AECOM Environment

Prepared for:
City of Kenosha
Kenosha, Wisconsin

Prepared by:
AECOM
Milwaukee, WI
60328684
April 2015

Remedial Action Options Report
Former Kenosha Engine Plant
5555 - 30th Avenue, Kenosha, Wisconsin

WDNR FID 230004500, BRRTS #02-30-000327

AECOM Environment

Prepared for:
City of Kenosha
Kenosha, Wisconsin

Prepared by:
AECOM
Milwaukee, WI
60328684
April 2015

Remedial Action Options Report
Former Kenosha Engine Plant
5555 30th Avenue, Kenosha, Wisconsin

In conformance with NR 712.09 submittal certification requirements:

"I, Lanette Altenbach, hereby certify that I am a hydrogeologist as that term is defined in s. NR 712.03 (1), Wis. Adm. Code, am registered in accordance with the requirements of ch. GHSS 2, Wis. Adm. Code, or licensed in accordance with the requirements of ch. GHSS 3, Wis. Adm. Code, and that, to the best of my knowledge, all of the information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code."

WISCONSIN
LANETTE L. ALTENBACH
G - 167
MILWAUKEE, WI
PROFESSIONAL GEOLOGIST
4/6/15

Reviewed By: Lanette Altenbach, P.G.
Senior Hydrogeologist

"I, Kevin Brehm, hereby certify that I am a registered professional engineer in the State of Wisconsin, registered in accordance with the requirements of ch. A-E4, Wis. Adm. Code; that this document has been prepared in accordance with the Rules of Professional Conduct in ch.A-E8, Wis. Adm. Code, and that, to the best of my knowledge, all of the information contained in this document is correct and the document was prepared in compliance with all applicable requirements in chs. NR 700 to 726, Wis. Adm. Code."

WISCONSIN
Kevin L. Brehm
E30567
Milwaukee, WI
PROFESSIONAL ENGINEER
4/6/15

Reviewed By: Kevin L. Brehm, P.E.
Principal Engineer

Contents

List of Tables

List of Figures

List of Acronyms

AMC	American Motors Corporation
AST	Aboveground Storage Tank
bgs	below ground surface
CLP	Contract Laboratory Program
CS	Chrysler Sites
DNAPL	Dense non-aqueous phase liquid
ERD	Enhanced Reductive Dechlorination
ESA	Environmental Site Assessment
ES	Enforcement Standard
eV	electron volt
Hz	Hertz
ID	Inner diameter
ISCO	In Situ Chemical Oxidation
KEP	Kenosha Engine Plant
LNAPL	Light Non-Aqueous Phase Liquid
MNA	Monitored Natural Attenuation
MS	matrix spike
MSD	matrix spike duplicate
MSL	mean sea level
OD	Outer diameter
PAHs	Polycyclic aromatic hydrocarbons-compounds commonly associated with petroleum fluids
PAL	Preventive Action Limit
PCBs	polychlorinated biphenyls
PID	photo-ionization detector
ppm	Part per million
PRB	Permeable Reactive Barrier
PVC	Polyvinyl chloride
RAOR	Remedial Action Options Report
RCLs	Residual Contaminant Levels
RECs	Recognized Environmental Conditions
SI	Site Investigation
TCE	trichloroethene (or also trichloroethylene), a common chlorinated volatile organic compound used in the degreasing of metal parts and equipment.
USCS	Unified Soil Classification System
USEPA	United Stated Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tank
VOCs	volatile organic compounds
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources
WTM	Wisconsin Transverse Mercator

Executive Summary

AECOM Technical Services, Inc. (AECOM) has prepared this remedial action options report (RAOR) for the City of Kenosha to address impacts to soil and groundwater from automotive manufacturing operations at the former Kenosha Engine Plant (KEP). This report was prepared to meet Wisconsin Administrative Code (WAC) NR 722 requirements.

The KEP is located at 5555 - 30th Avenue in the city of Kenosha, Kenosha County, Wisconsin and includes approximately 100 acres of land. The property is currently vacant; however, the former building floors remain to act as a temporary barrier until remediation is conducted. The site is relatively flat with perimeter soil berms present along the north property boundary (along 52nd Street) and the east property boundary (26th Avenue) of the KEP. The KEP is divided into 12 separate areas or Chrysler Sites (CS areas), CS1 through CS12, to aid the investigation and remediation of the overall site. The purpose of the subdivision is to provide a means to focus on individual areas where current and historic uses provided logical groupings and to allow for added flexibility in future redevelopment. For this RAOR, the CS areas are used for identification and will allow for a phased remediation approach.

Widespread low-level impacts observed over most of the western two-thirds of the site are associated with the use of petroleum fuels, lubricants and metals. The magnitude of the soil impacts in this area varies from low levels just above groundwater pathway Residual Contaminant Levels (RCLs) to areas where contaminants occur in higher concentrations that warrant remedial action. The berms surrounding the property primarily have low concentration impacts by metals and polycyclic aromatic hydrocarbons (PAHs) which limits the use of the soil, particularly if not retained on-site.

Chlorinated volatile organic compounds (VOC) impacts were identified in CS3 extending northward into CS5 and eastward across the northern part of CS4 into CS8 at concentrations exceeding the groundwater pathway RCLs. Some of the detected concentrations were identified above 1,000 micrograms per kilogram (ug/kg), a value used to identify areas of source soil that may warrant active remediation. Smaller areas of chlorinated VOC impact (with generally lower concentrations) were identified in CS2, CS6, CS7 and CS10.

Groundwater impacts are present at the water table as well as deeper in the shallow aquifer, just above the clay till aquitard. The existing groundwater recovery systems are not treating the sources of the groundwater contamination but are primarily controlling groundwater flow and limiting migration of contamination. More active groundwater treatment at the source areas would be necessary to reduce contaminant mass to support stable to receding groundwater plume conditions where site closure could be achieved.

Five deeper source areas of trichloroethene (TCE) soil and groundwater impact have been identified in CS3-Building 53, CS5-Building 65 and at the northeastern boundary of CS4 extending into CS8. These source areas are degrading naturally via reductive dechlorination as evidenced by the higher concentrations of cis-1,2-dichloroethene and vinyl chloride observed in CS4 east of the source area in CS3. The degradation process appears to have stagnated at the vinyl chloride stage of the reductive dechlorination process because lesser dechlorination compounds such as 1,1-dichloroethene are not detected in the groundwater at the KEP.

The purpose of the RAOR is to present an appropriate range of alternatives for remediating impacted soil and groundwater at the KEP based on the chemicals present, the nature and extent of the contaminated media, site characteristics, and potential redevelopment plans. The initial phase of the remedial action option evaluation process focused on identifying remedial technologies that could be reasonably implemented to address impacts identified at one or more of the CS areas. Those remedial technologies deemed technically

and economically feasible for implementation at KEP were retained and then the retained remedial technologies were combined to form remedial alternatives/approaches that were evaluated in more detail.

The assembled alternatives were then evaluated in general accordance with NR 722. Based on this evaluation, Alternative 4 (Soil and Groundwater Source Control) appears to be the most technically and economically feasible alternative for implementation at the KEP. This remedy includes a combination of excavation, capping, and in-situ treatment using insitu chemical oxidation (ISCO) and/or enhanced reductive dechlorination (ERD). The selected approach addresses the remediation goals and objectives for site-wide management of residual soil and groundwater impacts, focusing on protection of human health and the environment while considering potential redeveloped site uses and available funding for remediation.

Additional pre-design data is needed to verify selection and implementation methods for ISCO and ERD. ISCO treatability testing is recommended to aid in the selection of the appropriate treatment chemistry and to establish site specific dosing needed to meet the remedial objectives. A properly designed ISCO dosing strategy can mitigate the over use of chemicals and water resources during field implementation. Based on the results of the treatability testing, field scale pilot testing will be performed to assess effectiveness in the field and to refine critical parameters needed for full scale design (delivery method, spacing, and dosages). Similarly, additional data is needed to support the selection and design for the ERD component of the remedial design, including possible field scale testing.

1.0 Introduction

AECOM Technical Services, Inc. (AECOM) has prepared a remedial action options report (RAOR) for the City of Kenosha to address impacts to soil and groundwater from automotive manufacturing operations at the former Kenosha Engine Plant (KEP). This report was prepared to meet Wisconsin Administrative Code (WAC) NR 722 requirements.

1.1 Project Participants

Owner	Consultant
City of Kenosha 625 52nd Street, Room 305 Kenosha, WI 53140 Contact: Shelly Billingsley 262-653-4149	AECOM 1555 River Center Drive, Suite 214 Milwaukee, WI 53212 Contact: Lanette Altenbach 414-944-6186

Oversight Agencies

Wisconsin Department of Natural Resources Southeast Region 141 NW Barstow St, Room 180 Waukesha, WI 53188 Contact: David Volkert 262-574-2166	US Environmental Protection Agency Region 5 77 W. Jackson Boulevard, Chicago, Il 60606 Contact: Kyle Rogers

1.2 Site Location and Description

The KEP is located in southeast ¼ of the southeast ¼ of Section 36, Township 2 North, Range 22 East (Figure 1). The KEP includes approximately 100 acres of land and is located at 5555 - 30th Avenue in the city of Kenosha, Kenosha County, Wisconsin. The property is currently vacant; however, the former building floors were retained to act as a temporary barrier until remediation is conducted. The site is relatively flat with soil berms present on the northern and eastern portions of the site. The overall site layout, including the surrounding properties, is shown on Figure 2.

The KEP is divided into 12 separate areas or Chrysler Sites (CS areas), CS1 through CS12, to aid the investigation and remediation of the overall site. The purpose of the subdivision is to provide a means to focus on individual areas where current and historic uses provided logical groupings and to allow for added flexibility in future redevelopment. For this Remedial Action Option Report (RAOR), the CS areas are used for identification and will allow for a phased remediation approach. The CS areas are depicted in Figure 3.

The site is relatively level and covered by impervious paving (asphalt and concrete that includes former building floors, loading docks, etc.) over 90% of the site. The former loading docks remain in place, but are planned for removal as remedial activities are conducted. Around the northern and eastern periphery are landscaped berms which have a maximum height of eight feet above the surrounding property and are composed of fill soils, likely originating from the site. Some of the berm soils may be suitable for reuse on-site as fill material for remedial excavations or low points in the topography when the loading docks are removed. These soils should not be used at depths below the water table. The site is enclosed by chain-link fencing.

1.3 Report Objectives

The purpose of this RAOR is to identify and evaluate the remedial options that will meet the following objectives:

1. Be regulatory compliant and acceptable to the oversight agencies.
2. Result in a reasonable cost and timeframe for remediation.
3. Permit non-residential redevelopment.

This report provides a general description of the extent of the identified soil and groundwater impacts, summarizes the interim remedial actions taken to date, and evaluates the remedial options for the KEP.

2.0 Background

The KEP consists of approximately 100 acres of land of which approximately 50 acres are covered by the former building footprints. The buildings were demolished in 2013 and the building floors were retained to act as a temporary cap. Historic operations at the site included complete automobile manufacturing and assembly, while more recent operations were focused on the manufacture of automotive engines.

