Vol 1 of 3

15-59022

0312310003 - Cook
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**ERM**

FILE COPY

March 11, 2015

Mr. Ed Salch
Illinois Environmental Protection Agency
Bureau of Land
Remedial Project Management Section
Site Remediation Program
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

RE: Focused Remedial Action Completion Report
LPC# 0312310003 – Cook County
Former Andrew Corporation Facility
10500 West 153rd Street
Orland Park, Illinois

Dear Mr. Salch:

On behalf of on behalf of Andrew, LLC, Environmental Resources Management, Inc. (ERM) is submitting one original and one copy of the enclosed Focused Remedial Action Completion Report (RACR) for the subject site (the "Site") for review and approval.

This report presents the successful remedial actions completed as proposed in the ERM's *Focused Remedial Action Plan* dated July 2013.

Please feel free to contact me at 847-258-8983 with any questions or comments.

IEPA-DIVISION OF RECORDS MANAGEMENT
RELEASABLE
APR 10 2015
REVIEWER: MJK

Sincerely,

Keith R. Fetzner

Keith R. Fetzner, P.G.
*Principal Consultant*

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MAR 24 2015
IEPA/BOL

Enclosure: Focused Remedial Action Completion Report

CC: Joee Kvetensky (with enclosure)
William Toole, Esq. (with enclosure)
Andrew Masura, Orland Park Library – Andrew Site Repository (with enclosure)

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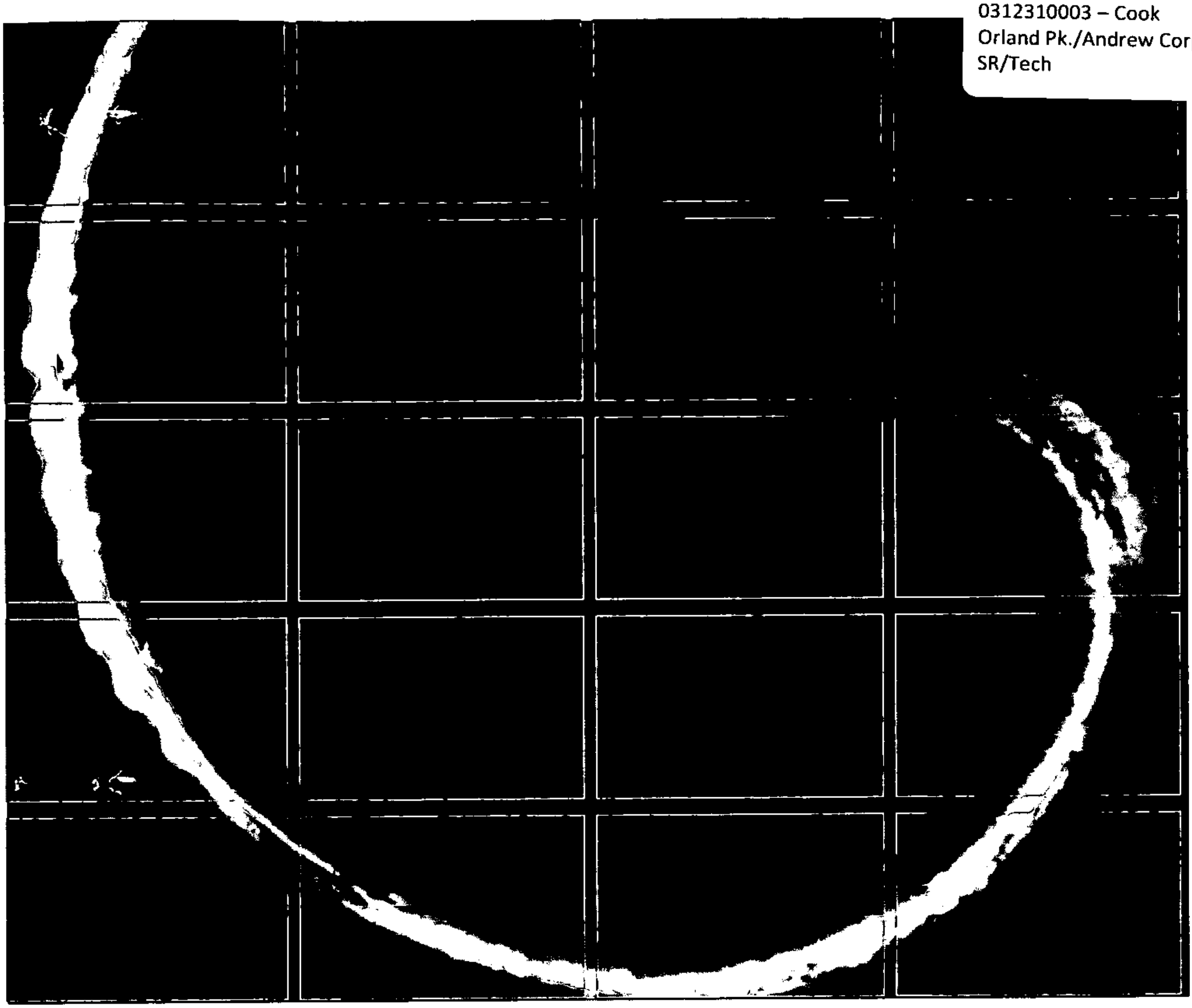

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# Focused Remedial Action Completion Report

**Andrew, LLC**
**LPC# 0312310003**
**10500 WEST 153rd STREET**
**ORLAND PARK, ILLINOIS**

March 2015

**www.erm.com**

Andrew, LLC

# Focused Remedial Action Completion Report

*10500 West 153rd Street*
*Orland Park, Illinois*

March 2015

Project Number: 0240393

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## *EXECUTIVE SUMMARY*

Environmental Resources Management, Inc. (ERM) prepared this Focused Remedial Action Completion Report (RACR) on behalf of the Remedial Applicant, Andrew, LLC (Andrew), regarding the site located at 10500 West 153rd Street in Orland Park, Illinois (the "*Site*").

Andrew is pursuing a focused industrial-commercial use No Further Remediation (NFR) letter through the Illinois Environmental Protection Agency's (IEPA) Site Remediation Program (SRP). This RACR addresses the last of three tasks necessary for the issuance of the NFR letter, specifically remediation of chlorinated solvent, non-aqueous phase liquid (NAPL) located on the northern portion of the Site. The first of the three tasks involved recording the IEPA-approved environmental land use control (ELUC) prohibiting the use of ground water on the eastern adjoining Norfolk Southern Railroad right-of way parcel in May 2013. The second involved the removal of a concrete floor impacted by polychlorinated biphenyls (PCBs) in the summer of 2013. The remediation was documented in the *Focused Remedial Action Completion Report* dated November 2013, which was approved by the IEPA in a letter dated January 23, 2014. The final action was remediation of solvent NAPL impact proposed in ERM's *Remedial Action Plan* dated July 2013 (the "2013 RAP"), which is described in this report.

