accommodate two-inch diameter skimming pumps. Recovery wells R-1, R-2, and R-3 can accommodate four-inch diameter skimming pumps. Recovery operations were initiated at the Site on August 2, 2005. During the 2010 Program, recovery efforts were focused on wells MW-12, MW-13, MW-18, R-1, R-2, and R-4.

As part of the 2010 Program, groundwater monitoring activities were conducted on August 25 and 26, 2010. Groundwater samples were collected for field and laboratory analysis at 11 monitoring wells (i.e., MW-6, MW-15, MW-16, MW-19, MW-21, MW-22, MW-23, MW-24, MW-25, MW-26, and MW-31). With the exception of MW-6 and MW-31, these wells are located along the periphery of the

Former Fueling and Distribution Area and are located outside the area of observed free-phase hydrocarbons. Monitoring well MW-6 is located within the area of known hydrocarbon impacts, but has not historically exhibited measurable free-phase hydrocarbon. This well was added to the groundwater monitoring program to provide a representation of dissolved groundwater impacts within the hydrocarbon plume area and to supplement the evaluation of natural attenuation processes in groundwater. Monitoring well MW-31 was installed as a plume monitoring well and is located approximately 15 feet from plume monitoring well MW-27, where measurable free-phase hydrocarbon has been observed. Monitoring well MW-31 was added to the groundwater monitoring program to evaluate dissolved petroleum constituents immediately downgradient of the edge of the hydrocarbon plume.

Summary

Hydrocarbon Recovery

Based on the results of the 2010 Program, hydrocarbon recovery activities at the Site continue to meet the objectives presented in the 2007 Annual Report. The hydrocarbon recovery objectives are provided below along with information related to progress toward achieving the specific objective:

<u>Objective: Site wide LNAPL transmissivity assessment and reduction through practicable recovery.</u>

- Based on Interstate Technology and Regulatory Council (ITRC) guidance, and a review of the LNAPL site conceptual model, an appropriate endpoint for hydraulic recovery of LNAPL at the Site is between 0.1 to 0.8 ft^2/day. Continued hydraulic recovery of LNAPL once transmissivities achieve this range will not significantly reduce the dissolved phase hydrocarbon impacts or limit migration risk.
  - The LNAPL transmissivities at the center of the LNAPL plume are within or near the range of endpoint transmissivities. For these wells (i.e., MW-13, R-1, and R-4), LNAPL mechanical recovery will continue to lower transmissivities further.
  - On the edges of the LNAPL plume, the transmissivities are as much as two orders of magnitude below this range and recovery has been, or will be, suspended at wells MW-12, MW-17, MW-19, MW-20, R-3, and R-2.
- The mechanical hydrocarbon recovery rate observed during the 2010 Program was 1.2 gpd. The hydrocarbon recovery rate has declined since active hydrocarbon recovery was initiated in August 2005 (i.e., from 5.4 gpd to 1.2 gpd) – the recovery rate decrease is likely related to both a reduction in free-phase hydrocarbon mobility as a result of recovery activities and the operational efficiency of the hydrocarbon recovery system.
- Approximately 504 gallons of free-phase hydrocarbon were recovered from the Site in 2010 (i.e., via mechanical and manual methods).
- Approximately 3,717 gallons of free-phase hydrocarbon have been recovered at the Site since 2005.
- At the current hydrocarbon recovery rate, it would take more than 20 additional years to recover the estimated 20,000 to 30,000 gallons of remaining recoverable free-phase hydrocarbon volume (i.e., as presented in the 2007 Annual Report) – the actual recovery time may be significantly longer as the recovery rate will continue to decline with time.

- As discussed in the 2007 Annual Report, it is not feasible to remove all of the estimated recoverable free-phase hydrocarbon.
- Demonstration of plume stability is a more appropriate metric to evaluate hydrocarbon conditions at the Site as opposed to a volumetric or recovery rate based endpoint.

Objective: Analyze site gradients and their effect on the stability of the LNAPL plume

- Existing data indicate that the free-phase hydrocarbon gradient at the Site is toward the west.
- The reduction in hydrocarbon mass (i.e., 3,717 gallons of free-phase hydrocarbon removed from the Site) has decreased the hydrocarbon gradients and has reduced the potential for off-site migration.
- Free-phase hydrocarbon transmissivities decrease significantly from the center of the plume to the edge of the hydrocarbon plume – this indicates that no significant free-phase hydrocarbon migration is occurring from the center of the plume toward the western periphery.
- Seepage velocity calculations at the edge of the LNAPL plume support that LNAPL would require many years to migrate any significant distance.

Objective: Analyze LNAPL formation thickness and entry pressure head at the edge of the LNAPL plume

- The plume stability evaluation has illustrated that the free-phase hydrocarbon at the edge of the hydrocarbon plume currently has insufficient capillary head to migrate beyond the observed plume extent (i.e., based on the low transmissivities observed at MW-27, MW-28, and MW-29).
- LNAPL at the edge of the plume has not appeared in new wells since the installation of the plume migration monitoring wells in 2007.

Groundwater

The following summary statements are based on groundwater monitoring data gathered as part of the 2010 Program:

- Groundwater flow continues to be primarily toward the west/northwest.
- Only one exceedance of the applied screening criteria was noted for groundwater samples collected during the 2010 Program.
    - An exceedance of the screening criteria for THC as diesel fuel was noted in the sample collected from well MW-6. This well is located within the area of free-phase hydrocarbon at the Site.
- The majority of the dissolved phase parameters detected during the 2010 Program were associated with samples collected from wells within, or immediately adjacent to, the free-phase hydrocarbon plume (i.e., MW-6 and MW-31).
    - Benzene and ethylbenzene were detected in the groundwater sample collected from MW-6 at concentrations below the applied screening criteria.

  - THC as gasoline was only detected in the groundwater sample collected from well MW-6 during the 2010 Program, at a concentration below the applied screening criteria.
  - THC as diesel fuel was detected in samples collected from wells MW-6 and MW-31. The concentration of THC as diesel fuel noted at MW-6 exceeds the applied screening criteria.
  - PAH parameters consisting of acenaphthene (MW-6 and MW-31), acenaphthylene (MW-6 and MW-31), anthracene (MW-6, MW-24, and MW-31), benzo(a)anthracene (MW-24), benzo(a)pyrene (MW-24), benzo(b)fluoranthene (MW-24), chrysene (MW-24), fluoranthene (MW-6 and MW-24), fluorene (MW-6 and MW-31), naphthalene (MW-6 and MW-31), phenanthrene (MW-6 and MW-31), and pyrene (MW-6, MW-24, and MW-31) were detected at concentrations below the applied screening criteria.

- Certain low-level PAH parameters were detected in only one of the monitoring wells located along the periphery of the Former Fueling and Distribution Area (i.e., MW-24). No detections of the 2010 analytical program parameters were noted in peripheral wells MW-15, MW-16, MW-19, MW-21, MW-22, MW-23, MW-25, and MW-26.
- Natural attenuation data collected during the 2010 Program indicated the continued occurrence of *in situ* biodegradation processes in groundwater.