2.1 Site Investigation and Prior Remedial Actions

Historic environmental impacts resulting from manufacturing operations were reported to the WDNR as they were discovered. To some extent these impacts were investigated and remedial efforts were conducted. Investigations were conducted in the 1990's prior to demolition of buildings where operations were discontinued. Underground storage tanks (USTs) were upgraded or removed and some remediation was conducted. The remediation generally consisted of soil removal and disposal and the installation of groundwater recovery systems.

A more recent site investigation was completed in 2014 conducted in general conformance with NR 716, Wis. Adm. Code (AECOM, March 2015). This section provides a general description of the site geology, hydrogeology, recent interim remedial actions, and a summary of the site investigation results.

2.1.1 Geology

Fill material covers the entire site; below, the site geology consists of glacio-lacustrine sand and silt that comprises the upper or shallow aquifer unit of the water table. Beneath the sand aquifer is the clay till that acts as an aquitard to the deeper bedrock aquifers due to its low hydraulic conductivity and permeability, moderate thickness, density, and regional extent. This clay till may contain groundwater at some locations, but is not capable of containing or transmitting significant quantities groundwater. A detailed description of the lithology encountered at the sites includes the following:

- The fill layer generally consists of clay, sand, silt, crushed gravel, and in some areas foundry sand, concrete, brick, wood, and demolition debris. The fill ranges in thickness from approximately 1.5 to 18.5 feet deep, with an average thickness of seven to nine feet. A fill thickness map, Figure 4, depicts the contoured thickness of fill across the KEP as well as locations of the foundry sand.
- Silty Clay/Clayey Silt – a discontinuous thin layer of fill material generally consisting of silty clay and clayey silt underlies the above fill unit. This layer is generally described as very dark brown to black, dry to moist, slightly-cohesive, low-plasticity, and soft.
- Sand/Silty Sand – this shallow aquifer generally consists of a brown, dry to wet, loose to dense sands and silts.
- Silt/Clayey Silt – a discontinuous layer of lacustrine silt and/or clay separates the fine sand aquifer from the glacial clay till below. This lacustrine layer is generally described as grayish brown, wet, cohesive, medium plasticity and firm to still.
- Clay till – a glacial till layer, which consists of dark gray, wet, cohesive, plastic, and hard clay with stones.

Cross-sections A-A' and B-B' (Figure 5), C-C' and D-D' (Figure 6) are representative of the site's geology.

2.1.2 Hydrogeology

The water table at KEP typically occurs at a depth of 8 to 11 feet below ground surface (bgs). Horizontal groundwater flow is generally towards the northeast, east, and southeast across the site, both at the water table and just above the clay-till boundary as depicted in Figure 7 (Water Table Contours – December 2014) and Figure 8 (Potentiometric Surface – KEP Piezometers – December 2014). The groundwater flow direction is fairly consistent throughout the year with a general eastward flow modified by the effect of the existing groundwater recovery systems. There is little seasonal variation.

Vertical gradients are generally low (less than 0.01 ft/ft to 0.11 ft/ft) and mixed (varying with recharge and other natural influences). There are five groundwater recovery systems which, when operating, influence local areas of flow on-site and help to maintain hydraulic containment of impacted groundwater.

The transmissivity (or ability to move water through the subsurface materials) is approximately 10^{-2} centimeters/second (cm/sec) in the sand (water table) portion of the uppermost aquifer and 10^{-3} cm/sec to 10^{-4} cm/sec deeper in the aquifer in silt, just above the clay till interface. Calculated horizontal linear velocities indicate that at the water table, in flow paths to existing groundwater recovery systems, the flow could be as high as 1700 feet per year. Other areas and within the silt portion of the aquifer, the flow rate ranges from a few feet per year to 200 feet per year.

2.2 Summary of Prior Remedial Actions

Historically, remedial activities conducted at the KEP by Chrysler responded to reported releases to the environment and subsurface conditions encountered during reconstruction of the facility. These remedial activities generally included soil excavation and installation/operation of groundwater recovery systems as documented in prior reports. In many cases the remedial activities were not complete remediation, but were instead implemented as source control measures. The residual impacts remaining after implementation of these historic remedial efforts were treated as impacted areas during the evaluation of the 2014 site investigation data.

2.2.1 Soil Excavation

In addition to the historic excavation activities conducted by Chrysler, more recent remedial excavations were conducted between 2012 and 2014 by the City of Kenosha. These excavation areas are illustrated on Figure 2 and are described below.

CS3

A release of hydraulic fluid occurred in the late 1990's or early 2000's resulting in an area of LNAPL accumulation along the western side of the former Building 53. Two recovery wells were installed by Chyrsler for the purposes of LNAPL removal. For approximately 10 years, Chrysler used passive recovery then in 2012 converted the wells to active pumping with limited success. Excavation of the impacted soils to the water table interface occurred in December 2014 during which approximately 4900 tons were removed. The soil excavation activities effectively removed the LNAPL from this area of the KEP. The soil removal and post-removal soil sample results are documented in the report titled "Remedial Action Documentation Report – Soil Removal under former Building 53, Kenosha Engine Plant", dated February 2015.

CS4

Removal of five underground storage tanks (USTs) occurred in November 2012. The USTs were newer tanks that were observed to be in good condition at the time of removal. Two historic releases were previously documented in the vicinity of the tank pit and the backfill surrounding the USTs had oily impact. Soil excavation activities were conducted concurrent with the UST removals to remove as much of the impacted soil as possible. The boundaries of the removal were limited by the presence of a nearby loading dock and some residual petroleum impacts remain at the excavation boundaries. Approximately 5,600 tons of impacted soil was removed as part of these actions. The UST removals and soil excavation activities are described in the report titled *Interim Action Report – UST and Soil Removal in CS4*, dated December 2012.

CS6

Two excavations conducted in the CS6 area in July 2014 removed petroleum-impacted soil identified near the former tank farm. Subsurface conditions encountered in each excavation included multiple former foundation and subgrade walls as well as demolition debris that were used as backfill. Although one of the excavations occurred in or near a former tank farm that was reportedly backfilled with clay, the former tank pit was not revealed in either excavation. The former foundations and walls limited the complete removal of impacted soil and some impacted soil remains at the boundaries of the excavations. Approximately 5,100 tons of impacted soil was removed as part of these actions. The soil excavation activities were documented in the report titled *Remedial Action Documentation Report – Soil Removal in CS6 and CS10, Kenosha Engine Plant*, dated October 2014.

CS10

An excavation was conducted in 2014 around MW-1002, where high petroleum VOC concentrations were observed in the soil during well installation. The excavation successfully removed the impacted soil around the identified well, but some impacted soils remained on the eastern side of the excavation. The unexpected soil impact beyond the planned excavation was not removed because of contract limits. Approximately 2,100 tons of impacted soil were removed as part of these actions. The soil excavation activities were documented in the report titled *Remedial Action Documentation Report – Soil Removal in CS6 and CS10, Kenosha Engine Plant*, dated October 2014.

2.2.2 Groundwater Recovery and Treatment

There are five groundwater recovery systems currently operating at the KEP. The locations of the recovery sumps are depicted in Figure 2. These systems were installed historically by Chrysler to address groundwater impacts that resulted from UST system or subsurface process piping releases. For each of these systems, groundwater is pumped from the recovery sump(s) to the treatment building, treated, then discharged to the Kenosha Water Utility sanitary system. The systems are routinely monitored and maintained. The five systems, their installation dates, impact type, treatment type and outfall locations are described in the table below.

Former Area / Current Area Reference	Recovery Location(s)	Date Installed (Approximate)	Recovery System Treatment	Impacts treated	Outfall Location
Northern Area/ CS6 - Former Tank Farm	Sump 4 Sump 5	Installed in 1990 Installed in 1996	Oil-water separator then through air stripper followed by discharge to sanitary sewer	Sump 4 – primarily benzene and other petroleum VOCs Sump 5 – primarily chlorinated VOCs	North Outfall on 52nd Street right-of-way near Manhole #200
Northern Area/ CS6 - Former Tank Farm	Sump 9 Sump 9A	Installed in 1996 Installed in 2012	Air stripper followed by discharge to sanitary sewer	Petroleum and chlorinated VOCs	North Outfall on 52nd Street right-of-way near Manhole #200
Northern Area/ CS7 - Outdoor Trailer Storage	Sump 6	Installed in 1993	Air stripper followed by discharge to sanitary sewer	Petroleum / groundwater	East Outfall on 54th Street right-of-way
Central Area/ CS4 - Central Remediation Area	Sump 18 Sump 23	Installed in 2002 Installed in 2005	Oil-water separator then through air stripper followed by discharge to sanitary sewer	Chlorinated VOCs	North Outfall on 52nd Street right-of-way near Manhole #200
Southern Area / CS10 - Southern Remediation Area	Sump 7, 15 and 17R	Installed in 2002	Oil-water separator then through air stripper followed by discharge to sanitary sewer	Chlorinated VOCS	South Outfall on 60th Street right-of-way

2.3 Summary of CS Areas and Identified Impacts

A site investigation was conducted at the KEP as the culmination of investigative efforts that began in 2011 (*Phase I Environmental Site Assessment*, dated March 2011) and were completed in 2014 (*Site Investigation Report*, dated March 2015). The site investigation included the evaluation of 1,155 soil sample and 1,009 groundwater samples collected over the five year time period. The soil analytical results were compared to the industrial direct contact and groundwater pathway RCLs calculated using the USEPA Regional Soil Screening Levels as described in the WDNR guidance document RR-890 using the standard default exposure assumptions and the June 2014 update. The groundwater analytical results are compared to the Wisconsin Administrative Code Ch. NR 140.10, Table 1, Public Heath Groundwater Quality Standards Enforcement Standards (ES). The ES is a health-risk based concentration and exceedances of ESs usually results in further subsurface investigation, remedial action requirements, or monitoring. Figures depicting the extent of impacts are included on the following figures:

- Figure 9 Extent of Industrial Direct Contact Exceedances in Soil
- Figure 10 Extent of Groundwater Pathway Exceedances in Soil
- Figure 11 Extent of RCL Exceedances in Saturated Soils
- Figure 12 Extent of Groundwater ES Exceedances in Water Table Wells – September 2014
- Figure 13 Extent of Groundwater ES Exceedances in Piezometers – September 2014
- Figure 14 TCE Isoconcentration Contours in Groundwater in Monitoring Wells (September 2014)
- Figure 15 TCE and Vinyl Chloride Isoconcentration Contours in Groundwater in Piezometers (September 2014)

The site investigation report summarized the impacts identified in each CS area and identified remediation and/or redevelopment concerns. These summaries are provided below:

2.3.1 CS1

The CS1 area was the former location of a 50,000 gallon above ground storage tank (AST) that held water for the plants fire suppression system. Two diesel powered backup generatorswere used for operation of the fire suppression system pumps and were housed in a small building attached to the water storage tank. A small diesel fuel AST was connected to each generator and at one point were filled via a remote fill pipe located on the outside of the building. These facilities were razed in 2013 and the ASTs were removed as part of the demolition. The southern portion of the CS1 area has a 10-foot high landscaped berm.

Soil Impacts

- Surface petroleum impacts at GP-129 under the former remote diesel fill port.
- Arsenic and PAHs were detected at concentrations that exceed industrial direct contact RCLs from one to two feet below ground surface in the central southeastern portion of CS1.
- Berm soils have benzene, naphthalene and PAH impacts.

Groundwater impact

- Groundwater impact was not identified in CS1.