In 2011 and 2012, NAPL was found at various depths up to 16 to 20 feet below ground surface (BGS) in two areas approximately 1,000 square feet ($ft^2$) and 3,000 $ft^2$ in area located south of former Building B near the zero valent iron remediation pilot study area. The NAPL consisted primarily of 1,1,1-trichloroethane (1,1,1-TCA), but also contained a mixture of other chlorinated and non-chlorinated volatile organic compounds (VOCs) including trichloroethene (TCE), tetrachloroethene (PCE), xylenes, acetone, and various degradation products.

In the approved 2013 RAP, Andrew outlined a pathway for obtaining a focused NFR letter that included the exclusion of the exposure routes of concern (i.e., the industrial-commercial and construction worker outdoor inhalation, indoor inhalation, and ground water ingestion pathways) and removal of free product to the extent practicable (Title 35, Illinois Administrative Code (IAC), 742.320) and the selected remediation technology was *in situ* Electrical Resistance Heating (ERH). The ERH system was installed from June to September 2014 and operated from September to November 2014. The ERH system increased the average subsurface temperature from nominally 15 °C to 83.5 °C which promoted vaporization of 1,1,1-TCA and other VOCs in the NAPL-impacted areas. The subsurface heating also enhanced the rate of degradation of 1,1,1-TCA and volatilization of the other dissolved gases which aided in the volatilization of VOCs. Interim sampling suggested that the NAPL removal was completed by mid-November 2014, approximately seven weeks after startup. No NAPL was observed during confirmation soil and ground water sampling in the two remediation areas conducted between November 2014 and January 2015 and the detected VOC concentrations are not indicative of the presence of NAPL.

Based on the completion of the remedial actions described in this report, ERM respectfully requests that the IEPA approve the completed remedial action for the NAPL and issue a focused NFR letter incorporating the environmental land use controls and engineering controls proposed in the 2013 RAP. The proposed land use controls and engineering controls consist of the following:

- A site-wide industrial-commercial property use restriction;
- Engineered barriers in accordance with 35 IAC 742 1105(c)(3) in the area shown on Figure 5-1 to exclude the industrial-commercial outdoor inhalation exposure route (the area is currently paved with asphalt);
- Construction worker caution in the areas shown on Figure 5-1;
- A site-wide ground water use restriction; and
- Site-wide requirement for installation and operation of a building control technology in accordance with 35 IAC 742 Subpart L to exclude the indoor inhalation exposure route.

The Site Remediation Program DRM-2 form is included in Appendix A of this report.

## 1.0 INTRODUCTION

Environmental Resources Management, Inc. (ERM) prepared this Focused Remedial Action Completion Report (RACR) on behalf of the Remedial Applicant (RA), Andrew, LLC (Andrew), regarding the site located at 10500 West 153rd Street in Orland Park, Illinois (the "*Site*"). Figures 1-1 and 1-2 show the Site location and layout. Note that Andrew demolished the buildings at the Site in 2013 and that Figure 1-2 shows the Site layout before the demolition activities.

Andrew is pursuing a focused industrial-commercial use No Further Remediation (NFR) letter through participation in the Illinois Environmental Protection Agency's (IEPA) Site Remediation Program (SRP). This RACR addresses the last of three tasks necessary for the NFR letter, specifically remediation of chlorinated solvent non-aqueous phase liquid (NAPL) located on the northern portion of the Site. The following sections further describe the Site, past investigations, and remedial actions conducted regarding the chlorinated solvent NAPL.

### 1.1 SITE DESCRIPTION

The Site consists of approximately 75 acres of land located west of the Norfolk Southern Railroad, north of 153rd Street, east of 108th Avenue and south of 143rd Street in Orland Park, Illinois (Figures 1-1 and 1-2).

The Site was formerly improved with six main buildings ranging in size from 9,730 square feet ($ft^2$) to 345,815 $ft^2$. Two former water supply wells used for the former industrial processes were previously located on the Site and were abandoned in December 2012 as described in ERM's letter report submitted to the IEPA on March 11, 2013. The Site also includes an 11.5-acre drainage retention pond (also known as Lake Andrew) located in the northwestern portion of the Site.

The surrounding property uses are residential to the east and residential and recreational (golf course) to the north and west. The property south of the Site is currently being redeveloped into multi-unit residential properties. A Norfolk Southern railroad line is located along the eastern Site boundary.

As described in reports previously submitted to the IEPA, the Site has been unoccupied since 2007 when Andrew moved operations to other facilities. The historical operations at the Site included the manufacture of communication equipment, antennas, connectors, and antenna cables for the telecommunications industry from 1954, when the first portion of Building A was constructed, to 2007. Andrew demolished the Site buildings in 2013.

## 1.2 *BACKGROUND*

ERM's *Focused Site Investigation and Remediation Objectives Report* dated July 2010 (the "*FSIROR*") describes past investigations that have been conducted at the Site since 2005. The investigation activities included the collection of soil, ground water, surface water, and sediment samples, and analyses for volatile organic compounds (VOCs), polynuclear aromatic hydrocarbons (PNAs), polychlorinated biphenyls (PCBs), Resource Conservation and Recovery Act (RCRA) metals, and total hexavalent chromium.

Concentrations of chlorinated VOCs, namely 1,1,1-trichloroethane (1,1,1-TCA), trichloroethene (TCE), and tetrachloroethene (PCE) were identified in soil and ground water in two areas of the Site ("*North Area*" and "*South Area*") at concentrations above the Tier 1 soil or ground water remediation objectives (ROs) in Title 35, Illinois Administrative Code (IAC), Part 742 (35 IAC 742) entitled *Tiered Approach to Corrective Action Objectives* (TACO). The source of the VOCs detected at the Site is unknown, but is suspected to be related to the historical use of solvents at the Site.

Additional investigations were conducted on the eastern adjoining residential properties in the fall of 2010 to assess the presence of VOCs to the east of the Site. No off-site impacts were found beyond the Norfolk Southern Railroad right-of way. Potential impacts that may have migrated onto the adjoining railroad right-of-way are addressed with the IEPA-approved environmental land use control (ELUC) implemented on the railroad right-of-way in May 2013, which prohibits the use of ground water and eliminates the potential exposure route of concern.