Recommendations

Based on data collected during the 2010 Program, AECOM recommends the following activities for the Site in 2011:

- Complete one round of groundwater sampling, including collection of natural attenuation assessment parameters (July 2011)
- Continue operation of the hydrocarbon recovery system and associated monthly Site inspections.
  - To maintain compliance with IDNR regulatory requirements related to free-phase hydrocarbon
  - To allow further evaluation of plume migration potential
  - Operation of the recovery system may be suspended at times to allow certain wells to reach equilibrium prior to baildown testing
- Collect undisturbed soil cores at three locations from within and along the edge of the free-phase hydrocarbon plume to confirm the LNAPL saturations and soil properties at the Site.
- Continue to opportunistically schedule baildown tests to evaluate hydrocarbon recovery rate (i.e., to allow comparison to system hydrocarbon recovery rates) and to monitor hydrocarbon transmissivities within and along the downgradient edge of the hydrocarbon plume.
- Continue to gauge recovery wells and plume monitoring wells in order to provide data useable for gradient analysis.
- Re-develop certain recovery wells and plume monitoring wells, as needed, to ensure that free-phase hydrocarbon collection is not being inhibited by siltation within the wells.

- Plume stability evaluation efforts will be focused on the interior of the plume and on the interaction between the interior of the plume and migration potential at the periphery. If additional data demonstrates interior plume stability, recovery wells could be shutdown in a phased approach until Site data warrants a full system shutdown.
- LNAPL site conceptual models (LSCMs) will be updated as new data from the planned 2011 activities is obtained.

1.0 Introduction

On behalf of the Chicago Central & Pacific Railroad (CCPR), AECOM Technical Services Inc., (AECOM) has been conducting groundwater monitoring and hydrocarbon recovery activities at the CCPR railyard in Council Bluffs, Iowa (Site). This document summarizes the results of the 2010 groundwater monitoring and hydrocarbon recovery and evaluation program (2010 Program) completed within the vicinity of the Former Fueling and Distribution Area.

The CCPR has completed a Phase I Environmental Site Assessment (ESA), a Phase II ESA, a Phase IIIA ESA, and a Pilot Study at the Site. The Phase I ESA, Phase IIIA ESA, and Pilot Study were completed by The RETEC Group, Inc. (RETEC), now AECOM. The Phase II ESA was completed by Earth Tech, Inc. (Earth Tech), now AECOM. Additionally, groundwater monitoring and hydrocarbon recovery activities have been completed at the Site by AECOM since 2005.

The subject area of the Site is located within Property Identification Number (PIN) 2160-IAPR-100084. Figure 1 shows the Site location. Figure 2 depicts the generalized configuration of the Site. The scope of work for the 2010 Program was presented in the AECOM document entitled, *Proposal for 2010 Continued Operation and Maintenance, Monitoring and Reporting at the Chicage Central & Pacific Railroad – Council Bluffs, Iowa* dated December 18, 2009 (2010 SOW).

1.1 Background

The project background information pertinent to this report, and summarized in the subsequent sections, was developed based on information presented in the following project documents:

- Phase I Environmental Site Assessment, RETEC, December 2001 (Phase I ESA)
- Phase II Environmental Site Assessment – Council Bluffs Yard, Earth Tech, May 2003 (Phase II ESA)
- Phase IIIA Environmental Site Assessment – Council Bluffs Yard, RETEC, April 2004 (Phase IIIA ESA)
- Pilot Study Report – Council Bluffs Yard, RETEC, April 2005 (Pilot Study)
- LNAPL Skimming System Operation Manual and As-Builts – Council Bluffs Yard, RETEC, November 2005 (As-Builts)
- 2005 LNAPL Recovery Operations and Maintenance Report – Council Bluffs Yard, RETEC, March 2006 (2005 O&M Report)
- 2005 Groundwater Monitoring Report – Council Bluffs Yard, RETEC, April 2006 (2005 Monitoring Report)
- 2006 Hydrocarbon Recovery and Groundwater Monitoring Report, Former Fueling and Distribution Area – Council Bluffs Yard, RETEC, April 2007 (2006 Annual Report)
- 2007 Hydrocarbon Recovery and Groundwater Monitoring Report, Former Fueling and Distribution Area – Council Bluffs Yard, ENSR Corporation, May 2008 (2007 Annual Report)

- 2008 Hydrocarbon Recovery and Groundwater Monitoring Report, Former Fueling and Distribution Area – Council Bluffs Yard, AECOM, September 2009 (2008 Annual Report)
- 2009 Hydrocarbon Recovery and Groundwater Monitoring Report, Former Fueling and Distribution Area – Council Bluffs Yard, AECOM, March 2011 (2009 Annual Report)

Additional details related to the project background are provided in the subject reports. Executive summaries of pertinent assessment reports are provided in Appendix A.

1.1.1 Site Description

The Site is located in the city of Council Bluffs, Pottawattamie County, Iowa. The Site is a north-south trending property that is approximately 1.6 miles long and 1/8-mile wide. The United States Geological Survey (USGS) Council Bluffs North, Iowa, Quadrangle 7.5 Minute Series Topographic Map shows the Site is located in Township 15 North, Range 14 East, Sections 23 and 26.

1.1.2 Site Background Information

1.1.2.1 Investigation Area Summary

The Council Bluffs yard was historically used as a locomotive fueling and light maintenance facility. The Council Bluffs yard and mainline comprising PIN 2160-IAPR-100084 are approximately defined by the area extending east to the Union Pacific Railroad yard, extending west to the intersection of the CCPR rail line and 15th Street North, extending north to the intersection of the CCPR rail line and Big Lake Road, and extending south to the intersection of the CCPR rail line and Broadway Avenue.

Railroad facilities currently located at the Site include a classification yard, locker/office building, tool house, three equipment and material storage buildings, sand tower, coal chute, electric meter house, and an inactive turntable. A recovery system control building is located within the Former Fueling and Distribution Area to facilitate on-going hydrocarbon recovery activities at the Site. A pole storage yard was constructed at the Site in 2007 to the east of the recovery system control building. Former structures associated with historic railroad operations include a roundhouse, fueling area, a 200,000-gallon diesel fuel aboveground storage tank (AST), a 500-gallon gasoline AST, and a 500-gallon diesel fuel AST.

1.1.2.2 Physical Characteristics

<u>Geologic Conditions</u>

Three stratigraphic units have been identified in the shallow subsurface of the Site. The shallow subsurface is composed of a sand and gravel fill unit (Fill Unit) overlying a clayey silt unit (Fine-Grained Unit). The Fill Unit is composed primarily of sand and gravel with variable amounts of silt, clay, and non-soil debris such as wood, and coal slag. Where present the Fill Unit ranges in thickness from 2 to 6 feet. The Fine-Grained Unit is composed primarily of medium plastic clays and low plasticity silts, with areas of highly plastic clays and isolated horizons of clayey sand and sand. The Fine-Grained Unit is considered an aquitard at the Site. A silty sand unit (Coarse-Grained Unit) is present below the Fine-Grained Unit. The Coarse-Grained Unit is considered to be the shallowest water-bearing unit and a confined aquifer at the Site. Cross-sections prepared for the Phase IIIA ESA and Pilot Study reports have been included in Appendix B.

Hydrogeologic Conditions

Based upon data generated during the previous investigations, it is evident that the water table at the Site occurs near or above the interface of the Fine-Grained Unit and the Coarse-Grained Unit. The Fine-Grained Unit at the Site is acting as an aquitard and exhibits a sufficiently low permeability such that the Phase II ESA wells, which terminate in the fine-grained unit, exhibit a perched water table. Historical groundwater elevation data have indicated that the groundwater flow direction is generally towards the west/northwest, in the direction of the Missouri River.