Remediation/Redevelopment Considerations

- The CS1 berm soils have benzene and PAH impacts but, may be suitable as backfill for reuse on-site. If not remediated or removed a cap and maintenance plan will be required to achieve for case closure under WAC NR726.
- The impacted surficial soil in the central-southeastern portion of the will require remediation or a cap and maintenance plan for case closure under WAC NR726.

2.3.2 CS2

The CS2 area uses included (chronologically); a foundry, manufacturing of automotive parts, and most recently a warehouse. The subsurface at CS2 has historic fill consisting of foundry sand and former machine pits and trenches. The former machine pits and trenches were filled (or partially filled) with concrete. A steam tunnel (formerly connected) at the east side of the former Building 19 was identified as part of the CS1 evaluation of the steam tunnel under 60^{th} Street, however, documentation of its full location, extent and abandonment was not available. Several areas had concrete more than two feet thick and as a result, drilling activities were not able to penetrate some portions of the subsurface below former Building 19.

Soil Impacts

- Petroleum likely indicative of oil or oily soil in former Building 19 at GP-227, MW-200, MW-201 and MW-204.
- Industrial direct contact RCL exceedances occurred at GP-SL-59 (arsenic [over 100 milligrams per kilogram (mg/kg)] and PAHs) and at GP-213 (lead and arsenic).
- A benzo(a)pyrene exceedance above the industrial direct contact RCLs occurred at GP-221.

Groundwater Impacts

- LNAPL has been measured in MW-200 and MW-204, at observed thicknesses of 0.2 to one foot. However, petroleum VOCs were not detected in the groundwater samples from the affected monitoring wells.
- Benzene was detected at concentrations above the ES in the groundwater sample from MW-201.
- Chlorinated VOCs were detected in the central and eastern portion of CS2. TCE concentrations were slightly above to slightly below the ES. Higher concentrations of the breakdown chlorinated

VOCs, cis-1,2-dichloroethene and vinyl chloride were detected in groundwater samples from multiple wells.

Remediation/Redevelopment Considerations

- The concrete floors over most of the east ½ of former Building 19 are heavily oil stained and the stained portion of concrete may not be suitable for recycling.
- Building 19's historic uses were modified over the years from foundry to machining and the locations of former equipment and machine pits as well as other subsurface conduits are not known based on currently available information. On the east side of the buildings of CS2, historical reports document the presence of subgrade concrete vaults as well as electrical or steam line concrete conduits. The locations of these features were not documented or available from the former owner. Subsurface obstructions or voids may be encountered during remediation or redevelopment

2.3.3 CS3

The CS3 area was used for automotive engine part manufacturing throughout most of its developed use. The area was completely covered with buildings and the building slab currently remains as a temporary cap. The manufacture of automotive engine parts used hydraulic oils as a coolant and the oils were transported by underground piping to the cutting machines. After use the coolant was collected in a trench below the conveyor line that bore the manufactured part. The collection trenches drained coolant and metal cuttings by gravity to a larger collection pit where the metal fines were mechanically removed and the coolant was pumped through filters and recycled. After the part was completed, the conveyor took the part through a washer. Prior to 1980s it is assumed that trichloroethylene (TCE) was the washing fluid; after 1980, a water-based detergent was used. When the buildings were razed the pits and trenches were steam cleaned and filled with clay.

Soil Impacts

- Much of the soil in CS3 was impacted by both chlorinated and petroleum VOCs. The impacts extend through much of the aquifer down to the clay till aquitard. The TCE contaminated soils include three deep (20 feet bgs) point sources that will require remediation.
- Several areas of foundry sand and two areas of lead concentrations in the soil above direct contact RCLs will require active management during redevelopment. Based on recent experience at the site, the areas of higher lead concentrations may require pre-treatment if removed for disposal.

Groundwater Impacts

- The contaminant concentrations in groundwater are sufficiently high that left untreated, the contaminant plume is likely to expand.
- Concentrations of TCE in the groundwater samples from water table monitoring wells range from 500 to 700 ug/L and from 12,000 to 83,000 ug/L in the source area piezometers. Lesser concentrations of TCE breakdown products (cis-1,2-dichloroethene and vinyl chloride) are also present throughout the plume area. Benzene was detected above the PAL or ES at a few scattered wells, but other petroleum VOCs were not detected in the groundwater samples. Free-phase, dense non-aqueous phase liquids (DNAPLs), have not been measureable, the high TCE concentrations in the deeper soil and groundwater indicate that some TCE may be present in the interstitial pores.

Remediation/Redevelopment Considerations

- The area has multiple machine pits and former fluid trenches that extend from two feet to eight feet bgs. The machine pit bottoms were perforated and the pits and trenches were filled will clay from a documented, apparently uncontaminated source. CS3 also had a conveyor trench that was six feet wide, 10 feet deep and 150 feet long. This trench bottom was perforated and the trench was filled with clean clay soil. The presence of these pits and trenches will increase the effort required to prepare the area for redevelopment.

2.3.4 CS4

CS4 historically housed an assortment of buildings for multiple uses, including the compressor building and oil management area. Additionally, there were a number of subsurface pipes; for production carrying coolant (oil), wastewater, fire suppression water piping as well as utility lines including potable water and sanitary sewer. A number of spills or “releases” were reported in this area including a fuel oil spill (contained within the UST backfill and remediated during the UST removals), an earlier gasoline release and a later coolant release from subsurface piping. The gasoline release resulted in the installation of a groundwater recovery system referred to as the “Central Remediation System”. An area of LNAPL observed adjacent to the 48-inch storm sewer is likely related to the gasoline release. The LNAPL in this area appears to be residual product trapped within the soil in the water table smear zone (zone of water table fluctuation).

<u>Soil Impacts</u>

- The western half of CS4 (the portion adjacent to CS3) has chlorinated VOC impact in the soil that extends westward, but the concentrations are not sufficiently high enough to consider them source soils, but industrial DC and/or groundwater pathway exceedances warrant additional control or management..
- PCB-impacted soils were found in two locations on the west side of CS4. These PCB-impacted soil should be removed prior to redevelopment.
- There are also areas devoid of impact and this is likely due to prior undocumented removal of contaminated soil by the prior owner.

<u>Groundwater Impacts</u>

- Chlorinated VOC contamination in the groundwater has more TCE degradation compounds than TCE source material. The groundwater contaminant plume covers most of CS4 and the degradation appears to have stalled at vinyl chloride.
- LNAPL is present along the east side of CS4, associated with a historic gasoline release. The residual LNAPL is located in well adjacent to the 48-inch storm sewer that traverses the site from south to north. These residually-impacted soils should be removed, because the groundwater recovery system operated for over 15 years and has not fully removed the LNAPL from this area of the KEP.

<u>Remediation/Redevelopment Considerations</u>

- The subsurface on the west side of CS4 likely has subsurface production piping and fire protection piping in addition to sanitary and storm sewer.
- Multiple former foundations are present and oily impacted soil may be present adjacent to the foundation structures, but were not evident by the SI.

2.3.5 CS5

CS5 had a number of buildings and uses over the years of manufacturing. In the mid-1990’s, two older buildings were razed and the building to the south expanded northward over those former building areas. This resulted in the placement of fill in a former building basement (the rectangular thick fill area depicted in Figure 4).

<u>Soil Impacts</u>

- TCE soil impacts extend across the center and southern portions of CS5 and in a small area in the location of the former hazardous waste storage area. The source areas for TCE are likely within CS3 because source soils were not identified in CS5 except at two locations. A large area within CS5 was previously excavated and likely explains the limited area of soil impact.
- Soil contamination by petroleum VOCs are present in the center of CS5.
- Lead, above the industrial direct contact RCL was identified at GP-520, immediately west of former Building 61 (used for hazardous materials storage).

Groundwater Impacts

- TCE groundwater impacts extend across the center and southern portions of CS5 and in a small area in the location of the former hazardous waste storage area.
- Groundwater contamination by petroleum VOCs are present in the center of CS5.

Remediation/Redevelopment Considerations

- The area has multiple machine pits and former fluid trenches that extend from two feet to eight feet bgs. The machine pit bottoms were perforated and the pits and trenches were filled will clay from a documented uncontaminated source.

2.3.6 CS6

Historically, CS6 contained Building's 40, 40A and 40B which were razed in the early 1990's. In 1989, 14 USTs were removed from a tank farm located in the central portion of the area. Product was delivered to the former USTs using a former railspur. Reportedly, a subsurface product delivery piping trench, (taken out of service in approximately 1945) was located from the southeast corner of historic Building 40 which distributed product from the tank farm to Buildings 11 and 15 located to the east of historic Building 40. Five additional USTs were located on the north side of historic Building 40 under what is now identified as the berm. These tanks were closed in place or removed, but the actual data of tank closures were not documented.

A "Northern Remediation System" was installed to remove measurable LNAPL associated with releases identified during the UST removals. Areas of petroleum impacted soil persist in the central portion of CS6 in and around the purported former UST farm location. A remedial excavation was conducted in July 2014 to remove source soil for the LNAPL that was still present in an isolated monitoring well (MW-10). During the excavation, it was revealed that MW-10 had been installed inside a 10 foot by 10 foot concrete vault which explained why this well continued to exhibit LNAPL despite the operation of the groundwater recovery systems in CS6. Many buried concrete structures (raceways and conduits) and demolition debris were also uncovered during the excavation. It is anticipated that the buried concrete structures and demolition debris exist across much of CS6 as well as CS7, CS8 and CS9.

Soil Impacts

- Concentrations of chlorinated VOCs in soil in the northern berm act as source soil impact for the chlorinated VOC groundwater impacts observed in monitoring wells along the northern property boundary, most notably at MW-31 and MW-601 where chlorinated VOCs exceed 500 μg/L and 60 μg/L, respectively. Capping or removal of the contaminated soil is necessary reducing continued leaching to groundwater.
- LNAPL at MW-602 led to the identification of benzene impact source soil identified at MW-654. The impacted soil was not present at the surface, but encountered at 4-8 feet bgs. These impacts are near a former manufactured gas plant (MGP) gas line and valve pit near the 52nd Street right-of-way. However this area is also a former entrance to the site and may have been an area where a surface spill had occurred and these impacts are residual to an incomplete spill cleanup.
- Soil contaminated with PAHs is present in the center of CS6 above direct contact and groundwater pathway RCLs and in the soil that comprise the northern berm.

Groundwater Impacts

- The TCE contaminated groundwater at the northern property boundary is migrating into the City of Kenosha right-of-way. Dehalogenated by-products of TCE (cis-1,2-dichloroethene and vinyl chloride) are present in the aquifer just above the clay till.

Remediation/Redevelopment Considerations

- Multiple buried foundations were identified during remedial excavations. Residual impacts obscured by the buried foundation are likely present and as yet in unidentified locations.

- The berm soils, except for the TCE-contaminated portion, may be suitable as backfill for reuse on-site. If not remediated or removed a cap and maintenance plan will be required to achieve for case closure under WAC NR726.

2.3.7 CS7

Historically CS7 was covered by a series of automotive assembly buildings that were razed in the 1990's. Fill soil covers much of CS7 approximately 8 to 12 feet in thickness. An area of foundry sand bounded by MW-703, GP-736, GP-730, GP-732, BP-721, MW-704, GP-720 and PZ-26 was identified in the southwestern portion of the CS7 area. It is likely that some fill could be demolition debris and undocumented foundation walls, conduits and raceways may be present in the subsurface.