Andrew conducted a pre-demolition building materials survey in 2011 that identified polychlorinated biphenyl (PCB) concentrations in a portion of the main facility (former Building A) concrete floor that were above the unrestricted use TACO Tier 1 ROs. The source of the PCBs was unknown. ERM submitted a *Focused Remedial Action Plan* dated February 2012 (the "*2012 RAP*") to remove and dispose of the concrete floor during building demolition. The 2012 RAP was approved by the IEPA in February 2013, and the work was completed from August 2013 to September 2013. Remedial activities for the PCB impacted concrete are described in ERM's *Focused Remedial Action Completion Report* dated November 2013, which was approved by the IEPA in a letter dated January 23, 2014.

A pilot remediation study involving the introduction of approximately 21 tons of zero valent iron (ZVI) and 16.5 tons of bentonite was conducted in

October 2010 pursuant to the *ZVI/Clay In-Situ Pilot Study Work Plan* dated August 19, 2010, as described in the Zero Valent Iron/Clay *In-Situ* Remediation Pilot 3-Month Status Report dated May 2011. Later that year NAPL was detected in the North Area during ground water monitoring conducted in connection with the ZVI/bentonite remediation pilot study. The NAPL consisted primarily of 1,1,1-TCA, but also contained a mixture of other chlorinated and non-chlorinated VOCs including TCE, PCE, xylenes, acetone, and various degradation products. The presence of the NAPL impacted the effectiveness of the pilot study.

The NAPL had not been detected during prior investigations and the extent was not known. To further evaluate the NAPL, ERM conducted additional investigation of the extent from August 2012 to November 2012 as described in ERM's *Northern Impacted Area Additional Site Investigation* dated March 2013 (the "*NAPL Investigation Report*") approved by the IEPA in a letter dated April 11, 2013. The investigation identified two areas of detectable or potential free-phase NAPL:

- The eastern area, adjacent to the pilot study area, contains detectable NAPL and is approximately 3,000 $ft^2$ in area to a depth between 16-20 below ground surface (BGS); and
- The western area, located 100 feet west of the pilot study area, is approximately 1,000 $ft^2$ in area and to a similar depth as the eastern area. NAPL was not detected in the western area, however, VOC concentrations in the soil and ground water suggest the likely presence of NAPL in this location.

The two areas are shown on Figure 1-3.

Andrew anticipates obtaining a focused NFR letter incorporating an industrial-commercial use restriction through the exclusion of the exposure routes of concern. The exposures routes of concern are (1) industrial-commercial and construction worker outdoor inhalation, (2) indoor inhalation, and (3) ground water ingestion. A requirement for exclusion of the ground water ingestion exposure route is the removal of free product to the extent practicable (Title 35, Illinois Administrative Code (IAC), 742.320). As a result, corrective action was necessary to remediate the NAPL to the extent practicable. ERM submitted the *Focused Remedial Action Plan* dated July 2013 (the "*2013 RAP*"), which proposed *in situ* electrical resistance heating (ERH) to increase the subsurface temperature to promote vaporization and degradation of 1,1,1-TCA and other VOCs in the NAPL-impacted areas. The IEPA approved the 2013

RAP in a letter dated August 13, 2013 and the remediation work was conducted in the fall of 2014.

The following sections describe the work conducted at the Site to implement the remedial actions proposed in the 2013 RAP.

## 2.0 *FIELD ACTIVITIES*

## 2.1 *DESCRIPTION OF THE REMEDIATION WORK*

The FSIROR and NAPL Investigation Report described the investigations conducted that identified the two NAPL-impacted areas designated for ERH treatment. As described in the RAP, ERM proposed to remediate the NAPL *in situ* using ERH to heat the subsurface soil and ground water to enhance volatilization and the ongoing hydrolysis of the NAPL. The ERH system consisted of 34 electrodes placed in the subsurface throughout the remediation areas, a power control unit (PCU), vapor recovery system, steam condensation and vapor-liquid separation system with a cooling tower, and three carbon vessels to control air emissions. Further description of the individual system components is included in the RAP.

ERM subcontracted the remediation services of the TRS Group of Longview, Washington, a licensed supplier of ERH equipment and services and an ERM-approved subcontractor. TRS conducted the installation and operation of the remediation system. ERM provided TRS with direction on where the system electrodes needed to be installed to remediate the NAPL-impacted areas and also conducted the monitoring and confirmation sampling and analysis. Those activities are described further in the following sections:

### 2.1.1 *Permitting*

ERM submitted an application to enter the Site and ERH system into the IEPA's Registration of Smaller Sources (ROSS) program in March 2014. The IEPA issued a permit in April 2014. Key emission limitations under the ROSS program include:

- < 5 tons per year (TPY) combined criteria pollutants
- < 0.5 TPY of hazardous air pollutant (HAP) emissions
- < 0.05 TPY of lead emissions
- < 0.05 TPY of mercury emissions

Lead and mercury were not potential emission issues since the impact is from VOCs. ERM conducted air emission sampling during the remediation activities to monitor VOC emissions as described further in Section 2.1.3.

The only other applicable permit was for installation of the electrical service to the ERM system, which TRS obtained from the Village of Orland Park. Copies of the applications and permits are included in Appendix B.

### 2.1.2 *ERH System Installation*

Site preparation and paving to reduce ponding of rainwater in the eastern remediation area started in Jun 2014. The system installation phase was completed in July 2014 and included drilling and constructing the electrodes in the two NAPL-impacted areas. These are shown as Area 1 to the west and Area 2 to the east on Figure 2-1. Originally, 24 electrodes total, on an approximately 20-foot spacing were proposed for both the remediation areas. During installation, additional NAPL impact was found beneath a former subsurface electrical line along the western boundary of the east NAPL area (Area 2). As a result, 10 additional electrodes were installed to address the expanded area. The area along the electric line could not be investigated in the past because the electrical line was energized until the facility was demolished in 2013. Figure 2-1 shows the electrode locations. Photographs from the installation activities are included in Appendix C.

TRS subcontracted Terra Probe Environmental, Inc. from Ottawa Lake, Michigan to install the electrodes and remediation monitoring wells. Terra Probe used solid stem auger drilling methods to drill each electrode location to a depth of approximately 21 feet BGS using 12-inch diameter augers. The electrodes in the ZVI pilot study area were installed to a depth of approximately 25 feet BSG, since that area is mounded approximately 3 feet above the surrounding grade. Soil boring logs are included in Appendix D.

To construct the electrode, an approximately 18-foot long section of carbon steel angle iron was placed in the borehole with two electrical wire leads connected to the top. The annular space was backfilled with electrically conductive graphite material with approximately 5-10% iron pellets. A 3-foot section of 1.5-inch diameter stainless steel vapor recovery well screen was place above the top of the electrode, backfilled with sand, and the surface finished with concrete. The vapor recovery well screen was connected to 1.5-inch diameter flexible hosing that was connected to the 3-inch diameter PVC vapor recovery system piping installed later.