Surface Water Drainage Conditions

Surface drainage at the Site is mainly overland flow to low areas on or around the Site, drainage ditches, or storm sewers. The southeast side of the Site drains to Indian Creek, which subsequently drains to the Missouri River. The Missouri River is located approximately one mile to the west of the Site. A culvert pipe installed under the number seven, eight, and nine railroad tracks acts to drain the track area to the east into a ditch located between the Site and the adjacent Union Pacific Railroad yard. This ditch drains the eastern side of the Site north to Big Lake, located approximately three-fourths of a mile north of the Site. Much of the yard area drains toward the waste sump area located on the west side of the yard. A wetland area is located northwest of the Site. The storm sewers drain to the Missouri River.

1.1.3 Summary of Previous Groundwater Analytical Data

Based on recent groundwater data, the following conditions are noted to exist at the Site:

- Benzene, toluene, ethylbenzene, xylene (BTEX), total hydrocarbons (THC) as diesel fuel, or THC as gasoline have not typically been detected in groundwater samples collected from wells located along the periphery of the Former Fueling and Distribution Area and active remediation area
  - Only wells MW-6 and MW-31 have exhibited detections of BTEX, THC as diesel fuel, and THC as gasoline since the groundwater monitoring program was initiated in 2005
  - THC as diesel fuel exceedances have only been noted in well MW-6 in 2007 and 2010 – monitoring well MW-6 is located within the hydrocarbon plume area
- Low levels of polycyclic aromatic hydrocarbons (PAHs) have been detected in certain Site wells located along the periphery of the Former Fueling and Distribution Area at concentrations below the applied regulatory criteria
  - PAH detections have been limited to seven Site wells including MW-6 (i.e., in 2007, 2008, 2009, and 2010), MW-15 (i.e., in 2005, 2006, 2007, and 2009), MW-22 (i.e., in 2005), MW-24 (i.e., in 2005,2009, and 2010), MW-25 (i.e., in 2005), MW-26 (i.e., in 2005 and 2009), and MW-31 (i.e., in 2008, 2009, 2010)
  - PAH exceedances have only been noted in a sample collected from monitoring well MW-6 in 2007 – monitoring well MW-6 is located within the hydrocarbon plume area
- Natural attenuation processes are occurring in groundwater at the Site

1.1.4 Summary of Free-Phase Hydrocarbon Recovery

Based on recent and historic fluid measurement data available for the Site, the following conditions are noted to exist with regards to the presence of free-phase petroleum hydrocarbons:

- Measurable free-phase hydrocarbons have historically been detected in 13 monitoring and recovery wells (i.e., MW-1, MW-6, MW-10R, MW-11, MW-12, MW-13, MW-17, MW-18, MW-20, R-1, R-2, R-3, and R-4) and five plume monitoring wells (i.e., MW-27, MW-28, MW-29, MW-30, and MW-34) located near the Former Fueling and Distribution Area. MW-6 has not contained measurable free-phase hydrocarbon since 2005.
- Measurable free-phase hydrocarbons have recently been detected in 11 historic Site wells (i.e., MW-10R, MW-11, MW-12, MW-13, MW-17, MW-18, MW-20, R-1, R-2, R-3, and R-4) and five plume monitoring wells (i.e., MW-27, MW-28, MW-29, MW-30, and MW-34) located near the Former Fueling and Distribution Area.
  - Free-phase hydrocarbons have not been observed in wells downgradient of the free-phase hydrocarbon plume (i.e., MW-14, MW-15, MW-16, MW-19, MW-22, MW-31, MW-32, and MW-33)
- Nine Site monitoring and recovery wells (i.e., wells MW-12, MW-13, MW-17, MW-18, MW-20, R-1, R-2, R-3, and R-4) are currently connected to the active hydrocarbon recovery system, System operations focused on wells MW-12, MW-13, MW-18, R-1, R-2, and R-4 which have historically had the highest free-phase hydrocarbon transmissivity. Wells R-3, MW-17, and MW-20 were allowed to equilibrate to assess equilibrium fluid levels.

1.2 Project Objectives

The objectives of the 2010 Program were as follows:

- Further evaluate the extent, magnitude, and stability of dissolved hydrocarbons within the Former Fueling and Distribution Area
- Further evaluate the extent, magnitude, and mobility of free-phase hydrocarbons within the Former Fueling and Distribution Area
- Evaluate the status of the Site in the context of the applicable Iowa regulatory program

To meet these objectives, the following tasks were completed as part of the 2010 Program:

- Continued operation of the hydrocarbon recovery system located within the former Locomotive Fueling and Distribution Area
- One groundwater monitoring event was completed in August 2010 to evaluate the extent of dissolved hydrocarbon impacts at the Site
- Collection of monthly fluid level measurements from wells part of, and in the vicinity of, the active recovery system
- Collection of monthly fluid level measurement from monitoring wells to evaluate the migration, if any, of the free-phase hydrocarbon plume
- Completed baildown tests at wells R-3, MW-10R, MW-27, MW-28, and MW-29 during August 2010

1.3 Document Organization

Section 1 of this document provides pertinent Site background information. Section 2 summarizes the scope of work conducted as part of the 2010 Program. Field and laboratory results for the 2010 Program are summarized in Section 3. Section 4 presents a summary and recommendations based on the results of the 2010 Program. References used in the development of this report are presented in Section 5.

2.0 Summary of Hydrocarbon and Groundwater Monitoring Programs

The fieldwork associated with the 2010 Program was completed between January and December 2010. The following sections describe the field activities, sample collection methodology, laboratory analyses, and data evaluation activities that were completed as part of the 2010 Program.

2.1 System Performance Monitoring and Hydrocarbon Recovery Program

2.1.1 Hydrocarbon Recovery Program

Monthly operations and maintenance inspections were completed from January to December 2010. The July 2010 inspection was delayed until early August in preparation for site baildown testing later in August 2010. Monthly operations and maintenance activities included collecting fluid level measurements from certain system and non-system wells, inspecting recovery points and equipment, recording of fluid levels in recovery drums and the on-site storage tank, and transferring recovered hydrocarbon from the recovery drums to the on-site storage tank. Manual free-phase hydrocarbon recovery (i.e., using bailing or pumping methods) was generally not completed in 2010 except in August and December at select wells (i.e., MW-10R, MW-27, MW-28, MW-29, MW-30 and MW-34) to allow effective evaluation of hydrocarbon plume migration and mechanical hydrocarbon recovery. Sixteen monitoring and recovery wells were scheduled to be gauged on a monthly basis during the 2010 Program (i.e., MW-10R, MW-11, MW-12, MW-13, MW-15, MW-16, MW-17, MW-18, MW-19, MW-20, MW-22, MW-26, R-1, R-2, R-3, and R-4). Additionally, plume monitoring wells MW-27 through MW-34 were included in the monthly fluid level gauging program. On occasion, certain wells were not gauged during the monthly inspection event due to weather conditions, obstructions covering the well, or other pertinent reasons. Operations and maintenance field documents were completed for each monthly event to document hydrocarbon recovery, system operating parameters, and fluid measurements from surrounding wells. These data were collected to allow evaluation of plume stability and monitor the performance of the system. The 2010 operation and maintenance results are summarized on the monthly field forms provided in Appendix C.