Soil Impacts

- Concentrations of TCE at GP-730 (42,600 micrograms per kilogram (ug/kg) at 2-3 feet bgs and 105,000 ug/kg at 9-10 feet bsg) is the likely source for chlorinated VOC impact in the groundwater, with the degradation compounds of vinyl chloride migrating downgradient to the east. Other scattered areas of chlorinated VOCs are present in the near surface, at the water table and in two locations in the saturated zone 12 feet or deeper.
- Concentrations of petroleum VOCs and PAHs exceed either the industrial direct contact or the groundwater pathway across much of the central portion of CS7. The impact is anticipated to be not contiguous and may be compartmentalized if placed as fill between foundations or in former building basements.
- The berm soil present along the north and eastern CS7 boundary has metal impacts (arsenic, lead and nickel) as well as PAHs above the non-industrial direct contact, but below the industrial direct contact RCLs.

Groundwater Impacts

- Chlorinated VOC impacts occur in an area around groundwater recovery Sump 6 at the water table and a deeper plume of vinyl chloride extends beyond CS7 down the city right-of-way. The impacts are likely migrating along a sewer lateral.

Remediation/Redevelopment Considerations

- The former buildings were razed in the early 1990's and the foundations and/or building basements may be present in CS7 based on the thickness of fill encountered in the borings across CS7. The source of the fill material is unknown and may include demolition debris.
- The berm soils may be suitable as backfill for reuse on-site, but if reused on-site would require a cap and a continuing obligation in the form of a maintenance plan in the area of reuse.

2.3.8 CS8

Historically CS8 was covered by a series of automotive assembly buildings that were razed in the 1990's. There is an average of eight to nine feet of fill present over most of CS8. It is likely that much of this fill could be demolition debris and undocumented foundation walls, conduits and raceways may be present in the subsurface.

A groundwater recovery and soil vapor extraction system was installed near the southwest corner of the CS8 area and was later removed during construction of Building 70 to the south. Residual source soils detected at MW-803 included petroleum and chlorinated VOCs that were not excavated or fully remediated by the in-situ system and may continue to leach to the groundwater. A small area of TCE impact in the unsaturated zone at MW-805 was also identified outside the area of influence of the former remedial system. Remedial excavation would remove these small source area soils.

The berm soil present along the eastern CS8 boundary has metal impacts (arsenic direct contact and nickel, groundwater pathway) as well as PAHs above the non-industrial RCLs. The berm soils may be suitable as backfill for reuse on-site, but would require a cap and a continuing obligation in the form of a maintenance plan.

Soil Impacts

- Petroleum VOCs are identified at concentrations exceeding the direct contact RCL at MW-803.
- Petroleum and chlorinated VOCs exceedances of the groundwater pathway are present over much of the western ½ of CS8.
- A small area of deep soil impact by chlorinated VOCs extends from MW/PZ-61 to MW/PZ-801.
- The berm soil has arsenic, lead and nickel present at concentrations that exceed the groundwater pathway.

Groundwater Impacts

- The chlorinated VOC ES exceedances at the water table extend from the source areas in CS3 and CS4 to the northwest and southwest corners of the CS8 area.
- A small area of petroleum VOC (primarily benzene) ES exceedance at the water table was identified in MW-803 and MW-804.
- Chlorinated VOC ES exceedances occur in the groundwater in the piezometers in the western half of CS8.

Remediation/Redevelopment Considerations

- The former buildings were razed in the early 1990's and the foundations and/or building basements may be present in CS8 based on the thickness of fill encountered in the borings across CS8. The source of the fill material is unknown and may include demolition debris.
- The berm soils may be suitable as backfill for reuse on-site, but if reused on-site would require a cap and a continuing obligation in the form of a maintenance plan in the area of reuse.

2.3.9 CS9

Historically CS9 was occupied by buildings used for manufacturing automobiles. After the buildings were removed in the mid-1990's, Building 70 was constructed to manufacture automobile engines. The eastern portion of the CS9 area was former residences that were razed to expand the KEP to accommodate Building 70 and access to the building. Building 70 was reportedly constructed over coarse gravel backfill that had been dynamically compacted. Historically, two monitoring wells in CS9 had TCE impact, but these wells were abandoned with the construction of Building 70. The investigation did not identify additional groundwater impact or TCE source soils in CS9. However, residual petroleum impact was identified in soil at approximately 10 to 12 feet in depth at MW-910. During installation, the location of MW-910 was moved 60 feet northward due to refusal on top of old building foundations. It is likely that much of the fill within CS9 is demolition debris and buried concrete walls and foundations may be present.

An internal memo from DaimlerChrysler dated December 2, 1999 indicated that a 12-inch layer of foundry sand was present under the concrete in the eastern portion of former Building 70 as shown on Figure 4. The existence of the foundry sand was not confirmed during the recent site investigation, as no soil probes or monitoring wells were placed within the reported foundry sand area.

Soil Impacts

- Arsenic, lead and nickel exceed the groundwater pathway RCL in CS9. An area in the northwest corner of CS9 also has lead concentrations in soil above the groundwater pathway RCL.
- A small area of chlorinated VOC impact above the groundwater pathway RCL is present at GP-913.

Groundwater Impacts

- The chlorinated VOC ES exceedances at the water table extend from the source areas in CS3 and CS4 to the northwest and southwest corners of the CS9 area. The area of impact across the southwest corner of CS9 is likely under the influence of the southern groundwater recovery system.
- Chlorinated VOC ES exceedance occur in the groundwater in the piezometers in the western ½ of CS9.

Remediation/Redevelopment Considerations

- The former buildings were razed in the early 1990's and the foundations and/or building basements may be present in CS9 based on the thickness of fill encountered in the borings across CS9. The source of the fill material is unknown and may include demolition debris, foundry sand and soil with oily impact adjacent to buried former foundations.
- The berm soils may be suitable as backfill for reuse on-site, but if reused on-site would require a cap and a continuing obligation in the form of a maintenance plan in the area of reuse.

2.3.10 CS10

Historically, CS10 was used for material storage with shipping and receiving areas including a railroad dock for unloading railcars. CS10 was also the location of the former steam plant which was fueled initially by coal and later by fuel oil. Three, railroad-size USTs were placed into the coal bin and served as fuel storage for the steam plant. In the 1990's these USTs were removed, a release was identified, a soil removal action was conducted, and a groundwater recovery system was installed.

With the construction of Building 70, the groundwater recovery systems were reinstalled. After the systems began pumping, TCE was detected in the recovered groundwater. TCE impacted source soils were not identified on-site during recent investigation activities, but that may be the prior soil removal activities conducted in the CS10 area. Chlorinated VOCs were detected in the shallow groundwater at concentrations above the ES. In off-site wells, southeast of the KEP across the railroad tracks, chlorinated VOCs concentrations in groundwater included TCE at 8,100 ug/L, cis-1,2-dichloroethene at 3,300 ug/L, and vinyl chloride at 76 ug/L.

Petroleum VOC impacts and measurable LNAPL were identified in MW-1002 and the area surrounding the well was included as part of a remedial soil removal. The soil removal was documented in the report described in Section 2.2.1. A second area of petroleum VOC impacts and measurable LNAPL were identified at MW-1006 concurrently with the soil removal at MW-1002. Due to budget and contract constraints, the soil at MW-1006 remains in-place.

Soil Impacts

- An approximate two-acres area on the east side of CS10 has PAH direct contact RCL exceedances. Two smaller areas of benzo(a)pyrene direct contact exceedance are found at GP-1020 and between GP-SL-57 and GP-SL-58.
- Petroleum and chlorinated VOC soil concentrations exceeding the groundwater pathway RCL cover most of CS10 except for a 300 foot-wide swath in the center of CS10.
- Two small areas of deep soil chlorinated VOC groundwater pathway RCL exceedances occur at GP-SL-49 (adjacent to PZ-78) and GP-SL-56 (adjacent to PZ-1000).
- One small area of PCBs greater than one milligram per kilogram were identified in the unsaturated zone soil at GP-SL-54 and MW-1005.

Groundwater Impacts

- The chlorinated VOC ES exceedances at the water table and in the piezometers extend from the source areas in CS3 and CS4 to the western portion of the CS10 area, likely under the influence of the southern groundwater recovery system.

- A second area of chlorinated VOC ES exceedances at the water table occur from MW-77 northeastward, parallel to the railroad tracks to MW-905 and extend southward, under the railroad tracks to the Jockey property parking lot (formerly a Chrysler property). The extent of southern impacts are bounded by wells in the Jockey parking lot and the right of way on 60th Street.
- Chlorinated VOC ES exceedances occur in the groundwater in the piezometers in the western ½ of CS9.
- Chlorinated VOC ES exceedances occur at PZ-78 and the extent of impact is defined by no exceedances found at MW-905 to the northeast and PZ 1004 to the southwest.

Remediation/Redevelopment Considerations

- A number of remedial excavations in CS10 were conducted as evidenced by the thickness of fill encountered in the borings across CS10. There were at least three prior groundwater recovery trenches with recovery sumps installed and operated in the 1990's. The recovery sumps were abandoned when Building 70 was constructed in 1999-2000. A current groundwater recovery system continues to operate.
- The area has water and sewer infrastructure on the property that parallels the railroad and 60th Street. The former water tank on CS1 (on the south side of 60th Street) provided fire suppression water to a series of hydrants formerly located in the southeastern part of CS10. Two stormwater lift stations are located in CS10. The stormwater lines remain active. The sanitary and water lines are capped and may need to be managed or removed during remediation or redevelopment.
- A former steam tunnel ran under 60th Street from CS1 (the water tank) to CS10. The steam tunnel was depicted as making a right angle on CS10 to the west. The exact location of the steam tunnel on-site has not been identified. Observations of the steam tunnel from the CS1 area indicated the portion of the tunnel under 60th Street was filled with concrete.
- The berm soils may be suitable as backfill for reuse on-site, but if reused on-site would require a cap and a continuing obligation in the form of a maintenance plan in the area of reuse.

2.3.11 CS11: South 30th Ave Parking Lot and CS12: North 30th Ave Parking Lot

These areas were former residential properties that were razed and converted to parking lots.

The soil below the parking lot in CS11 has one PAH (benzo(a)pyrene) at the middle and southern sampling locations in concentrations that exceeded the non-industrial direct contact RCL. In soil at a the northern location, several PAHs exceed the non-industrial direct contact RCL and benzo(a)pyrene exceeded the industrial direct contact RCL. VOCs were not detected above RCLS at the tested locations in CS11. If not removed, a cap and maintenance plan will be required to achieve case closure under NR 726.

Impacts to the soil were not detected in the soil below the parking lots at CS12 except for the near surface sample at the northern end of CS12 (GP-1201). One PAH, benzo(a)pyrene exceeded the non-industrial direct contact in the soil from 1 to 2 feet bgs and was not detected in the soil sample from 6 to 7 feet bgs. If the pavement is removed, the area of soil around GP-1201 should be removed and disposed of properly. No further remediation would be necessary for unrestricted use, but WDNR concurrence would be necessary.

Groundwater impacts were not identified in groundwater samples collected from temporary wells at both CS11 and CS12.