Five temperature monitoring points (TMP) were installed to a depth of approximately 20 feet BGS. Each TMP thermocouple was connected to a

1-inch diameter black steel pipe. The annular space was backfilled with cement grouted to the surface. Four temperature sensors were set in each location at depths of 6, 10, 14, and 18 feet BGS. The sensors were connected to the ERH control system in the PCU.

Four remediation monitoring wells were installed in key locations shown on Figure 2-1 (RMW-1 through RMW-4). Each monitoring well was installed at a depth of approximately 20 feet BGS and constructed using 2-inch diameter 10-foot long stainless steel screens with stainless steel risers. The annular space was filled with sand up to 2 feet above the screen and then sealed with cement grout to the surface. The surface was finished with a stickup well cover and each well capped with a sealed fitting and valve-sample tubing assembly set to collect a sample from a depth of approximately 15 feet BGS. This valve-sample tubing assembly was used to ensure safe handling of hot liquids.

The wells were constructed of stainless steel, rather than polyvinyl chloride, to withstand the elevated temperatures during heating. Also, the wells were sealed with threaded removable caps fitted with dedicated Teflon sampling lines to reduce the risk of exposure to steam, hot vapors, and heated water in addition to reducing the potential for exposure to electrical energy during operation of the system.

Soil cuttings from the electrode, monitoring well, and TMP installation were collected in five 20 cubic yard roll off boxes and disposed by Heritage Thermal Services. Copies of the waste disposal records are included in Appendix E.

The aboveground system components were installed between August and September 2014 and included the power control unit (PCU), steam condensation and vapor-liquid separation system, equipment/tool storage Conex box, 25 horsepower vacuum blower, two 1,000-pound vapor phase, granular activated carbon vessels, two step down electrical transformers, and vapor recovery piping. Security around the remediation area was maintained using a fence line surrounding the area and a security system consisting of motion-detecting sensors that would disconnect power to the system and notify the Orland Park police department.

ComEd connected the electrical service to the system on September 16, 2014. TRS finished the system installation and testing and began operation on September 23, 2014.

### 2.1.3 *ERH System Operation*

The system was operated between September 23, 2014 and November 14, 2014. The vapor extraction system continued to operate for two additional weeks until November 29, 2014, until the confirmation sample analyses results were received. During operation, the system consumed a total of 327,144 kilowatt hours of electricity and increased the average subsurface temperature from nominally 15 °C to 83.5 °C with the highest being 101 °C at TMP D9 at 10 feet BGS.

TRS measured air exhaust flow from the vacuum blower throughout operation. ERM conducted 24 air emission sample events (approximately three per week) collecting air samples before and after the two carbon vessels using the TO-15 sampling method. Sampling results indicated that approximately 960 pounds of total VOCs were extracted from the subsurface and approximately half was captured by the carbon vessels. The carbon vessels were changed out on October 31, 2014 after emission sampling suggested the carbon was spent.

After confirmation sampling was completed, TRS demobilized the aboveground equipment and fencing from the Site in December 2014. The electrical transformer was removed from the site on December 23, 2014 by ComEd and the carbon vessels were removed from the Site by Calgon on January 19, 2015. Copies of the waste disposal records are included in Appendix E.

## 2.2 *INTERIM AND CONFIRMATION SAMPLING*

### 2.2.1 *Interim Sampling*

ERM conducted interim sampling in the four remediation ground water monitoring wells in the two remediation areas up to seven times during the remediation activities. Some wells were sampled more than others depending on how quickly remediation objectives were met. The wells are labeled as RMW-1, RMW-2, RMW-3, and RMW-4 on Figure 2-1.

The interim sampling consisted of analysis of the ground water samples for the following:

- VOCs;
- pH;
- Total Organic Carbon;
- Nitrogen, Nitrate-Nitrite;

- Sulfide;
- Chloride;
- Potassium;
- Calcium;
- Iron;
- Magnesium;
- Manganese;
- Sodium;
- Sulfate;
- Alkalinity (as $CaCO_3$);
- Dissolved methane;
- Dissolved ethane;
- Dissolved ethene;
- Dissolved carbon dioxide;
- Dissolved oxygen;
- Dissolved nitrogen; and
- Compound Specific Isotope Analyses (CSIA) for $^{13}C$ for the isomers, 1,1,1-TCA, 1,1-DCE, 1,1-DCA, 1,1,1-TCA and cis-1,2-DCE.

Additionally, field readings were collected for:

- Temperature (°C);
- Dissolved Oxygen (milligram per liter [mg/L]);
- Oxidation-Reduction Potential (mV);
- pH (pH units); and
- Conductivity (µS/cm).

Ground water samples were collected for analysis using low-flow sampling procedures. As the subsurface temperatures increased, the water samples were cooled prior to collection by running the sample through a dedicated copper tubing cooling coil placed in an ice bath. The samples were placed in laboratory-supplied and preserved containers and then placed in a cooler with ice as preservation for delivery to the laboratory.

The increase in the 1,1,1-TCA concentration in the November 5, 2014 sample event in RMW-2 raised concerns that vapors were condensing as a result of ponded water on the surface. ERM suspected the ponded water was infiltrating into the granular sub-base beneath the pavement, cooling the shallow subsurface soils and vapors causing the 1,1,1-TCA to condense. The condensed 1,1,1-TCA would have reacted with the flow-through cell (used to monitor some Site ground water geochemical parameters) damaging the components, so subsequent sampling of the remediation monitoring wells was conducted using bailer sampling methodology.

Site wide ground water monitoring well water level measurements were collected on November 5, 2014 to assess ground water flow direction during operations. Shallow ground water is found at depths generally between 5 to 10 feet BGS and the flow direction is generally to the west towards Lake Andrew similar to past measurements in the FSIROR. Figure 2-2 presents the ground water contours based on those measurements.

The interim samples were submitted to ALS for VOC, major ion, and dissolved gasses (except hydrogen) analyses and to Pace in Pittsburg, Pennsylvania, for dissolved hydrogen and CSIA analyses. The field measurement, major ion, and dissolved gases results are summarized in Table 2-1. The VOC analytical results are summarized in Table 2-2. The CSIA analyses are summarized in Table 2-3. The ALS laboratory analytical reports and Pace dissolved hydrogen laboratory analytical reports are included as Appendix F. The CSIA laboratory analytical reports are included in Appendix G.

The sample laboratory analytical results showed a significant decrease in the VOC concentrations in ground water to levels that indicate the NAPL is no longer present. Generally, VOCs in all wells decreased consistently from the baseline concentrations except monitoring well RMW-2 (located in the ZVI pilot study area). 1,1,1-TCA fluctuated initially in well RMW-2 and then continually to decreased after four weeks.