2.1.2 Recovery System Description

The mechanical recovery system located within the Former Fueling and Distribution Area is a pneumatic skimming system that includes a control building to house the system components and underground piping to protect air and recovery lines. Nine Site recovery wells and converted monitoring wells are attached to the control building via the underground piping (i.e., MW-12, MW-13, MW-17, MW-18, MW-20, R-1, R-2, R-3, and R-4). Each recovery point, when operational, can be outfitted with Xitech® hydrocarbon skimming pumps to facilitate hydrocarbon removal. Recovery wells MW-12, MW-13, MW-17, MW-18, MW-20, and R-4 can accommodate two-inch diameter skimming pumps. Recovery wells R-1, R-2, and R-3 can accommodate four-inch diameter skimming pumps. Recovery operations were initiated at the Site on August 2, 2005. During the 2010 Program, recovery efforts were focused on wells MW-12, MW-13, MW-18, R-1, R-2, and R-4.

The system control building is located in the vicinity of MW-17 and is designed to protect and house the recovery system components. The recovery system consists of a pneumatic Xitech® skimmer control box, an air compressor, an air dryer, 55-gallon hydrocarbon recovery drums equipped with high-level shut-offs for each active recovery well, and a 1,000-gallon hydrocarbon recovery tank equipped with a high-level shut-off. Concrete barriers surround the recovery tank to protect the tank from increased traffic related to the adjacent pole storage operation.

2.1.3 Plume Stability Monitoring

Eight monitoring wells were installed at the Site in 2007 to facilitate the evaluation of hydrocarbon plume migration (i.e., wells MW-27 through MW-34). Fluid level measurements were collected from each of the plume monitoring wells on a monthly basis during the 2010 Program. Plume monitoring data supports the evaluation of hydrocarbon plume stability monitoring and hydrocarbon mobility at the edge of the hydrocarbon plume. The fluid level measurements for the plume monitoring wells were summarized on the operations and maintenance field forms provided in Appendix C.

2.1.4 Hydrocarbon Baildown Testing

Hydrocarbon baildown tests were performed at R-3, MW-10R, MW-27, MW-28, and MW-29 in August 2010 to assess transmissivity of free-phase hydrocarbons at these locations. Data collected from the tests are included as part of Appendix E.

2.2 Groundwater Monitoring

As part of the 2010 Program, groundwater monitoring activities were conducted on August 25 and 26, 2010. Groundwater samples were collected for field and laboratory analysis at 11 monitoring wells (i.e., MW-6, MW-15, MW-16, MW-19, MW-21, MW-22, MW-23, MW-24, MW-25, MW-26, and MW-31). With the exception of MW-6 and MW-31, these wells are located along the periphery of the Former Fueling and Distribution Area and are located outside the area of observed free-phase hydrocarbons. Monitoring well MW-6 is located within the area of known hydrocarbon impacts, but has not historically exhibited measurable free-phase hydrocarbon. This well was added to the groundwater monitoring program to provide a representation of dissolved groundwater impacts within the hydrocarbon plume area and to supplement the evaluation of natural attenuation processes in groundwater. Monitoring well MW-31 was installed as a plume monitoring well and is located approximately 15 feet from plume monitoring well MW-27, where measurable free-phase hydrocarbon has been observed. Monitoring well MW-31 was added to the groundwater monitoring program to evaluate dissolved petroleum constituents immediately downgradient of the edge of the hydrocarbon plume.

2.2.1 Groundwater Sampling Procedures

Fluid level measurements were collected at the groundwater monitoring wells during the subject sampling event to aid in the evaluation of groundwater flow conditions at the Site. A portable, down-hole electronic sounding device was used to obtain depth to water measurements from the top of the inner well casing.

The fluid level measurements were recorded on the applicable groundwater sampling form maintained for each monitoring well where groundwater samples were collected. If encountered, the presence of free phase hydrocarbons, petroleum-like odors, or sheens were also recorded on the forms. Copies of the groundwater sampling forms for the 2010 groundwater monitoring event are provided in Appendix D.

Prior to collecting groundwater samples from a particular monitoring well, the well was purged to ensure that fresh formation groundwater was available for sample collection and subsequent laboratory analysis. Monitoring wells were purged with a peristaltic pump and dedicated disposable polyethylene tubing using low flow methods. This slow purging method was used to minimize the potential for entrainment of sediment during the collection of groundwater samples.

During purging activities, field parameters (i.e., pH, temperature, and conductivity) were monitored using a flow-through cell and a portable water quality meter to identify when fresh formation water was entering the well. Oxidation-reduction potential (Redox Potential) and dissolved oxygen (DO) were also measured at each well to support the evaluation of the occurrence of natural attenuation processes in the subsurface. Sampling was conducted once a minimum of three well volumes of water had been removed and the field parameters had generally stabilized (i.e., parameters had stabilized to within approximately 10% of the previous measurement). In the event that three well volumes of water could not be removed due to insufficient groundwater recharge rates, the subject well was pumped dry and was then sampled once fresh water entered the well. Levels of ferrous iron were also measured during sample collection activities to support the evaluation of natural attenuation process occurring at the Site. Hach® field test kits were used to collect ferrous iron measurements. Field parameter measurements obtained at each monitoring well was also recorded on the applicable groundwater sampling form.

2.2.2 Groundwater Sampling Analytical Program

With the exception of samples collected for analysis of volatile organic constituents, groundwater samples for laboratory analysis were collected using a peristaltic pump and disposable tubing. Samples submitted for volatile organic constituent analysis were collected using a dedicated, disposable polyethylene bailer. The samples were placed in laboratory-supplied containers with the appropriate preservatives, when required, and transported to the laboratory in coolers containing ice following standard chain-of-custody procedures.

Groundwater samples were submitted for laboratory analysis of petroleum constituents and a set of parameters selected to support the evaluation of the potential occurrence of natural attenuation processes (natural attenuation parameters). The groundwater samples were submitted for the following analyses:

Petroleum Parameters

- OA1 – BTEX and THC as gasoline – Iowa Method OA1 GCS
- OA2 – THC as diesel fuel – Iowa Method OA2 GCV
- PAHs – EPA Method 8270 SIM

Natural Attenuation Parameters

- Total Organic Carbon (TOC) – Method SM5310C
- Total Kjeldahl Nitrogen (TKN) – EPA Method 351.2
- Nitrate/Nitrite – EPA Method 353.2
- Total Phosphorus – EPA Method 365.4
- Sulfate – ASTM D516-9002

- Methane – RSK175 Air Headspace

For Quality Assurance/Quality Control (QA/QC) purposes, one duplicate groundwater sample was collected during the 2010 groundwater monitoring event for analysis of the petroleum parameters. In addition, trip blank samples, prepared by the laboratory, were placed in the coolers that contained samples submitted for volatile organic constituent analyses (i.e., OA1 analysis) during transport to the laboratory. The trip blanks were analyzed for the presence of BTEX and THC as gasoline to identify potential cross-contamination that could have occurred during sample storage and transport to the laboratory.

2.3 Variations to the Planned 2010 Program

Monitoring well MW-14 could not be located during the 2010 groundwater sampling event. This well is located in an area of the Site where recent construction and grading activities have likely buried and/or damaged the well. Additional variations to the planned 2010 Program were related to certain operational issues associated with the recovery system skimming pumps in February 2010. These operational issues are discussed in Section 3.1.1. The operational issues noted during the hydrocarbon recovery program did not significantly affect the data evaluation completed for 2010, nor did they affect the approach to free-phase hydrocarbon management at the Site.

3.0 Results

This section presents the results of the activities conducted as part of the 2010 Program.