2.4 Conceptual Site Model

The KEP site has more than 100-year history of manufacturing. The KEP originated with a bicycle manufacturer who advanced to truck then automotive manufacturing as technology and consumer needs advanced. The KEP has been reconfigured many times in its history and some of that history is buried in former building footprints.

2.4.1 Contaminants of Concern

Automotive manufacturing uses many petroleum-based fluids and historically chlorinated solvents were also used to remove the oily petroleum residues from the manufactured product. Uses of the liquids resulted in releases to the environment over the years. As identified by the site investigation the following are the contaminants of concern:

Petroleum VOCs: Benzene, naphthalene and to a lesser extent xylenes.

Chlorinated VOCs: Tetrachloroethylene (several isolated and limited areas), trichloroethylene (the primary contaminant) and their dechlorinated breakdown compounds of cis-1,2-dichloroethylene and vinyl chloride.

Metals: Lead, nickel and isolated areas of arsenic greater than 100 mg/kg.

PCBs: CS4 and CS10 have small areas identified with PCB concentrations in soil that are between 1 and 27 mg/kg.

2.4.2 Extent of Soil Impacts

Widespread low-level impacts observed over most of the western two-thirds of the site are associated with the use of petroleum fuels, lubricants and metals. The magnitude of the soil impacts in this area varies from low levels just above groundwater pathway RCLs to areas where contaminants occur in higher concentrations that warrant remedial action. The berms surrounding the property primarily have low concentration impacts by metals and PAHs which limits the use of the soil, particularly if not retained on-site.

Chlorinated VOC impacts were identified in CS3 extending northward into CS5 and eastward across the northern part of CS4 into CS8 at concentrations exceeding the groundwater pathway RCLs. Some of the detected concentrations were identified above 1,000 ug/kg, a value used to identify areas of source soil that may warrant active remediation. Smaller areas of chlorinated VOC impact (with generally lower concentrations) were identified in CS2, CS6, CS7 and CS10.

2.4.3 Extent of Groundwater Impacts

Groundwater impacts are present at the water table as well as deeper in the shallow aquifer, just above the clay till aquitard. The existing groundwater recovery systems are not treating the sources of the groundwater contamination but are primarily controlling groundwater flow and limiting migration of contamination. More active groundwater treatment at the source areas would be necessary to reduce contaminant mass to support stable to receding groundwater plume conditions where site closure could be achieved.

Five deeper source areas of TCE soil and groundwater impact have been identified in CS3-Building 53, CS5-Building 65 and at the northeastern boundary of CS4 extending into CS8. These source areas are degrading as evidenced by the higher concentrations of cis-1,2-dichloroethene and vinyl chloride. The degradation process appears to have stagnated at the vinyl chloride stage of reductive dechlorination.

2.4.4 Extent of LNAPL

Isolated areas of LNAPL have been detected in water table monitoring wells at CS2 (MW-200 and MW-204), CS3 (MW-350 and MW-351), CS4 (MW-405); CS6 at MW-602 and in CS10 at MW-1006. LNAPL areas are illustrated on Figure 10.

2.4.5 Potential Receptors

Potential exposures to receptors include vapor intrusion, direct contact to contaminated soils, and inhalation of contaminated soil/dust. Residential properties located within 0.1 miles west of the site are hydraulically up-gradient of the area of known impact. Direct contact is not currently an exposure pathway of concern since the site is currently covered with concrete building floors and asphaltic pavement and surrounded by a chain-link fence.

Potential VOC migration pathways include vapor migration through the subsurface vadose zone and groundwater transport. The United States Environmental Protection Agency (USEPA) conducted a subsurface vapor migration study in September 2011, which was provided to the DNR. The vapor study collected samples in the areas around both of the specific potential pathways identified, as well as other areas surrounding the KEP. No impacts to the residents were identified during the EPA study.

Subsurface utilities, such as storm sewer and sanitary sewer lines, are also potential contaminant migration pathways. The storm sewers on the north half of the KEP drain to Pike Creek at 50th Street. Pike Creek flows to the east-southeast and eventually into Lake Michigan. Storm sewers in the southern half of the KEP drain to the main sewer in 60th Street. Specific potential pathways include migration to the 52nd Street right-of-way to the north near CS6 and migration down the utility corridors of 54th Street to the east, near CS7.

The KEP is served by the City of Kenosha municipal water supply and sanitary sewer. The City uses water from Lake Michigan for its potable water supply.

3.0 Remediation Goals and Objectives

The goals and objectives are for site-wide management of impact, focusing on protection of human health and the environments while considering potential redeveloped site uses and available funding for remediation.

3.1 Anticipated Post-Remedial Site Conditions

The site is currently zoned M-1 Light Manufacturing and M-2 Heavy Manufacturing. Redevelopment after remediation assumes the following:

- Post-remediation uses are anticipated to be commercial or light manufacturing.
- Residential uses for the site will not being considered.
- The City of Kenosha will require the use of a vapor barrier system for new construction.
- As redevelopment occurs, the buildings, pavement and landscape will provide the final cap.
- Until a final cap is in place (through redevelopment) the site may be capped temporarily by vegetated soil.

3.2 Soil Remedial Action Goals

The goals of the soil remedial action include addressing the following:

- Industrial direct contact RCL exceedances identified from 0 to 4 feet bgs
  - various VOCs
  - multiple PAH exceedances (individual areas with just benzo(a)pyrene industrial direct contact exceedances are excluded)

- Source Soils
  - LNAPL
    - measured LNAPL in wells (greater than 0.5 feet thick in multiple measurement events)
    - high petroleum VOC or PAH concentrations at the water table interface that may result in future LNAPL

  - Chlorinated VOCs
    - TCE concentrations in unsaturated soil (0 to 12 feet bgs) that are greater than 1,000 ug/kg

These goals have been selected to effectively address the direct contact exposure pathway while also reducing source area contaminant mass that could continue to serve as a source for ongoing groundwater impacts. Although the groundwater migration pathway RCLs were considered, active remediation to these criteria levels may not be technically or economically feasible for KEP given available funding sources and potential post development property use.

3.3 Groundwater Remediation Goals

Groundwater remediation will address known source areas to reduce the contaminant mass such that the groundwater plume is stabilized as demonstrated by monitored natural attenuation to be stable or receding without the use of the existing groundwater recovery systems. It is assumed that listing on the WDNR GIS registry will be required as post remediation groundwater impacts are expected to remain at concentrations above the WAC Chapter NR 140 ES.

4.0 Remedial Action Options

The purpose of this section is to present an appropriate range of alternatives for remediating impacted soil and groundwater at the KEP based on the chemicals present, the nature and extent of the contaminated media, Site characteristics, and potential redevelopment plans. The initial phase of the remedial action option evaluation process focuses on identifying remedial technologies that could be reasonably implemented to address impacts identified at one or more of the CS areas described in Section 2.3. Those remedial technologies deemed technically and economically feasible for implementation at KEP were retained. The retained remedial technologies were then combined to form remedial alternatives/approaches that were evaluated in more detail as described in the following sections.

4.1 Identification and Evaluation of Remedial Action Technologies

Various remedial technologies were initially screened with respect to technical implementation, effectiveness, and relative cost. The remedial technologies considered in the initial screening evaluation for soil and groundwater, are presented in Table 1 and Table 2, respectively. Remediation of residual LNAPL has been incorporated into the soil and groundwater remedial alternatives, as appropriate, and is therefore not screened separately. Only those remedial technologies deemed reasonably feasibly for one or more of the CS areas at the KEP were retained for more detailed evaluation.

Each retained remedial action technology for soil and groundwater was further evaluated against EPAs nine criteria: Threshold Criteria (overall protection of human health and the environment and compliance with ARARs), Primary Balancing Criteria (long-term effectiveness; short-term effectiveness; reduction of toxicity, mobility or volume; implementability; and relative cost), and Modifying Criteria (state/support agency acceptance; and community acceptance). This evaluation for the retained soil and groundwater technologies are included in Table 3 and Table 4, respectively.

4.1.1 Summary of Retained Remedial Technologies

The technically feasible technologies that were retained from the screening conducted above will be combined to form remedial alternatives (Section 4.3). The retained technologies for soil and groundwater impacts identified at the KEP are provided in the following sections.

4.1.2 Retained Technologies for Soil

The following technologies are retained for soil impacts at one or more of the CS areas at the KEP and will be used for the development of remedial options:

<u>Institutional Controls</u>

Institutional controls are responsible party or agency-mandated controls that are legally binding. Institutional controls may include actions such as deed restrictions/notifications or limits on property use as a means to control the potential for unacceptable exposure. All such affected properties in Wisconsin with continuing obligations at the time of case closure are listed on the Geographical Information System (GIS) Registry of Closed Remediation Sites. Continuing obligations that may be applicable to the KEP for residual soil at the time of closure may include, but are not limited to, the following:

- Notification of residual soil contamination above either the direct contact or migration to groundwater RCL;
- Maintenance of a barrier (e.g., soil cover, engineered cover, pavement) is required;
- Land use is limited to industrial, due to the application of industrial soil standards for closure; and

- A structural impediment (e.g. a building foundation and/or cement slab) is present which impeded complete investigation and/or cleanup. Further action will be required if removed.

Institutional controls do not reduce contaminant mass or toxicity, but instead limit the potential for unacceptable exposure to impacts. Institutional controls are considered a low cost alterative as there is no capital equipment to purchase or any long term operation and maintenance related requirements. Although institutional controls alone will not achieve the remedial goals and objectives for KEP, they will be necessary as part of an overall remedial strategy.

Surface Cap

Areas of identified soil contamination exceeding direct contact and groundwater protection standards would be rendered inaccessible by capping with an engineered barrier. Typical engineered barriers consist of asphalt, concrete pavement and/or geomembrane liners. Earthen and/or landscaped cap may be suitable in some situations. Depending on the material utilized, the cap would also mitigate infiltration and percolation of surface water through the soil and prevent the continued transport of contaminants into the groundwater.

Similar to institutional controls, surface capping does not reduce contaminant mass or toxicity however it can affect the mobility of contaminants. Costs associated with implementation are limited to the initial cap installation and periodic inspection and maintenance. The surface cap will be effective in both the short and long-term as long as it remains in place and is properly maintained. Temporary caps may be installed in areas of anticipated future development where buildings and/or pavement may later be constructed. Due to nature and extent of impacts at the KEP surface capping is not suitable as a standalone remedy, however it will be a critical component of the overall remedial strategy for the site.

Excavation

Excavation would include the removal of impacted soil to desired depths to achieve the remedial objectives. Under this remedial technology, impacted soils will be transported off-site for landfill disposal. The disposition of the excavated soils will be based on regulatory waste characterization under the Resource Conservation and Recovery Act (RCRA). The excavations would be backfilled with clean fill material obtained from either an on-site or off-site source. Where appropriate, berm soil present in several of the CS areas may be suitable for use as backfill material, however prior regulatory approval would be required.

As noted in section 2.2.1, a number of excavations have already taken place at select areas of the KEP and have successfully removed accessible contaminant mass from the site. This remedial technology has been proven effective at removing contaminant mass, including LNAPL, from the subsurface. The presence of subsurface structures associated with prior operations at the KEP will pose some unique challenges during implementation of the remedial alternative and related site development activities.