### 2.2.2 *Inorganic Groundwater Chemistry*

ERH treatment results in soil and ground water heating and degradation of chlorinated VOCs, causing an increase in chloride. Changes in redox potential and pH also occur resulting in changes in the groundwater chemistry, which can impact the operation of the treatment system. For example: the precipitation of minerals such as dolomite ($CaMg(CO_3)_2$) and hematite ($Fe_3O_4$) that may result from these physical and chemical changes related to ERH have the potential for silting of wells and clogging of filters.

ERM analyzed the ground water for inorganic chemistry parameters on the same schedule as the remediation progress monitoring to evaluate the potential for system operational issues. The analytical results are summarized in Table 2-1.

ERM modeled this data (Ca, Mg, Na, K, alkalinity, chloride, sulfate, iron, and manganese) using the REACT module of the Geochemist's Workbench®[1] for the purpose of comparing the data to equilibrium conditions, tracking the changes in groundwater chemistry, and providing input on the nature of the mineral precipitate, which could then be used to direct the operator as to the appropriate maintenance. Figure 2-3 graphically depicts the data on a Piper Trilinear Diagram to display the data from all of the samples together. From Figure 2-3, it can be seen that there is a greater variation in anion concentrations versus cation concentrations, as is typical for *in situ* thermal treatment. The reason for this is the dehalogenation of 1,1,1-TCA and TCE, resulting in increased chloride concentrations.

ERM also sampled the groundwater for acetic acid because it is the hydrolysis reaction daughter compound for 1,1,1-TCA. Together, the compound specific isotope analysis (CSIA; Section 2.2.4) and the acetic acid concentrations provided ERM with the data to interpret the concentration reduction mechanisms.

### 2.2.3 *Dissolved Gas Concentrations*

ERM monitored dissolved gases in groundwater throughout the treatment. The measured dissolved gas concentrations are summarized in Table 2-1. The gases ethane and ethene are end point products generated from the sequential reductive dehalogenation of the trichlorinated ethane and ethene compounds, respectively. Methane is produced by the breakdown of organic matter in water under highly anaerobic conditions, where oxygen from the water molecule or carbon dioxide provides the terminal electron acceptor in this reaction. Nitrogen, carbon dioxide, and oxygen are present reflecting equilibrium with the atmosphere as modified by such processes as de-nitrification, producing nitrogen gas from nitrate and nitrite. $CO_2$ may be produced through organic and inorganic reactions and as noted above, may be consumed in the methanogenesis reaction. Carbonate minerals in groundwater provide buffering to neutralize acids. Acetic acid is produced in the hydrolysis reaction breaking down 1,1,1-TCA. The lowering of the pH in association with the production of acetic acid also increases carbon dioxide concentrations. This neutralization reaction will naturally adjust the pH to more natural levels with time.

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[1] Copyright, the University of Illinois

### 2.2.4 *Compound Specific Isotope Analysis.*

ERM used compound specific isotope analysis (CSIA) as part of the monitoring to better define the concentration reduction mechanisms at the various monitoring locations. This involved the analysis for $^{13}C$ isotope in the isomers 1,1,1-TCA, TCE, cis-1,2-dichlorothene 1,1-dichloroethane, and 1,1-dichloroethene. According to Hunkeler, et al., (2008)[2], CSIA can provide an in-depth understanding of biodegradation or abiotic transformation processes in contaminated aquifers. The site remediation goal was removal of NAPL. While this is typically tracked by monitoring the concentrations of VOCs in groundwater confirmed by VOC concentrations in soil, CSIA analysis allowed ERM to take the data a step further. CSIA was used to evaluate the concentration reduction processes that took place during heating and continued after the power input was discontinued. Table 2-3 presents a summary of the VOC concentrations and associated values for $\delta^{13}C$.

$\delta^{13}C$ values are referenced to an international standard known as Pee Dee Belmonite, referring to a carbonate rock formation in South Carolina. $\delta^{13}C$ can be negative or positive relative to this standard. Isotope ratios are presented in units of "per mil" (‰). The accuracy of the measurements for $\delta^{13}C$ are ± 1‰ and because of this, changes in $\delta^{13}C$ greater than 2‰ are considered significant for the interpretation of fractionation. As the chemicals degrade in the groundwater, the $^{12}C$ bonds are broken in preference to the $^{13}C$ bonds. Since the convention is to reference to $^{13}C$, $^{13}C$ becomes relatively enriched relative to $^{12}C$ and the isotope ratio is said to get heavier. The process is referred to as "fractionation". This fractionation provides insight into the concentration reduction mechanisms.

Figures 2-4 and 2-5 present $\delta^{13}C$ for 1,1,1-TCA and TCE respectively for the four wells that were used to track the remedial progress. For each well, the isotope ratio trajectory of the change in $\delta^{13}C$ from one measurement to the next is diagnostic of the concentration change mechanism. For example, Figure 2-4 identifies the grouping of concentrations and $\delta^{13}C$ ratios that represent the source ratio. Subsequent measurements tracking to the upper left quadrant represent a degradation

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[2] Hunkeler, D., R.U. Meckenstock, B.S. Lollar, T.C. Schmidt, & J.T. Wilson (2008). A guide for assessing biodegradation and source identification of organic ground water contaminants using compound specific isotope analysis (CSIA). U.S. Environmental Protection Agency, Office of Research and Development, EPA 600/R-08/148.

("D" in Figure 2-4) mechanism (i.e., $\delta^{13}C$ gets heavier, while concentrations decrease). $\delta^{13}C$ ratios tracking to the lower left quadrant represent vaporization (V; Sturchio, et al., 2000[3]). Tracking to the lower right quadrant represents heat-enhanced dissolution (HED) and to the upper right represents the least observed heat enhanced condition of heat enhanced dissolution plus degradation (HED+D).

For 1,1,1-TCA (Figure 2-4) at well RMW-1, we see $\delta^{13}C$ in the encircled source isotope range, and with the concentration of 110 mg/L, 1,1,1-TCA was likely present as NAPL (i.e., 8.46% of aqueous solubility; 1,300 mg/l per 35 IL Admin Code 742). At 25°C, the 1,1,1-TCA concentration is reduced ( from 110 mg/l to 24 mg/l) and the isotope ratio is lighter, indicating vaporization is the dominant concentration reduction mechanism, although $\delta^{13}C$ is increased from -23.72‰ to -23.29‰, which may not be significant. All subsequent measurements for RMW-1 show a degradation mechanism. Similarly, well RMW-2 showed $\delta^{13}C$ and concentrations consistent with the source ratios and concentrations becoming heavier source ratios and concentrations up until the November 18, 2014 sampling. The last measurement taken on December 4, 2014 shows degradation as the dominant concentration reduction mechanism for 1,1,1-TCA, while concentration reductions continued in December 4, 2014 (14 mg/l) and January 15, 2015 (10 mg/l). Wells RMW-3 and 4 show vaporization as the predominant concentration reduction mechanism.