3.1 System Monitoring and Hydrocarbon Recovery Results

3.1.1 System Monitoring

As part of the 2010 hydrocarbon recovery program, routine recovery system operations and maintenance inspections were conducted on a monthly basis from January through December 2010. As part of each inspection event, fluid level measurements and recovery pump settings were evaluated to aid in optimizing recovery system performance. As necessary, adjustments in the recovery system configuration were completed (e.g., skimming pump depth, run time, operational status). Recovered hydrocarbon and water were periodically pumped out of the recovery drums and transferred to the on-site hydrocarbon storage tank. Cumulative fluid level gauging data are presented in Table 1. The 2010 operation and maintenance results are summarized on the field forms provided in Appendix C.

The hydrocarbon recovery system experienced minimal operational and maintenance issues during February 2010 due to compressor faults. Upon arrival to the Site in February, the compressor circuit breaker was tripped which prevented the skimming pumps from operating.

Due to low recovery observed during 2008, active recovery efforts at wells MW-17, MW-20, and R-3 were suspended during 2009 and 2010 to assess equilibrium fluid levels in these wells.

3.1.2 Mechanical Hydrocarbon Recovery

Table 2 provides a summary of mechanical hydrocarbon recovery for each of the active recovery wells during the 2010 Program. As indicated in Table 2, approximately 476.5 gallons of free-phase hydrocarbon were mechanically recovered from the recovery system during the January, and March through December 2010 periods (i.e., the months the system was active), resulting in an average Site wide recovery rate of 3.12 gallons per day (gpd). Hydrocarbon recovery from wells MW-13 and R-4 contributed to the majority of the 2010 total recovered volume.

Table 3 summarizes system-wide hydrocarbon recovery activities for all years of recovery system operation. As presented in Table 3, approximately 3,717 gallons of hydrocarbon have been mechanically recovered since the system was installed in August 2005. Based on the average recovery rate values provided in Table 3, a decrease in the observed recovery rate of approximately 42% has occurred since 2005 (i.e., 5.4 gpd to 1.2 gpd). The recovery rate estimates presented in Table 3 take into account obvious non-operational periods; however, minor operational issues are not considered (e.g., insignificant down-time at a single skimming well). As discussed later in this document, it is estimated that the observed decrease in the overall system recovery rate is related to reduction in hydrocarbon mobility as well as the operation efficiency of the recovery system itself.

3.1.3 Manual Hydrocarbon Recovery

Manual recovery was only completed as part of the baildown tests in August 2010 and again in December 2010 at wells R-3, MW-10R, MW-27, MW-28, MW-29, MW-30, and MW-34 17, and MW-20 to purge free-phase hydrocarbon and to confirm fluid levels in these wells. Approximately 18.25 gallons were purged from baildown test wells in August 2010. Approximately 12 gallons of hydrocarbon was recovered during the December 2010 Site visit from the wells MW-27, MW-28, MW-29, MW-30, and MW-34. Manual recovery was purposely limited during the 2010 Program to support plume migration, gradient monitoring, and baildown testing efforts.

3.1.4 Plume Migration Monitoring

3.1.4.1 Free-Phase Hydrocarbon Baildown Testing Results

Hydrocarbon baildown testing was conducted at R-3, MW-10R, MW-27, MW-28, and MW-29 wells during the 2010 Program. Table 4 summarizes the hydrocarbon transmissivities which have been estimated using the baildown test data provided in Appendix E. The following summarize the main observations related to the baildown testing activities:

- Plume monitoring wells R-3, MW-10R, MW-27, MW-28, and MW-29 required in excess of four months to equilibrate after the purging of hydrocarbons at the start of the test.
- Overall, free-phase hydrocarbon transmissivity decreases by three orders of magnitude in the downgradient direction over a 100 foot span (i.e., from wells R-4 to MW-27).

Since 2003, when initial baildown tests were performed at the Site, the transmissivities at wells MW-12, MW-13, and MW-17 have decreased between 29% and 98% due to recovery efforts as noted in Table 4. Baildown tests completed in 2010 focused on wells on the edges of the LNAPL extent at the Site (i.e., MW-10R, MW-27, MW-28, and MW-29) and free-phase hydrocarbon transmissivities in these wells ranged from 0.002 to 0.01 ft^2/day.

Based on the large decrease in transmissivity towards the property boundary, and the very low transmissivities exhibited at the plume edge, no significant free-phase hydrocarbon migration is occurring from the center of the plume towards the western periphery near MW-27. If significant free-phase hydrocarbon migration is occurring at the Site, it is expected that hydrocarbon transmissivities would increase over time. Continued baildown test information will provide a valuable data for future Site plume migration monitoring activities and support the evaluation of continued operation of the recovery system.

3.1.4.2 Free-Phase Hydrocarbon Plume Monitoring

Another function of the plume monitoring wells is to support estimation of the free-phase hydrocarbon gradient at the Site. The hydrocarbon gradient can be another tool used to evaluate the potential for hydrocarbon to migrate from the Site. To calculate the hydrocarbon gradient, fluid level measurements are collected from wells which exhibit steady-state conditions (i.e., equilibrium) so that a free-phase hydrocarbon head can be calculated. Plume monitoring wells were allowed to equilibrate during a part of 2010, providing the data to calculate the free-phase hydrocarbon head and allowing calculation of the hydrocarbon gradient. The free-phase hydrocarbon head for each well was estimated using the methodology described in the following sections.

It has previously been demonstrated that free-phase hydrocarbon exists in a confined state below the water table at the Site (*Pilot Study Report, April 2005).* Based on this observation, the static hydrocarbon/water interface does not change significantly with changes in the water table. This is because free-phase hydrocarbon is confined from above by the finer grained confining layer as well as from below by the water. Both aquifer fluids (i.e., water and free-phase hydrocarbon) are also considered to be incompressible. As such, during confined conditions, the top and bottom of the mobile hydrocarbon interval remain at constant elevations. Therefore, if a well representing confined free-phase hydrocarbon reaches equilibrium and the hydrocarbon/water interface is gauged, then the static hydrocarbon/water interface is known for any water table conditions which result in the aquifer being confined.

In addition to the static hydrocarbon/water interface remaining constant with changes in the water table, the air/hydrocarbon interface is directly related to the water table under confined conditions. Both of these values, under static conditions, represent the confining pressure of the aquifer. However, the corrected groundwater elevation represents the aquifer pressure in terms of water head, whereas the air/hydrocarbon interface represents the aquifer pressure in terms of free-phase hydrocarbon head relative to the static hydrocarbon/water interface.

Although the fluid levels collected from the Site monitoring wells do not routinely represent equilibrium conditions for hydrocarbon, they are a good estimate of the equilibrium conditions in terms of water head, or corrected groundwater elevation, at the hydrocarbon/water interface. Under confined conditions, the static air/hydrocarbon interface also represents the aquifer pressure at the hydrocarbon/water interface. Therefore, if the static hydrocarbon/water interface and corrected groundwater elevation are known, the static air/hydrocarbon interface can be calculated using the difference in density of the two fluids.

To calculate the static air/hydrocarbon interface at certain Site wells, the corrected groundwater elevations that occurred during the high and low water table events at a majority of the wells in 2010 (i.e., August and January, respectively) were used in conjunction with the static hydrocarbon/water interface. The estimated static hydrocarbon/water interfaces for a line of wells that is generally parallel to the hydraulic gradient at the Site is shown in Figure 3. The hydrographs used to estimate these static hydrocarbon/water elevations are provided in Appendix F. The corrected groundwater elevations and the resulting calculated air/hydrocarbon interface elevation are also shown in Figure 3. Based on the data for wells presented in Figure 3, the hydrocarbon gradient for both high and low water table conditions are generally in the westerly direction. The very low hydrocarbon transmissivities observed for wells MW-27, MW-28, and MW-29, may be due to the variability in the elevation of the confining layer (i.e., the confining layer is located at a lower elevation in the vicinity of MW-27 and MW-29), as indicated in Figure 3, limiting the extent of the free-phase hydrocarbon plume.