Excavation of impacted soil removes contaminant mass and volume and is effective in both the short and long-term. Soil samples would be collected from the base and/or walls of the excavation to document achievement of remedial objectives. Costs associated with excavation can be significant; however, it can be implemented in a relatively short period of time and would not impact long-term site redevelopment plans.

In-Situ Chemical Oxidation

The remediation of soil contamination using in situ chemical oxidation (ISCO) involves injecting or mixing oxidants and potentially co-amendments directly into the impacted media. The oxidant chemicals react with the contaminants, producing innocuous substances such as carbon dioxide, water, and in the case of chlorinated compounds—inorganic chloride. Typical oxidant delivery methods include injection and soil mixing/blending. There are two main advantages of using ISCO over other conventional treatment technologies: 1) large volumes of waste material are not usually generated, and 2) treatment is commonly implemented over a relatively short time frame.

Under this alternative, chemical oxidation of the vadose zone soil (upper 4 feet exceeding direct contract RCL) and deeper unsaturated impacts within the source area (up to 12 feet bgs) would be treated. It is anticipated that the impacted soil would be treated by a combination of continual mixing/blending using an excavator and the simultaneous application of the preferred treatment chemistry by direct spraying until the desired amount of treatment chemistry is applied. This allows for direct contact of the treatment chemistry with the COC within the soil matrix, thus improving the treatment effectiveness. Oxidant delivery using injection deemed unsuitable for the near surface soils due presence of lower permeability soils and construction debris.

ISCO laboratory treatability study would be conducted during the remedial design phase. Soil samples would be collected from several locations within the remediation areas and submitted for treatability testing. The primary objective of the treatability study would be to evaluate potential oxidant chemistries and dosing to assess their effectiveness of treating the COCs identified at the KEP. Following completion of the treatability testing, field scale pilot testing is recommended to test oxidant delivery methods and overall effectiveness prior to full scale implementation.

4.1.3 Retained Technologies for Groundwater

The following technologies are retained for groundwater impacts at one or more of the CS areas at the KEP and will be used for the development of remedial options:

4.1.3.1 Institutional Controls

As described in section 4.2.1, institutional controls are responsible party or agency-mandated controls that are legally binding. Institutional controls may include actions such as deed restrictions/notifications or limits on property use as a means to control the potential for unacceptable exposure. All such affected properties in Wisconsin with continuing obligations at the time of case closure are listed on the GIS Registry of Closed Remediation Sites. Continuing obligations that may be applicable to the KEP for residual groundwater at the time of closure may include, but are not limited to, the following:

- Notification of residual groundwater present at concentrations above the NR140 ES;
- Continued monitoring is required;
- Prior approval is required for construction of a water supply well.

Institutional controls do not reduce contaminant mass or toxicity, but instead limit the potential for unacceptable exposure to impacts. Institutional controls are considered a low cost alterative as there is no capital equipment to purchase or any long term operation and maintenance related requirements. Although institutional controls alone will likely not achieve the remedial goals and objectives for KEP, they will be necessary component of an overall remedial strategy.

4.1.3.2 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) uses natural physical, chemical, and/or biological processes (e.g., volatilization, sorption, dispersion, dilution; and chemical or biologic stabilization, transformation, or destruction) to reduce and attenuate contaminant mass, toxicity, mobility, volume, or concentration to acceptable levels. Natural attenuation processes and rates of contaminant degradation are monitored by changes in contaminant concentrations and contaminant - daughter product ratios versus time and hydrogeochemical parameters.

Remediation by natural attenuation for groundwater contamination may be considered feasible if the contaminant plume is stable or receding and VOC and geochemical indicator data provide evidence that natural attenuation is occurring at a rate sufficient to protect human health and the environment. In order for the plume to stabilize or recede at a sufficient rate over time, the source(s) of continuing groundwater contamination must also be stabilized.

MNA has limited short term effectiveness but may be effective in the long term if it is accompanied with adequate source removal. Additional groundwater sampling will be required to determine if the contaminant concentrations have stabilized or are receding over time. However, the contributing contaminant source has not yet been removed or stabilized at the KEP.

4.1.3.3 Groundwater Recovery and Treatment

Groundwater recovery wells are placed to intercept the plume on-site (source) and/or at downgradient (barrier) locations. Pumping of groundwater creates a depression in the groundwater table thus controlling the direction and rate of groundwater flow. Rates of VOC mass removal from groundwater pumping systems are minimal, and the systems do not function efficiently to remove contaminant mass. Recovered groundwater is treated on-site by air stripping and/or by carbon adsorption. Treated groundwater can be released to the local POTW, to surface water, or re-injected.

As referenced in section 2.2.2, there are currently five groundwater recovery systems operating at the KEP. The systems were designed and installed to control groundwater gradient and to minimize off-site migration of impacts. Although these systems are functioning as intended, it is anticipated that the current system would require significant expansion if it was implemented as a standalone remedy for groundwater.

This is a long-term treatment method, often requiring years before contaminant concentrations in groundwater reach acceptable levels. The amount of piping and number of wells required to achieve capture of the impacted groundwater would be extensive, based on the size of the plume and the hydraulic conductivity of the treatment area. Both capital and long term operation and maintenance costs would be incurred. The long term maintenance requirements and extensive network of below grade piping needed may pose some challenges for future site development.

4.1.3.4 Permeable Reactive Barrier

Permeable reactive barriers (PRB) are in-situ remedial systems designed to limit plume migration by forcing impacted groundwater to flow through the PRB, usually under natural gradients. PRBs are constructed in the aquifer, perpendicular to groundwater flow, and filled with media, typically a mixture of zero valent iron and sand, to create an environment in which contaminants are degraded and/or destroyed. Aquifers with minimal anisotropy and a lower confining unit that can be keyed into are suitable candidates for this treatment technology. PRBs typically have greater treatment longevity than other in-situ alternatives and require minimal maintenance.

PRBs have long term effectiveness in treating dissolved phase VOC impacts with minimal maintenance provided the system is properly designed and constructed. The PRB truncates the plume of contaminated groundwater flowing away from the source zone and stops the migration of contaminated groundwater beyond the property boundary. PRBs are not typically installed within the source area. Groundwater monitoring is used to evaluate the PRB system performance.

At the KEP a PRB system could be installed along the downgradient edge of the plume, however this technology would not address the source area impacts. Laboratory testing is often used to design the media mixture in the barrier wall. Future development in the area of the PRB may be limited.

4.1.3.5 Enhanced Reductive Dechlorination

Enhanced reductive dechlorination (ERD) involves the addition of an electron donor containing biodegradable carbon to groundwater, which promotes the activity of bacteria and mediates reductive dechlorination reactions. The addition of electron donors can be augmented with the inoculation of a bacterial culture with proven ability to fully degrade common chlorinated VOCs.

Reduction of chlorinated VOC follows a sequential breakdown process in which TCE is degraded to DCE and then VC and then to ethene to complete the process. The presence of the correct conditions are required for the process to work efficiently and effectively i.e, reducing groundwater conditions and low dissolved oxygen concentrations. Treatment process can take up to several years to complete and can require numerous substrate injections to keep conditions favorable for efficient contaminant depletion.

Chlorinated VOC impacted groundwater would be treated in-situ to enhance the naturally occurring reductive dechlorination that is ongoing in some CS areas at the KEP, but which are currently not adequate to drive dechlorination to the final end products of carbon dioxide and water. This approach, along with the products used are well tested, accepted by regulators, commercially available, and have been shown to remediate groundwater at sites similar to KEP.

Within each area identified for treatment, an injection gallery consisting of a series of direct push borings would be advanced to the desired treatment depths. In some instances, temporary injection points may be left in place to allow for subsequent treatments.

ERD would effectively reduce the mass of chlorinated VOCs and would limit the expansion of the groundwater plume. It is considered effective in the short-term (source area remediation and long-term (decreased groundwater contamination/migration). Laboratory testing along with pilot scale field testing is recommended prior to full scale implementation to assess to test delivery methods, spacing and overall effectiveness.

4.1.3.6 In-Situ Chemical Oxidation

The remediation of impacted saturated soil and groundwater using in situ chemical oxidation (ISCO) involves injecting or mixing oxidants and potentially co-amendments directly into the impacted media. The oxidant chemicals react with the contaminants, producing innocuous substances such as carbon dioxide, water, and in the case of chlorinated compounds—inorganic chloride. Typical oxidant delivery methods include injection and soil mixing/blending. There are two main advantages of using ISCO over other conventional treatment technologies: 1) large volumes of waste material are not usually generated, and 2) treatment is commonly implemented over a relatively short time frame.

Under this alternative, chemical oxidation of the saturated impacts and associated groundwater within the source area would be treated using a network of direct push injection points. Treatment depths can be adjusted depending on conditions encountered at applicable CS areas.

ISCO laboratory treatability study would be conducted during the remedial design phase. Saturated soil and groundwater samples would be collected from several locations within the remediation areas and submitted for treatability testing. The primary objective of the treatability study would be to evaluate potential oxidant chemistries and dosing to assess their effectiveness of treating the COCs identified at the KEP. Following completion of the treatability testing, field scale pilot testing is recommended to test oxidant delivery methods, injection point spacing, and overall effectiveness.

4.1.3.7 Phytoremediation

Phytoremediation is the use of plants along with their associated microorganisms to stabilize or reduce contamination in shallow groundwater. It can be an effective remediation method on a variety of contaminants especially for sites with low concentrations of contaminants over a large area and at shallow depths. Hybrid poplar and willow trees have been successful in treating VOC's.

Due to the high concentrations present is some areas of the KEP, phytoremediation alone would not be effective alone in reducing groundwater contaminant mass. It could however be part of an effective long term remedial strategy in areas with lower concentrations or following initial source treatment or to provide some degree of hydraulic groundwater gradient control.

Phytoremediation is easily implemented but would need to take into consideration the long-term site redevelopment plans for the KEP. Although it is not effective in the short term, this technology has the potential to be effective in the long term. Costs associated with implementation of phytoremediation are generally considered low, however long term maintenance of the trees would be required.

4.2 Development of Remedial Action Alternatives

Due to the complexities of the KEP site, the retained remedial technologies for both soil and groundwater were combined to form several different remedial options or alternatives that are being considered to meet the remediation goals and objectives specified in Section 3.0. Remedial technologies have been combined for both soil and groundwater due to their interdependency at the KEP. Each alternative is designed to meet the remedial goals and objectives; however the aggressiveness, restoration timeframes, and effects on future site redevelopment for each remedial alternative varies. The components of each remedial alternative is presented in Table 5, and briefly described below. Note that although not specifically identified in any of the alternative discussed below, phytoremediation is being retained as an additional remedial measure that could potentially be utilized at the KEP as a means of providing additional treatment, if necessary.

A more detailed description of each alternative is presented in Section 5.0 as part of the remedial action options comparative analysis.

4.2.1 Alternative 1: No Further Action

The no further action alternative involves no additional treatment or monitoring of contaminated soil and groundwater at the KEP beyond those remedial actions already completed. This response typically serves as a baseline against which the other alternatives can be compared. If prevailing site conditions lead to the determination that the site poses no significant risk to human health or the environment, the no action response can be used as the sole remedial action. Due to the soil and groundwater impacts identified at the KEP, the No Further Action alternative would not achieve the remedial action goals and objectives identified in Section 3.0.