As depicted in Figure 2-5, TCE was tracked at three wells (RMW-2, -3, -4; TCE in RMW-1 was detectable at only one time during treatment). All three wells show TCE to follow a degradation pathway in the latter stages of treatment.

The CSIA data demonstrates continued concentration reduction through degradation mechanisms at all four monitoring locations.

### 2.2.5 *Confirmation Sampling*

As proposed in the 2013 RAP, ERM conducted confirmation soil and ground water sampling events in 10 locations in the two remediation areas in addition to the four remediation monitoring wells between

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[3] Sturchio, N. C., L. Heraty, B. D. Holt, L. Huang, T. Abrajano, and G. Smith (2000) *Stable Isotope Diagnostics of Chlorinated Solvent Behavior in Contaminated Aquifers.* Proceedings of the Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22-25, 2000, Monterey, CA

November 18, 2014 and December 8, 2014 after interim sample results suggested the NAPL impact was remediated. See Figure 2-1. The sample locations were based on locations with suspected or confirmed NAPL identified in the 2012 NAPL investigation and during installation of the ERH remediation system electrodes and remediation monitoring wells.

ERM contracted GeoServe, Inc. (GeoServe) of Woodstock, Illinois to drill the soil borings and install the temporary monitoring wells on November 18, 2014. Each soil boring was continuously sampled to a depth of 20 to 24 feet BGS using a 4-foot long sampler containing a new disposable plastic or Teflon™ liner for each 4-foot interval. Discrete soil samples were field screened for volatile organic compounds (VOCs) using the headspace technique and a Rugged MiniRAE 2000 meter photoionization detector (PID) equipped with a 10.6 eV bulb. Appendix D contains soil boring logs that describe the observations made during drilling and field screening.

It was not possible to field screen the soil samples for VOCs using a PID and the headspace method because of the elevated soil temperature (50-80 °C.) As a result, ERM sampled each 4-foot interval and placed the samples in laboratory-supplied and preserved containers using the United States Environmental Protection Agency (USEPA) Method 5035 for VOCs sampling protocol. The samples were then placed in a cooler with ice for preservation until delivery to the laboratory.

The soil samples were submitted to ALS Laboratory Group (ALS) in Holland, Michigan using standard chain-of-custody procedures. The soil samples were analyzed for VOCs by SW-846 Method 5035A/8260B. The soil sample analytical results are summarized in Table 2-4. Soil boring logs summarizing site geology, sample intervals, and boring descriptions are included in Appendix C. The laboratory analytical reports are included as Appendix H.

A 1-inch diameter polyvinyl chloride (PVC) temporary ground water monitoring well with a 10-foot screen was installed in each soil boring with the exception of locations CS-1, CS-3, and CB-9 which were located next to remediation monitoring wells RMW-1, RMW-4, and RMW-2, respectively. Each location was sampled using the methods used during the interim sampling. Ground water samples were collected for analysis on November 18, 2014, December 4, 2014, and December 8, 2014 using low-flow sampling procedures or a bailer. Some monitoring wells, (i.e. RMW-2, 3, and 4) were sampled on additional dates to further evaluate decreases in VOC concentrations. The samples were placed in laboratory-supplied and preserved containers and then placed in a cooler with ice for preservation until delivery to the laboratory. The samples were submitted to ALS for analysis of VOCs by SW-846 Method 8260B. The ground water sample analytical results are summarized in Table 2-5. The laboratory analytical reports are included as Appendix I.

The VOC concentrations in all 41 soil samples were below TACO Tier 1 soil saturation (Csat) concentrations. Additionally, none of the VOC concentrations in the final ground water samples suggested the presence of solvent NAPL. The soil sample analytical results are summarized in Table 2-4 and the ground water sample analytical results are summarized in Table 2-5. Tables 2-6 and 2-7 summarize VOC concentrations in soil and ground water, respectively, from past investigations in addition to the recent results for samples from the remediation activities.

## 3.0 *TIER 2 GROUND WATER EVALUATION*

As shown in Tables 2-6 and 2-7, residual concentrations of VOCs above Tier 1 ROs for the soil and ground water components of the Class II ground water ingestion pathway remain at the Site. To further evaluate these concentrations, ERM calculated Tier 2 ROs for the soil and ground water components of the ground water ingestion pathway.

## 3.1 *GROUND WATER COMPONENT OF THE CLASS II GROUND WATER INGESTION PATHWAY*

The following sections provide detail on the development of the Tier 2 ROs and demonstrate Site compliance with Tier 2 RO requirements. While Site ground water is classified as Class II, as a conservative measure Tier 2 ROs were calculated based on Class I ground water objectives.

### 3.1.1 *Characterization of the Extent for the Tier 2 Remediation Objective (35 IAC 742.805(a)[1])*

ERM's FSIROR describes the extent of soil and ground water impact at the Site. Tables 2-6 and 2-7 of this RACR summarize the concentrations of VOCs in soil and ground water at the Site following remediation. The extent of VOC impact above the Tier 1 ROs has been defined and is limited to two areas of the Site, one near the former railroad spur ("North Area") and the other on the eastern property line east of Building A ("South Area").

### 3.1.2 *Removal of Free Product (35 IAC 742.805(a)[2])*

This RACR documents the efforts completed by Andrew to remove free product at the Site. As discussed in Section 2.2.5, the soil and ground water sampling at the Site following remediation demonstrate free product has been removed. Therefore, this requirement has been met.

### 3.1.3 *Use of Equation R26 to Demonstrate Compliance with Tier 1 at the Point of Exposure (35 IAC 742.805(a)[3])*

In accordance with 35 IAC 742.805(a)[3], ERM calculated Tier 2 ROs for VOCs in ground water using Equation R26 based on a point of exposure at the Site Access Road on the east side of Lake Andrew. Andrew requests that a ground water use restriction for the Site be included in the NFR to allow for use of this compliance point. Equation R26 predicts the concentration of a dissolved compound at a distance X away from the source by using a measured concentration of the compound in the source area, the size of the source area, the degradation properties of the compound, and the hydraulic properties of the aquifer. For this Tier 2 RO calculation in which Site VOC impacts would meet the Tier 1 RO at distance X, the distance X equaled 354 feet for the North Area and 767 feet for the South Area to the point of exposure at the Access Road.