Based on the calculated static air/hydrocarbon interfaces, the hydrocarbon gradient between two sets of locations was estimated for both the high and the low water table events. These results are provided in Table 5. Additionally, the hydrocarbon seepage velocities were estimated based on the formation thickness of hydrocarbon and the transmissivities provided in Table 5. As indicated in Table 5, the calculated seepage velocities represent the high and low water table conditions, and illustrate hydrocarbon seepage velocities from the interior of the plume and downgradient, at the edge of the plume. These velocities are theoretical because they assume a homogenous soil type where hydrocarbon migration is not inhibited by entry pressure head effects. As indicated in Table 5, the hydrocarbon seepage rates (i.e., migration rates) at the interior of the plume are as high as 14 feet/year, whereas hydrocarbon seepage rates near the edge of the plume are as high as 0.06

feet/year. At this theoretical rate, at the edge of the plume, it would take more than 500 years for free-phase hydrocarbon to migrate from well MW-22 to MW-28.

3.1.4.3 Free-Phase Hydrocarbon Migration Monitoring

Although the free-phase hydrocarbon gradient exists to drive hydrocarbons beyond its current extent (Figure 3), entry pressure head effects, as well as recovery efforts, are likely inhibiting migration beyond the current plume extents. This conclusion is supported by the rapid decrease in free-phase hydrocarbon transmissivity near the edge of the plume (i.e., 0.5 ft^2/day down to $1x10^{-3}$ ft^2/day).

Additionally, laboratory core analyses completed in 2005, provided in Appendix G, used Site-specific fluids and soil combined with the centrifugal method (ASTM D6838M) to generate a capillary pressure versus free-phase hydrocarbon saturation profile. These tests can be used to estimate the minimum displacement pressure which free-phase hydrocarbon must possess to displace water out of adjacent pores (i.e., the minimum head to migrate under confined conditions). Highly permeable materials such as gravels have low entry pressure heads. Free-phase hydrocarbon can displace water existing in gravels easily because the pore spaces are large and represent low capillary pressure when free-phase hydrocarbon occupies the pore space. Whereas finer grained materials require higher free-phase hydrocarbon head because the pores are smaller in diameter and represent larger capillary pressure for free-phase hydrocarbon to overcome in order to displace water.

The 2005 laboratory data indicated that the minimum free-phase hydrocarbon head required for migration was between 1.25 feet and 1.8 feet. The low transmissivity at MW-27 indicates that the free-phase hydrocarbon at this location (i.e., at the edge of the hydrocarbon plume) has insufficient capillary head to migrate beyond the current plume extent. For example, recovery well MW-13 has approximately 2.4 feet of capillary head (i.e., formation thickness) and exhibits a transmissivity of 0.5 ft^2/day, whereas the calculated transmissivity for MW-27 of $9x10^{-3}$ ft^2/day would indicate a significantly lower capillary head at this location.

The 2005 core analyses were collected from two relatively coarse grained intervals at well MW-17. The mean grain size values from the capillary pressure samples were 0.124 mm and 0.081 mm. The average mean grain size measured from all samples measured at soil boring locations R-3, MW-12, MW-17 and R-2 near the mobile hydrocarbon interval was 0.051 mm. The grain size distribution data is provided in Appendix G. Based on this evaluation, the average soil type across the Site would be expected to be finer grained and represent a higher entry pressure head than the values represented by the two core samples. The existing free-phase hydrocarbon head differences near the edge of the plume do not represent the high potential for additional free-phase hydrocarbon migration.

3.1.5 Groundwater Flow

Table 6 presents groundwater elevation data calculated using the fluid level measurements collected at the Site during the August 2010 groundwater monitoring event. Figure 4 illustrates the groundwater elevation contours and generalized groundwater flow direction for the Site based on the August 2010 water level measurement data.

As indicated in Figure 4, groundwater flow is generally to the west/northwest. These results are consistent with groundwater flow data associated with previous fluid level monitoring activities.

3.1.6 Groundwater Field Measurement Results

Table 7 summarizes the groundwater field measurement data obtained during the August 2010 groundwater sampling event. As indicated in Table 7, DO ranged from 0.25 to 5.96 milligrams per liter (mg/L), Redox Potential ranged from -129.2 to 145.5 millivolts, pH in groundwater ranged from 6.75 to 7.24, conductivity ranged from 329 to 2,145 micromhos per centimeter, and temperature ranged from 13.65 to 16.50 degrees Celsius. Ferrous iron was not detected in groundwater samples collected during the 2010 Program.

3.1.7 Analytical Results

The following sections present the results of the data validation and laboratory analytical programs completed for the August 2010 groundwater sampling event. Copies of the laboratory analytical reports and chain-of-custody forms are provided in Appendix H.

3.1.7.1 Regulatory Framework

The laboratory analytical data generated during the 2010 Program has been tabulated and compared against applicable regulatory standards promulgated by the Iowa Department of Natural Resources (IDNR). The Statewide Standards for Non-Protected Groundwater (SSNGW) are the applicable regulatory standards for groundwater and were developed by the Iowa Land Recycling Program (ILRP). Because no standard exists for total extractable hydrocarbons in the SSNGW regulations, Leaking Underground Storage Tank (LUST) Tier 1 values were used for comparison purposes. The criteria applied to the August 2010 analytical data are provided in Table 8.

3.1.7.2 Data Validation Results

Upon receipt of the analytical reports, AECOM performed a QA/QC review (i.e., data validation) of the 2010 Program data. The data validation effort was based on currently applicable USEPA guidance. The purpose of the data validation effort was to ensure that the data generated during the 2010 groundwater monitoring program are valid for their intended uses. The results of the data validation program are presented in Appendix I. The data validation effort assessed the precision, accuracy, method compliance, and completeness of the data. The Relative Percent Difference (RPD) evaluation for the 2010 groundwater monitoring program data is provided as part of the Appendix I information.

The data validation results for this project indicate the subject data set is of acceptable quality and is valid for its intended use. During the data validation process, certain discrete data were qualified by the data validator due to the data not meeting certain validation criteria. However, these data qualifications did not affect the overall data completeness objective for the project data set. A summary of the data qualifications applied to the subject data set is provided in Appendix I.

3.1.7.3 2010 Program Laboratory Analytical Results

Table 8 presents PAH, OA1, and OA2 analytical results. Natural attenuation data associated with the 2010 Program are presented in Table 9.

<u>OA1 – THC as Gasoline and BTEX</u>

A total of 12 groundwater samples, including one duplicate sample collected at well MW-6, were analyzed for OA1 during the August 2010 groundwater sampling event. Parameters comprising the

OA1 analysis include THC as gasoline and BTEX. Table 8 summarizes the OA1 analytical results for groundwater samples collected during the 2010 Program.

As indicated in Table 8, benzene, ethylbenzene, and THC as gasoline were detected at low levels in the sample collected from monitoring well MW-6. The concentrations of benzene and ethylbenzene noted in the sample collected from well MW-6 were below the applied screening criteria. There is no applicable screening criterion for THC as gasoline. No OA1 parameters were detected in the samples collected from the remaining wells evaluated as part of the 2010 Program.