4.2.2 Alternative 2: Continued Groundwater Recovery/Treatment

Under Alternative 2, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

<u>Soil</u>

- Excavation
- Surface Cap
- Institutional Controls

<u>Groundwater</u>

- Groundwater Recovery/Treatment
- MNA
- Institutional Controls

Alternative 2 would include the excavation of those areas where LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. PCB impact areas would also be excavated. An earthen surface cap would be utilized to limit exposure to soils in excess of the industrial direct contact RCL (VOCs and multiple PAHs). The existing groundwater recovery/treatment systems would continue to operate to control off-site migration but would have limited impact on the reduction of source area impacts. Expansion of the system would likely be required to provide additional gradient control. Long term operation, maintenance, and monitoring would likely be required to achieve regulatory closure. MNA will be used to address residual groundwater impacts upgradient of the groundwater recovery system. Institutional controls would be required under this alternative to address the residual soil and groundwater impacts that would remain.

4.2.3 Alternative 3: Limited Active Source Groundwater Treatment with PRB

Under Alternative 3, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

<u>Soil</u>

- Excavation
- Surface Cap
- Institutional Controls

<u>Groundwater</u>

- ISCO
- ERD
- PRB
- MNA/Monitoring
- Institutional Controls

Alternative 3, like Alternative 2, would include the excavation of those areas where LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. PCB impacted soil would also be excavated. However, under Alternative 3, some limited areas of source soil (up to 12 feet bgs) would also be excavated to varying depths. An earthen surface cap would be utilized to limit exposure to soils in excess of the industrial direct contact RCL (VOCs and multiple PAHs). In-situ treatment, using ISCO and/or ERD, would be utilized to reduce saturated contaminant mass in select areas of the KEP. A PRB would be installed along select downgradient edges of the plume to limit off-site migration of groundwater impacts that will not be treated by the in-situ treatment methods. A significant period of groundwater monitoring would be required to demonstrate stable to receding groundwater conditions required for case closure. Institutional controls would be required under this alternative to address residual soil and groundwater impacts.

4.2.4 Alternative 4: Soil and Groundwater Source Control

Under Alternative 4, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

Soil
- Excavation
- Surface Cap
- Institutional Controls

Groundwater
- ISCO
- ERD
- MNA/Monitoring
- Institutional Controls

Alternative 4, like Alternatives 2 and 3, would include the excavation of those areas were LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. PCB impacted soil would also be excavated. However, under Alternative 4, a more extensive volume of source soil (up to 12 feet bgs) would also be excavated in select areas to further reduce contaminant mass and reduce leaching to groundwater. VOC impacted soil with industrial direct contact RCL exceedances would be excavated and an earthen surface cap would be utilized for an area with VOC migration to groundwater pathway exceedances. An earthen cap would also be utilized to address those areas where multiple PAHs and/or metals are present at concentrations above the industrial direct contact RCL. In-situ treatment, using ISCO and/or ERD, would be utilized to reduce saturated contaminant mass in a more extensive area of the KEP. MNA would be utilized to address residual groundwater impacts. Groundwater monitoring would be required to demonstrate stable to receding groundwater conditions required for case closure. Institutional controls would be required under this alternative to address residual soil and groundwater impacts.

4.2.5 Alternative 5: Extensive Soil Removal and Groundwater Treatment

Under Alternative 5, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

Soil
- Excavation
- Institutional Controls

Groundwater
- ISCO
- ERD
- MNA
- Institutional Controls

Alternative 5 would include excavation of the entire property to depths up to 8 feet bgs to remove unsaturated zone soil impacts and most subsurface structures. Excavation depths will be extended to 12 feet bgs in those areas were LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. In-situ treatment, using ISCO and/or ERD, would be utilized to reduce saturated contaminant mass and groundwater concentrations across the KEP. Post treatment groundwater monitoring would be required to demonstrate effective treatment. In areas with residual groundwater impacts above the ES, MNA monitoring would be required to demonstrate stable to receding groundwater conditions required for case closure. Institutional controls would be required under this alternative to address any residual soil or groundwater impacts not addressed by the remedial action.

5.0 Remedial Action Options Evaluation

The combined remedial option alternatives were evaluated in accordance with WAC Ch. NR 722 as described in the following sections and in accordance with USEPA guidance for feasibility studies as presented in Tables 3 and 4. The no action alternative was included as a general response action by which other actions are compared.

5.1 Evaluation Criteria

The retained remedial alternatives were evaluated using the criteria specified in WAC Ch. NR 722.07 as summarized below:

5.1.1 Technical Feasibility

The technical feasibility of potential remedial action options were evaluated using the following criteria:

1. Long-term effectiveness. The long-term effectiveness of remedial action options, taking into account the following factors;
    - The degree to which the toxicity, mobility and volume of the contamination is expected to be reduced; and
    - The degree to which a remedial action option, if implemented, will protect public health, safety and welfare and the environment over time.
2. Short-term effectiveness. The short-term effectiveness of remedial action options, taking into account any adverse impacts on public health, safety and welfare and the environment that may be posed during the construction and implementation period until case closure under ch. NR 726;
3. Implementability. The implementability of each remedial action options, taking into account the technical and administrative feasibility of construction and implementation of the remedial action options was evaluated. Disruption of local businesses and potential impacts to neighboring properties were also considered when evaluating the implementability of each alternative. In addition, the redevelopment potential of the KEP was also considered; and
4. Restoration timeframe. The expected timeframe needed to achieve the necessary restoration.

5.1.2 Economic Feasibility

The economic feasibility of each potential remedial alternative was evaluated considering the following criteria: capital costs, annual operation and maintenance costs, and total present worth of the costs. Costs associated with potential future liability and limitations on future development may be incurred but were not evaluated as part of this analysis. The economic feasibility of a remedial alternatives was determined by comparing the conceptual costs to what is expected to be technically achieved by that option, taking into account long-term effectiveness, short-term effectiveness, implementability, and the time until restoration is achieved for each option. The estimated remedial action option costs identified herein provide an accuracy of -30 percent to +50 percent. As such, an identified estimated remedial action option cost of $100,000, for example, could range between $70,000 and $150,000.

In addition, the overall sustainably of each option was considered during the evaluation process in accordance with NR722.09 (2m). The criteria used included energy use, generation of air pollutants, water use, enhancements to ecosystems, waste minimization, and optimizing sustainable practices.

5.2 Alternative 1: No Action

The no action response involves no additional treatment of contaminated soil or groundwater at the KEP. This no action alternative typically serves as a baseline against which the alternatives are compared. If prevailing site conditions lead to the determination that the site poses no significant risk to human health or the environment, then the no action response can be used as the sole remedial action. In that event, implementation of other types of action becomes unnecessary.

In terms of technical feasibility, the no action alternative would eventually reduce the magnitude of the existing risk by natural attenuation processes; however, the extent of these impacts would likely expand. Because no action is proposed in this alternative, the implementability is very high. No action is also a sustainable remedial option as there are no energy or water resources utilized during implementation. However, from an administrative feasibility point of view, this alternative will likely not be accepted by the WDNR as the remedy for the KEP because it would not adequately address soil impacts that could threaten human health and the environment (direct contact and inhalation pathways) and groundwater impacts that could migrate off-site.

This alternative was considered the lowest in terms of present worth cost and would result in minimal disruption to the subject property and neighboring properties. It has no associated capital costs or operation and maintenance costs. As indicated above, this alternative will likely not be accepted by the WDNR and is not retained for further evaluation.

5.3 Alternative 2: Continued Groundwater Recovery/Treatment

Under Alternative 2, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

<u>Soil</u>

- Excavation
- Surface Cap
- Institutional Controls

<u>Groundwater</u>

- Groundwater Recovery/Treatment
- MNA
- Institutional Controls

The conceptual layout for Alternative 2 is illustrated on Figure 16.

<u>Description of Alternative</u>

Alternative 2 includes the excavation of those areas were LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. Additionally, PCB impacted soil identified in CS4, CS8, and CS10 would also be removed. Excavation depths would extend from the ground surface to depths up to 12 feet bgs. It is estimated that approximately 34,100 cubic yards of impacted soil would be excavated from CS2, CS3, CS4, CS6, CS8,and CS10 as part of this alternative. Excavated soil would be transported off-site for treatment/disposal at a Subtitle D landfill. The excavation would be backfilled with clean soil obtained from an on-site or off-site source and graded to match the surrounding topography.

An earthen surface cap would be utilized to limit exposure to VOC and PAH impacted soils identified in CS1 through CS7 and CS10 that are in excess of the industrial direct contact RCL. The combined areas covering approximately 226,000 square feet would be capped with clean soil with vegetative cover. Periodic inspection and maintenance of the earthen surface cover would be required in perpetuity to ensure that it functions as intended. This earthen surface cap could later be replaced with pavement and/or buildings depending on future site redevelopment activities.

Under this alternative, the existing groundwater recovery/treatment systems described in Section 2.2.2 would continue to operate as a means to control off-site migration of impacted groundwater. System expansion and general upgrades would be needed to provide for adequate gradient control. A system performance evaluation and re-design would be required to maximize operational efficiency. For the purposes of this conceptual evaluation, it is assumed that additional recovery wells would be installed and additional treatment equipment would be added, as necessary, to handle the increased flow rate. Extracted groundwater would continue to be treated using air stripping technology and then discharged to the sanitary sewer under the current discharge permit. No active source area groundwater remediation would be conducted as part of this alternative. MNA would be used to address residual groundwater impacts throughout the plume. Long term operation, maintenance, and monitoring would likely be required to achieve regulatory closure. Institutional controls would be required at time of closure due to residual soil and groundwater impacts.

Technical Feasibility

Both soil excavation and installation of a cap can be implemented and are considered technically feasible. As long as the cap is maintained, this alternative is effective in the long-term at eliminating the direct contact pathway for VOC impacts; however, it is not effective in reducing the volume or toxicity of the impacted soil beyond the limited areas identified for LNAPL excavation. Under this alternative, soil in excess of both the direct contact and migration to groundwater pathway RCLs will remain at the KEP and may require special handling/disposal if disturbed during future site redevelopment activities.

Continued operation and expansion of the existing groundwater recovery and treatment system will help to address contaminant mobility by limiting off-site groundwater migration, but will have little impact on reducing the toxicity and volume of impacted groundwater within the primary source areas. MNA will help to reduce contaminant volume and toxicity; however, without adequate source removal the continual loading to groundwater will limit its effectiveness in achieving stable to receding plume conditions.

Overall this alternative has a moderate degree of short term effectiveness and there is minimal potential for exposure to contaminants during cap installation and long-term groundwater monitoring activities. The short-term potential exposure to contaminants could be high during performance of the LNAPL excavation activities or during future site redevelopment activities if not properly managed by following health and safety procedures and performing the necessary vapor mitigation and monitoring activities.

From an administrative/regulatory feasibility point of view, this alternative is acceptable as the remedy is anticipated to meet short-term remedial objectives (hot spot removal) and long-term objectives (decreased groundwater contamination and groundwater migration control). This alternative will have some short-term impact on the community during implementation due to the use of heavy equipment (excavators, loaders), increased truck traffic, and potential for dust generation. These potential impacts can be mitigated by implementing a project-specific health and safety plan, keeping excavation areas properly wetted (dust control), planning truck routes to minimize disturbances to the surrounding community, and other construction best-management practices.