The following conservative assumptions were made for the calculations:

- *Size of the Source Area:* North Area: 533 feet perpendicular to fluid flow ($S_w$); South Area: 200 feet
- *Type of Aquifer:* Class II aquifer, but Class I ROs were used as a conservative measure.
- *Direction of Ground Water Flow:* West
- *Hydraulic Conductivity:* Per IEPA direction, the middle value of the aquifer's hydraulic conductivity measurements obtained via slug testing was used ($3.57 \times 10^{-6}$ centimeters per second [cm/s]).
- *Hydraulic Gradient:* A hydraulic gradient value of 0.0244 ft/ft was used (see Section 4.4 of the FSIROR).
- *Concentration of Contaminant in Ground Water at the Source ($C_{source}$):* The concentration of each VOC at the source was assumed to be the maximum concentration remaining following remediation.
- *Concentration of Ground Water at the Exposure Point, $C_{(x)}$:* This concentration was assumed to be the Tier 1 RO for Class I ground water.
- *Soil Physical Properties:* The default properties for subsurface soil in Table B of Appendix C of TACO were used, with the exception of the FOC for which the site-specific value of 0.012 g/g was used (see Table 4-2 of the FSIROR).

Other parameters used in the calculations (including the degradation constant, solubility in water, organic carbon-water partition coefficient, and Henry's law constant) were obtained from Table E of Appendix C of TACO, and are presented in Appendix J. Figure 3-1 indicates the source area dimensions and Figure 3-2 identifies the distance to the compliance point.

As shown in Table 3-1, the calculated Tier 2 RO for each VOC at the Site is greater than the maximum residual concentration. Therefore, VOCs do not pose a risk to human health at the point of exposure.

### 3.1.4 *Concentrations within Setback Zones (35 IAC 742.805(a)[4])*

As discussed in Section 5 of the SIROR, no public water supply wells are present within 2500 feet of the Site. Additionally, there are no private wells within 200 feet of the Site. Therefore, the source of the release is not located within the setback zone of any area wells.

### 3.1.5 *Concentrations at the Point of Discharge to the Nearest Surface Water (35 IAC 742.805(a)[5])*

The closest surface water body to the impacted areas of the Site is Lake Andrew in the northwestern portion of the Site. To evaluate the potential for Site ground water to affect Lake Andrew, ERM compared the concentration of each VOC present at concentrations above the Tier 1 ground water RO to the surface water quality criteria in 35 IAC 302.208(e). The concentrations of the following analytes were less than the surface water quality criteria at the source:

- North Area: 1,1,2-Trichloroethane, 1,2-dichloroethane, chloroform, methylene chloride, tetrachloroethene, and vinyl chloride.
- South Area: 1,1,2-Trichloroethane, 1,2-dichloroethane, cis-1,2-dichloroethene, methylene chloride, trichloroethene, and vinyl chloride.

For the other VOCs with concentrations in the source areas above the surface water quality criteria, the distance at which the concentration would meet the surface water quality was calculated using the R26 equation and the parameters described above in Section 3.1.3. The distance X was varied until the modeled concentration met the surface water quality criteria. As shown in Table 3-1, the distance for each analyte to meet the Tier 1 ROs is less than 354 feet, which is the shortest distance to the Access Road east of Lake Andrew. Therefore, Site ground water does not pose a risk to area surface water.

### 3.1.6 *MIXTURE RULE FOR GROUND WATER*

The mixture rule does not apply to Class II ground water, so this analysis is not required.

## 3.2 *SOIL COMPONENT OF THE CLASS II GROUND WATER INGESTION PATHWAY*

The following sections provide detail on the development of the Tier 2 remediation objectives for the soil component of the ground water ingestion pathway. While Site ground water is classified as Class II, as a conservative measure Tier 2 ROs were calculated based on Class I ground water objectives, consistent with the ground water component calculations.

### 3.2.1 *Use of Equation R26 to Demonstrate Compliance with Tier 1 at the Point of Exposure (35 IAC 742.805(a)[3])*

ERM developed Tier 2 ROs for the soil component of the ground water ingestion pathway in accordance with Section 742.710(d) using the SSL Equations S17, S18, and S19 in Appendix C of TACO. Subsurface soil default parameters were used in the calculations, with the exception of the FOC, which used a Site FOC of 1.2%. Chemical parameters from Table E of Appendix C of TACO were used in the calculations for all analytes in TACO. As permitted under Section 742.710(d)(1)(C) of TACO, the value for the ground water objective ($GW_{obj}$) was calculated using Equation R26 in Appendix C of TACO based on the maximum allowable distance to reach Tier 1 Class I ground water ROs. This calculation determines the highest permissible concentration in the source area that modeling demonstrates will meet Tier 1 ROs at the point of human exposure. In this case, a ground water use restriction will be enacted on the Site and the ground water must meet the Tier 1 ROs at the compliance point, which is the Access Road east of Lake Andrew.

Figure 3-1 illustrates the source widths and distances to the compliance point and Table 3-2 summarizes the calculations and the calculated Tier 2 ROs. The calculations and the values used for all variables are presented in Appendix K and are consistent with those used for the ground water calculations.

As shown in Table 3-2, the maximum remaining soil concentrations in each source area are below the calculated Tier 2 ROs. Therefore, residual soil impacts do not pose a risk to human health via the ground water ingestion pathway.

### 3.2.2 *Concentrations at the Point of Discharge to the Nearest Surface Water (35 IAC 742.805(a)[5])*

As previously mentioned, the closest surface water body to the impacted areas of the Site is Lake Andrew in the northwestern portion of the Site. To evaluate the potential for residual concentrations in Site soil to affect Lake Andrew, ERM calculated the distance using the R26 equation for the concentration of each VOC remaining in soil above the Tier 1 RO to meet the surface water quality criteria in 35 IAC 302.208(e). The concentrations of the following analytes were less than the surface water quality criteria at the source:

- North Area: 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, 1,2-dichloroethane, methylene chloride, tetrachloroethene, trans-1,2-dichloroethene, and vinyl chloride.
- South Area: Tetrachloroethene and trichloroethene.

For the VOCs with concentrations in the source areas above the surface water quality criteria, the distance at which the concentration would meet the surface water quality was calculated using the R26 equation and the parameters described above in Section 3.2.1. The distance X was varied until the modeled concentration met the surface water quality criteria. As shown in Table 3-2, the distance for each analyte to meet the Tier 1 ROs is less than 387 feet, which is the shortest distance from the impacted soil area to the Access Road east of Lake Andrew. Therefore, Site soil does not pose a risk to area surface water.