OA2 – THC as Diesel Fuel

A total of 12 groundwater samples, including one duplicate sample collected at well MW-6, were analyzed for OA2 during the August 2010 groundwater sampling event. Parameters comprising the OA2 analysis include THC as diesel fuel, fuel oil, jet fuel, kerosene, mineral spirits, and motor oil. Table 8 summarizes the OA2 analytical results for groundwater samples collected during the 2010 Program. As indicated in Table 8, THC as diesel fuel was detected in the samples collected from monitoring wells MW-6 (i.e., primary and duplicate samples) and MW-31. The concentrations of THC as diesel fuel noted in the samples collected from MW-6 were above the applied screening criteria of 75 mg/L. The concentration of THC as diesel fuel noted in the sample collected from MW-31 was below the applied screening criteria. No OA2 parameters were detected in the samples collected from the remaining wells evaluated as part of the 2010 Program.

PAHs

A total of 12 groundwater samples, including one duplicate sample collected at well MW-6, were analyzed for PAHs during the August 2010 groundwater sampling event. Table 8 summarizes the PAH analytical results for groundwater samples collected during the 2010 Program. As indicated in Table 8, PAH parameters were detected in the samples collected from monitoring wells MW-6, MW-24, and MW-31. The concentrations of the detected PAH parameters in the samples collected from the subject wells were below the applied screening criteria. PAH parameters were not detected in the samples collected from the remaining wells evaluated as part of the 2010 Program.

Natural Attenuation Assessment Parameters

Samples from 11 groundwater monitoring wells were submitted for a set of natural attenuation assessment parameters during the 2010 Program. Natural attenuation assessment parameters included: methane, nitrate/nitrite, phosphorus, sulfate, TKN, and TOC. Table 9 summarizes the results of these laboratory analyses. Additionally, certain field parameters were measured as part of the natural attenuation assessment (e.g., Redox, DO). Table 7 summarizes the results of the field measurements collected during the August 2010 sampling event.

The natural attenuation assessment presented in this section includes a discussion of the Redox Potential, sulfate, nitrate, TKN, phosphorus, TOC, and methane parameters. These natural attenuation evaluation parameters provide a distinct pattern that is indicative of increased biological activity.

- Redox Potential – Redox Potential provides a measure of the level of aerobic and anaerobic groundwater conditions. Decreased values of Redox Potential in wells located within, or downgradient of, the area of petroleum hydrocarbon impacts (e.g., MW-6 and MW-31), compared to values at wells located outside the area influenced by petroleum hydrocarbons (e.g., MW-16, MW-21, MW-25, and MW-26), are indicative of enhanced microbiological activity.

- Sulfate – Sulfate is a potential electron acceptor that is reduced under anaerobic conditions. Decreased levels of sulfate are an indication of anaerobic biodegradation processes. The highest concentrations of sulfate were observed at groundwater monitoring wells MW-15, MW-25, and MW-26. Sulfate was not detected in monitoring wells MW-6 and MW-31, which are located within the area of petroleum impacts. This pattern of sulfate concentrations in groundwater provides evidence indicative of anaerobic biodegradation.
- Nitrate – Nitrate is a potential electron acceptor during denitrification. Nitrate was not detected in monitoring wells MW-6 and MW-31. Decreased levels of nitrate within the area of petroleum impacts (e.g., MW-6 and MW-31), compared to values at wells located outside the area influenced by petroleum hydrocarbons (e.g., MW-16, MW-19, MW-21, MW-25, and MW-26), are indicative of biodegradation via a denitrification pathway.
- Phosphorus/TKN/TOC – Increased levels of these parameters in wells located within the area of petroleum impacts (e.g., MW-6 and MW-31) provide an indication of the presence of nutrients in groundwater required for microbial metabolism and biodegradation.
- Methane – Methane is almost exclusively produced through biogenic processes. Methane was detected at much higher levels at monitoring wells MW-6 and MW-31 relative to other areas of the Site. Detection of methane in groundwater located within the area of petroleum hydrocarbon impacts provides a strong indication of microbiological activity. Highly reducing conditions required for methanogenesis to occur are also represented by the negative Redox Potential measurements in groundwater noted within the subject area of the Site.

The remaining parameters considered as part of the natural attenuation evaluation do not provide a clear or conclusive pattern indicative of increased biological activity.

4.0 Summary and Recommendations

The following sections summarize the results of the 2010 Program.

4.1 Summary

4.1.1 Petroleum Hydrocarbon Recovery

Based on the results of the 2010 Program, hydrocarbon recovery activities at the Site continue to meet the objectives presented in the 2007 Annual Report. The hydrocarbon recovery objectives are provided below along with information related to progress toward achieving the specific objective:

Objective: Site wide LNAPL transmissivity assessment and reduction through practicable recovery.

- Based on Interstate Technology and Regulatory Council (ITRC) guidance, and a review of the LNAPL site conceptual model, an appropriate endpoint for hydraulic recovery of LNAPL at the Site is between 0.1 to 0.8 ft^2/day. Continued hydraulic recovery of LNAPL once transmissivities achieve this range will not significantly reduce the dissolved phase hydrocarbon impacts or limit migration risk.
  - The LNAPL transmissivities at the center of the LNAPL plume are within or near the range of endpoint transmissivities. For these wells (i.e., MW-13, R-1, and R-4), LNAPL mechanical recovery will continue to lower transmissivities further.
  - On the edges of the LNAPL plume, the transmissivities are as much as two orders of magnitude below this range and recovery has been, or will be, suspended at wells MW-12, MW-17, MW-19, MW-20, R-3, and R-2.
- The mechanical hydrocarbon recovery rate observed during the 2010 Program was 1.2 gpd. The hydrocarbon recovery rate has declined since active hydrocarbon recovery was initiated in August 2005 (i.e., from 5.4 gpd to 1.2 gpd) – the recovery rate decrease is likely related to both a reduction in free-phase hydrocarbon mobility as a result of recovery activities and the operational efficiency of the hydrocarbon recovery system.
- Approximately 504 gallons of free-phase hydrocarbon were recovered from the Site in 2010 (i.e., via mechanical and manual methods).
- Approximately 3,717 gallons of free-phase hydrocarbon have been recovered at the Site since 2005.
- At the current hydrocarbon recovery rate, it would take more than 20 additional years to recover the estimated 20,000 to 30,000 gallons of remaining recoverable free-phase hydrocarbon volume (i.e., as presented in the 2007 Annual Report) – the actual recovery time may be significantly longer as the recovery rate will continue to decline with time.
  - As discussed in the 2007 Annual Report, it is not feasible to remove all of the estimated recoverable free-phase hydrocarbon.
  - Demonstration of plume stability is a more appropriate metric to evaluate hydrocarbon conditions at the Site as opposed to a volumetric or recovery rate based endpoint.

Objective: Analyze site gradients and their effect on the stability of the LNAPL plume

- Existing data indicate that the free-phase hydrocarbon gradient at the Site is toward the west.
- The reduction in hydrocarbon mass (i.e., 3,717 gallons of free-phase hydrocarbon removed from the Site) has decreased the hydrocarbon gradients and has reduced the potential for off-site migration.
- Free-phase hydrocarbon transmissivities decrease significantly from the center of the plume to the edge of the hydrocarbon plume – this indicates that no significant free-phase hydrocarbon migration is occurring from the center of the plume toward the western periphery.
- Seepage velocity calculations at the edge of the LNAPL plume support that LNAPL would require many years to migrate any significant distance.