## 4.0 TIER 2 EVALUATION OF THE SOIL INHALATION PATHWAY

### 4.1 UPDATED TIER 2 ROS FOR THE INDUSTRIAL-COMMERCIAL AND CONSTRUCTION WORKER OUTDOOR INHALATION PATHWAYS

ERM calculated and presented Tier 2 ROs for the industrial-commercial worker and construction worker outdoor inhalation exposure pathways in the 2010 SIROR. Since that time, IEPA released a new version of TACO in July 2013 that contained updated physical constants for several VOCs. Therefore, ERM updated the Tier 2 RO calculations following the procedure outlined in Section 7.1 of the SIROR and using the physical constants in the July 2013 TACO. The updated calculations are presented in Appendix L.

ERM compared the soil concentrations remaining after completion of the remedial efforts to the updated Tier 2 ROs, as shown in Table 2-4. TCE was detected above the Tier 2 ROs for the industrial-commercial and construction worker exposure scenarios. The concentrations of all other analytes were below the Tier 2 ROs. TCE concentrations above the Tier 2 RO for the industrial-commercial inhalation pathway have been addressed using an engineered barrier. Concentrations above the RO for the construction worker inhalation pathway will be addressed with a construction worker caution in the NFR.

### 4.2 MIXTURE RULE

The mixture rule was established to address the effects of similar-acting compounds (*i.e.*, compounds that affect the same organ or organ system) detected above Tier 1 at the Site. In the Illinois Pollution Control Board's Opinion and Order of the Board date December 4, 1997, it is stated that:

> *"The mixture rule for similar-acting chemicals in soil is graduated. At Tier 1, it is not applicable. At Tier 2, it is applicable to noncarcinogens only. And at Tier 3, it is applicable to carcinogens and noncarcinogens. The mixture rule for similar-acting chemicals in Class I ground water uniformly spans all three tiers of TACO. It is applicable to both similar-acting carcinogens and noncarcinogens under all three tiers."*

Since Tier 2 ROs were calculated for the industrial-commercial worker and construction worker outdoor inhalation exposure pathways, ERM evaluated the effects of similar-acting noncarcinogenic compounds for these pathways to determine whether the cumulative risk is unacceptable in any samples with concentrations above the Tier 1 ROs and below the Tier 2 ROs. The first step was to identify all samples with concentrations of one or more analytes above the Tier 1 RO(s) and below the Tier 2 RO(s). These samples are shown in Table 4-1 for the industrial-commercial worker exposure scenario and Table 4-2 for the construction worker exposure scenario. Next, ERM identified the target organs for each detected compound and evaluated whether any of the detected compounds affected the same target organ(s) as the analytes detected above the Tier 1 ROs and below the Tier 2 ROs. The cumulative risk was then evaluated for each applicable sample for each affected target organ according to 35 IAC 742.720 by calculating the weighted average. The concentration of each individual compound affecting the target organ was divided by the RO for that compound, and the value for each compound added to determine the weighted average. A weighted average greater than 1 for a sample indicates an unacceptable risk requiring corrective action.

For the industrial-commercial pathway, only TCE was detected above the Tier 1 RO and below the Tier 2 RO. The target organs for TCE inhalation are the eye and the nervous system. No other detected compounds affect the eye, so a cumulative risk evaluation was not necessary for this organ. Several analytes affect the nervous system, so the cumulative risk was calculated for each sample. As shown in Table 4-1, the weighted average for all samples was less than 1, demonstrating the cumulative risk is acceptable.

For the construction worker pathway, the liver and the nervous system both are target organs affected by more than one analyte detected above the Tier 1 RO and below the Tier 2 RO. Therefore, the cumulative risk for each target organ was calculated for each sample in which an analyte affecting the target organ was present above the Tier 1 RO and below the Tier 2 RO. As shown in Table 4-2, the sample collected at SB-32 has a weighted average greater than 1 for the liver, indicating an unacceptable cumulative risk. A construction worker caution will be used to address the risk in this area.

## 5.0 *SPECIAL CONDITIONS*

This section describes the Special Conditions Andrew is implementing at the Site as part of the remedial action, including land use restrictions and a ground water use restriction on the Site.

## 5.1 *LAND USE RESTRICTIONS*

The following restrictions on the Site are to be included in the NFR letter as described in the IEPA-approved RAP:

- A site-wide industrial-commercial property use restriction;
- Construction worker caution in the areas shown on Figure 5-1 based on the Tier 2 ROs in Section 4 and remaining VOC concentrations;
- A site-wide ground water use restriction in the requested NFR letter and the May 2013 ELUC implemented for the potential off-site impacts to the eastern adjoining Norfolk-Southern Railroad right-of-way; and
- Site-wide requirement for installation and operation of a building control technology (i.e., passive or active vapor mitigation system) in accordance with 35 IAC 742 Subpart L to exclude the indoor inhalation exposure route, should habitable buildings be constructed at the Site in the future.
- Engineered barriers in accordance with 35 IAC 742 1105(c)(3) in the area shown on Figure 5-1 to exclude the industrial-commercial outdoor inhalation exposure route (the area is currently paved with asphalt) based on the Tier 2 ROs in Section 4 and remaining VOC concentrations. An engineered barrier will be maintained in this area in perpetuity;

Engineered barriers in accordance with 35 IAC 742 1105(c)(3) are as follows:

A) Caps or walls constructed of compacted clay, asphalt, concrete, or other material approved by the Agency;

B) Permanent structures such as buildings and highways; and

C) Soil, sand, gravel, or other geologic materials that:

i) Cover the contaminated media;

ii) Meet the soil remediation objectives under Subpart E for residential property for contaminants of concern; and

iii) Are a minimum of 10 feet in depth and not within 10 feet of any manmade pathway.

## 6.0 *EFFECTIVENESS OF THE REMEDIAL ACTION*

The ERH remediated the NAPL-impacted area. The effectiveness of the removal was confirmed by confirmation sampling which did not detect VOCs concentrations indicative of chlorinated solvent NAPL.

## 7.0 *SUMMARY*

The proposed remedial action was *in situ* ERH which was conducted from September to November 2014. ERH system increased the average subsurface temperature from nominally 15 °C to 83.5 °C which promoted vaporization of 1,1,1-TCA and other VOCs in the NAPL-impacted areas. The subsurface heating also enhanced the rate of degradation of 1,1,1-TCA and volatilization of the other dissolved gases which added to the volatilization of VOCs. Interim sampling suggested that the NAPL removal was completed by mid-November 2014, approximately seven weeks after startup. Confirmation soil and ground water sampling was completed in 10 locations in the two remediation areas and identified no VOC concentrations indicative of chlorinated solvent NAPL.

Based on the completion of the remedial actions described in this report, ERM respectfully requests that the IEPA approve the remedial actions for the NAPL impact issue at the Site and issue the requested focused NFR letter. Appendix L includes the Site legal description and the base map to be used in the requested NFR letter.