Objective: Analyze LNAPL formation thickness and entry pressure head at the edge of the LNAPL plume

- The plume stability evaluation has illustrated that the free-phase hydrocarbon at the edge of the hydrocarbon plume currently has insufficient capillary head to migrate beyond the observed plume extent (i.e., based on the low transmissivities observed at MW-27, MW-28, and MW-29).
- LNAPL at the edge of the plume has not appeared in new wells since the installation of the plume migration monitoring wells in 2007.

4.1.2 Groundwater Conditions

The following summary statements are based on groundwater monitoring data gathered as part of the 2010 Program:

- Groundwater flow continues to be primarily toward the west/northwest.
- Only one exceedance of the applied screening criteria was noted for groundwater samples collected during the 2010 Program.
  - An exceedance of the screening criteria for THC as diesel fuel was noted in the sample collected from well MW-6. This well is located within the area of free-phase hydrocarbon at the Site.
- The majority of the dissolved phase parameters detected during the 2010 Program were associated with samples collected from wells within, or immediately adjacent to, the free-phase hydrocarbon plume (i.e., MW-6 and MW-31).
  - Benzene and ethylbenzene were detected in the groundwater sample collected from MW-6 at concentrations below the applied screening criteria.
  - THC as gasoline was only detected in the groundwater sample collected from well MW-6 during the 2010 Program, at a concentration below the applied screening criteria.
  - THC as diesel fuel was detected in samples collected from wells MW-6 and MW-31. The concentration of THC as diesel fuel noted at MW-6 exceeds the applied screening criteria.

- PAH parameters consisting of acenaphthene (MW-6 and MW-31), acenaphthylene (MW-6 and MW-31), anthracene (MW-6, MW-24, and MW-31), benzo(a)anthracene (MW-24), benzo(a)pyrene (MW-24), benzo(b)fluoranthene (MW-24), chrysene (MW-24), fluoranthene (MW-6 and MW-24), fluorene (MW-6 and MW-31), naphthalene (MW-6 and MW-31), phenanthrene (MW-6 and MW-31), and pyrene (MW-6, MW-24, and MW-31) were detected at concentrations below the applied screening criteria.

- Certain low-level PAH parameters were detected in only one of the monitoring wells located along the periphery of the Former Fueling and Distribution Area (i.e., MW-24). No detections of the 2010 analytical program parameters were noted in peripheral wells MW-15, MW-16, MW-19, MW-21, MW-22, MW-23, MW-25, and MW-26.
- Natural attenuation data collected during the 2010 Program indicated the continued occurrence of *in situ* biodegradation processes in groundwater.

4.2 Regulatory Status

To date, no information regarding the environmental status of the Site has been submitted to the Iowa Department of Natural Resources (IDNR). Applicable IDNR regulations require removal of free-phase petroleum hydrocarbons.

Regulations regarding groundwater and free-phase hydrocarbon impacts fall under three different regulatory programs within the IDNR including the overriding Iowa Groundwater Protection Act (IGPA), the Land Recycling Program (LRP), and the Underground Storage Tank (UST) Section. Dissolved phase concentrations within wells located outside the free-phase hydrocarbon plume area, as noted above, are consistently below the IDNR screening criteria applied to the Site. All of the programs reference the same metrics for free-phase hydrocarbon remediation, requiring recovery if either:

- Recovery rates exceed of 0.1 gal/month any month during a one year period unless another plan is approved by the department
- Free-phase hydrocarbon well thicknesses exceeds 0.02 feet during any month during a one year period

Each of the regulatory programs also provides language indicating other more practicable metrics could be applied to a site, on a site-specific basis.

4.3 Recommendations

Based on data collected during the 2010 Program, AECOM recommends the following activities for the Site in 2011:

- Complete one round of groundwater sampling, including collection of natural attenuation assessment parameters (July 2011)
- Continue operation of the hydrocarbon recovery system and associated monthly Site inspections.
  - To maintain compliance with IDNR regulatory requirements related to free-phase hydrocarbon
  - To allow further evaluation of plume migration potential

- Operation of the recovery system may be suspended at times to allow certain wells to reach equilibrium prior to baildown testing

- Collect undisturbed soil cores at three locations from within and along the edge of the free-phase hydrocarbon plume to confirm the LNAPL saturations and soil properties at the Site.
- Continue to opportunistically schedule baildown tests to evaluate hydrocarbon recovery rate (i.e., to allow comparison to system hydrocarbon recovery rates) and to monitor hydrocarbon transmissivities within and along the downgradient edge of the hydrocarbon plume.
- Continue to gauge recovery wells and plume monitoring wells in order to provide data useable for gradient analysis.
- Re-develop certain recovery wells and plume monitoring wells, as needed, to ensure that free-phase hydrocarbon collection is not being inhibited by siltation within the wells.
- Plume stability evaluation efforts will be focused on the interior of the plume and on the interaction between the interior of the plume and migration potential at the periphery. If additional data demonstrates interior plume stability, recovery wells could be shutdown in a phased approach until Site data warrants a full system shutdown.
- LNAPL site conceptual models (LSCMs) will be updated as new data from the planned 2011 activities is obtained.

The 2010 EIS Sheet is provided in Appendix J.

5.0 References

AECOM, Inc. (AECOM), 2009. *2008 Hydrocarbon Recovery and Groundwater Monitoring Report – Former Fueling and Distribution Area, Council Bluffs Yard, Council Bluffs, Iowa. St. Paul, Minnesota.* AECOM. September 2009.

AECOM, Inc. (AECOM), 2011. *2009 Hydrocarbon Recovery and Groundwater Monitoring Report – Former Fueling and Distribution Area, Council Bluffs Yard, Council Bluffs, Iowa. St. Paul, Minnesota.* AECOM. March 2011.

Earth Tech, Inc. (Earth Tech), 2003. *Phase II Environmental Site Assessment. - Council Bluffs Yard*. Minneapolis, Minnesota. Earth Tech May 2003.

ENSR Corporation (ESNR), 2008. *2007 Hydrocarbon Recovery and Groundwater Monitoring Report – Former Fueling and Distribution Area, Council Bluffs Yard, Council Bluffs, Iowa. St. Paul, Minnesota.* ENSR. May 2008.

The RETEC Group, Inc. (RETEC), 2001. *Phase I Environmental Site Assessment – Council Bluffs, Iowa.* St. Paul, Minnesota. RETEC. December 2001.

The RETEC Group, Inc. (RETEC), 2004. *Phase IIIA Environmental Site Assessment – Council Bluffs, Iowa*. St. Paul, Minnesota. RETEC. April 2004.

The RETEC Group, Inc. (RETEC), 2005. *Pilot Study Report – Council Bluffs, Iowa*. St. Paul, Minnesota. RETEC. April 2005.

The RETEC Group, Inc. (RETEC), 2005. *LNAPL Skimming System Operation Manual and As-Builts – Council Bluffs, Iowa.* St. Paul, Minnesota. RETEC. November 2005.

The RETEC Group, Inc. (RETEC), 2006. *LNAPL Recovery Operations and Maintenance Report – Council Bluffs, Iowa.* St. Paul, Minnesota. RETEC. March 2006.

The RETEC Group, Inc. (RETEC), 2006. *2005 Groundwater Monitoring Report – Council Bluffs, Iowa.* St. Paul, Minnesota. RETEC. April 2006.

The RETEC Group, Inc. (RETEC), 2007. *2006 Hydrocarbon Recovery and Groundwater Monitoring Report – Former Fueling and Distribution Area, Council Bluffs Yard, Council Bluffs, Iowa.* St. Paul, Minnesota. RETEC. April 2007.