The time required for implementation of the capping and excavation components of this alternative option is relatively short; however, the groundwater recovery/treatment system would need to operate for an extended period of time before regulatory could even be considered. Without adequate source removal it is assumed that the system may need to operate for 30 years or more before regulatory closure could be secured. Listing of the KEP on the WDNR GIS registry and the associated continuing obligations would be required in perpetuity.

Economic Feasibility

Considering the required work associated with implementing this alternative (from design through remedial action completion, including excavation, backfill, disposal, confirmation sampling, capping, groundwater recovery system expansion and long term operation and monitoring), the present worth cost for this alternative is estimated to range from $ 8,250,000 to $ 17,680,000. Conceptual costs are presented on Table 6. This conceptual estimate is based on a 30-year operational time period.

Sustainability

The soil excavation and capping portion of this alternative will have a moderate carbon footprint during implementation. Fossil fuel consumption would occur due to the off-site transportation of excavated materials to a local Subtitle D facility and trucking associated with transporting clean fill and cap material to the site. The potential for the use of clean on-site soils as backfill material could help to reduce this impact and should be evaluated during the remedial design phase. Long-term energy inputs are required due to continued operation of this groundwater recovery/treatment system. Waste generation will be moderate during implementation, with only limited options for reduction.

5.4 Alternative 3: Limited Active Source Groundwater Treatment with PRB

Under Alternative 3, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

Soil

- Excavation
- Surface Cap
- Institutional Controls

Groundwater

- ISCO
- ERD
- PRB
- MNA/Monitoring
- Institutional Controls

The conceptual layout for Alternative 3 is illustrated on Figure 17.

Description of Alternative

Alternative 3, like Alternative 2, includes the excavation of those areas were LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. PCB impacted soil identified in CS4, CS8, and CS10 would also be removed. Excavation depths would extend from the ground surface to depths up to 12 feet bgs. Under Alternative 3, the excavation area will be expanded to include additional areas of unsaturated soil impacts to reduce the continued loading to groundwater. It is estimated that a total of approximately 64,800 cubic yards of LNAPL, VOC, and PCB impacted soil would be excavated from CS2 through CS8, and CS10. Excavated soil would be transported off-site for treatment/disposal at a Subtitle D landfill. The excavation would be backfilled with clean soil obtained from an on-site or off-site source and graded to match the surrounding topography.

Similar to Alternative 2, an earthen surface cap would be utilized to limit exposure to VOC and PAH impacted soils identified in CS1 through CS7 and CS10 that are in excess of the industrial direct contact RCL. The combined areas covering approximately 216,000 square feet would be capped with clean soil with vegetative cover. Periodic inspection and maintenance of the earthen surface cover would be required in perpetuity to ensure that it functions as intended. This earthen surface cap could later be replaced with pavement and/or buildings depending on future site redevelopment activities.

Under this Alternative, ISCO and/or ERD will be utilized to treat both saturated soil and groundwater in-situ within the primary source areas from the groundwater surface to depths up to 20 feet bgs. The treatment zone may be expanded in select areas to treat up to 4 feet of unsaturated zone impacts above the water table. The goal of this in-situ treatment is to reduce contaminant mass to accelerate the time needed for MNA to achieve stable or receding groundwater conditions. The off-site impacts identified on the Jockey International property would also be treated in-situ using either ISCO or ERD as part of this alternative. It is estimated that approximately 128,300 cubic yards of saturated soil/groundwater will be treated in-situ in CS3, CS4, CS10, and a portion of the Jockey International parking area. ISCO laboratory treatability study would be conducted during the remedial design phase to identify treatment products and dosing best suited for the impacts identified at the KEP. Due to the varying contaminant types, concentrations, and distribution, soil and groundwater samples would be collected from several locations within the identified remediation areas and submitted for treatability testing. The results of the treatability testing will be utilized to design field scale pilot testing that can be conducted prior to full scale implementation. For the purposes of this evaluation, it is assumed that direct push injection would be utilized to deliver the treatment products to the subsurface. The number and spacing of injection points will be determined following completion of the field scale pilot testing.

Alternative 3 also includes the installation of two PRB walls along the downgradient edges of the plume to limit off-site migration of groundwater impacts that will not be treated using ISCO or ERD. For the purposes of this evaluation, it is assumed that zero-valent iron would be utilized as the treatment media. Conceptually the walls will be approximately 1,000 feet in length (extending from CS7 south to CS9) and 400 (along the CS10 property boundary) and would be completed at a depth of approximately 25 feet bgs (underlying clay confining layer). Treatability testing would be performed as part of the remedial design activities. This testing would involve laboratory column tests using groundwater from the site and commercial granular iron material. The results of these tests would provide data to predict PRB performance and to assist in the design of the system.

Groundwater monitoring will be required to evaluate the effectiveness of the in-situ treatment and confirm that the PRB is functioning as intended. The existing groundwater recovery and treatment systems would continue to operate during implementation of this alternative, with phased shutdown as remediation progresses. MNA monitoring will be performed for approximately 12 years to document a stable and reducing plume condition. Institutional controls would be required at time of closure due to the presence of any residual soil and groundwater impacts at the KEP.

Technical Feasibility

This alternative is considered technically feasibility and effective in achieving the remedial objectives and goal of risk reduction within a reasonable time period. As long as the cap is maintained, this alternative is effective in the long-term at eliminating the direct contact pathway. The LNAPL and source area excavations will reduce contaminant mass and loading to groundwater. Under this alternative, soil in excess of both the direct contact and migration to groundwater pathway RCLs will remain at the KEP and will require special handling/disposal if disturbed during future site redevelopment activities.

Treatment of source area impacted soil and groundwater will help to reduce the contaminant mass and should allow natural attenuation to occur much more rapidly than Alternative 2 that did not include source area groundwater treatment. The PRBs will address residual contaminant mobility by limiting off-site groundwater migration, but will have little impact on reducing the toxicity and volume of impacted groundwater within untreated areas of the KEP. MNA will help to reduce contaminant volume and toxicity; however, residual impacts not addressed through the active soil and groundwater measures described above may limit its effectiveness in achieving stable to receding plume conditions over a short period of time.

Overall this alternative is effective in the short-term with minimal potential for exposure to contaminants during cap installation and long-term groundwater monitoring activities. The short-term potential exposure to contaminants could be higher during performance of the LNAPL and source area excavation activities, ISCO implementation or during future site redevelopment activities if not properly managed by following health and safety procedures and performing the necessary vapor mitigation and monitoring activities. Additionally there is the potential for worker exposure to ISCO related chemical if proper handling procedures are not implemented.

From an administrative/regulatory feasibility point of view, this alternative is acceptable as the remedy is anticipated to meet short-term remedial objectives (hot spot remedy of groundwater impact) and long-term objectives (decreased groundwater contamination and groundwater migration control). Permits would be required as part of the remedial design and planning phases. This alternative will have some impact on the community during implementation due to the use of heavy equipment (excavators, loaders), increased truck traffic, and potential for dust generation. These potential impacts can be mitigated by implementing a project-specific health and safety plan, keeping excavation areas properly wetted (dust control), planning truck routes to minimize disturbances to the surrounding community, and other construction best-management practices.

The time required for implementation of the capping and excavation components of this alternative option is relatively short; however, a period of time will be required to demonstrate that MNA is able to address residual groundwater impacts and that the PRB is functioning as intended. Listing of the KEP on the WDNR GIS registry and the associated continuing obligations would be required in perpetuity.

Economic Feasibility

Considering the required work associated with implementing this alternative (from design through remedial action completion, including excavation, backfill, disposal, confirmation sampling, capping, ISCO, PRB installation, and groundwater monitoring), the present worth cost for this alternative is estimated to range from $18,780,000 to $ 40,240,000. Conceptual costs are presented on Table 6. This conceptual estimate is based on an estimated 15-year time period.

Sustainability

This alternative will have a large carbon footprint during implementation; however there are no long-term energy inputs required as part of this remedial option. Fossil fuel consumption would be high due to the off-site transportation of excavated materials to a local Subtitle D facility and trucking associated with transporting clean fill material to the site. The potential for the use of clean on-site soils as backfill material could help to reduce this impact and should be evaluated during the remedial design phase. Water and chemical use will take place during implementation and waste will be generated as part of the excavation activities. ISCO laboratory treatability testing will help establish the appropriate dosing to help minimize chemical and water usage while also achieving the desired level of treatment.

5.5 Alternative 4: Soil and Groundwater Source Control

Under Alternative 4, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

Soil

- Excavation
- Surface Cap

- Institutional Controls

Groundwater
- ISCO
- ERD
- MNA/Monitoring
- Institutional Controls

The conceptual layout for Alternative 4 is illustrated on Figure 18.

Description of Alternative

Alternative 4, like Alternative 2 and 3, includes the excavation of those areas were LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. PCB impacted soil identified in CS4, CS8, and CS10 would also be removed. Excavation depths would extend from the ground surface to depths up to 12 feet bgs. Under Alternative 4, the excavation area will be expanded to include those areas with industrial direct contact RCL exceedances and additional areas of unsaturated soil impacts to further reduce the continued loading to groundwater. It is estimated at approximately 111,200 cubic yards of impacted soil would be excavated from CS2 through CS8, and CS10, including removal of the berm in CS1. Excavated soil would be transported off-site for treatment/disposal at a Subtitle D landfill. The excavation would be backfilled with clean soil obtained from an on-site or off-site source and graded to match the surrounding topography.

An earthen surface cap would be utilized to limit exposure to VOC impacted soils in excess of the migration to groundwater RCL and also areas where multiple PAHs and/or metals exceed the industrial direct contact RCL. The combined areas covering approximately 795,000 square feet would be capped with clean soil with vegetative cover. Periodic inspection and maintenance of the earthen surface cover would be required in perpetuity to ensure that it functions as intended. This earthen surface cap could later be replaced with pavement and/or buildings depending on future site redevelopment activities.

Similar to Alternative 3, ISCO and/or ERD will be utilized to treat saturated soil and groundwater in-situ within the primary source areas; however the treatment area will be expanded to provide a greater degree of groundwater treatment. The treatment zone may be expanded in select areas to treat up to 4 feet of unsaturated zone impacts above the water table. The goal of this in-situ treatment is to reduce saturated contaminant mass and groundwater impacts such that the potential for off-site migration is significantly reduced and MNA is able to achieve stable or receding groundwater conditions. The off-site impacts identified on the Jockey International property would also be treated in-situ using either ISCO or ERD as part of this alternative. It is estimated that approximately 223,000 cubic yards of impacted soil and groundwater will be treated in-situ in CS3, CS4, CS5, CS10 and the Jockey International property. Laboratory treatability study would be conducted during the remedial design phase to identify treatment materials and dosing best suited for the impacts identified at the KEP. Due to the varying contaminant types, concentrations, and distribution, saturated soil and groundwater samples would be collected from several locations within the identified remediation areas and submitted for testing. The results of the treatability testing will be utilized to design field scale pilot testing that can be conducted prior to full scale implementation. For the purposes of this evaluation, it is assumed that direct push injection would be utilized to deliver the oxidant to the surface. The number and spacing of injection points will be determined following completion of the field scale pilot testing. Follow-up injections may be required to achieve remedial goals.

Groundwater monitoring will be required to evaluate the effectiveness of the in-situ treatment. It is anticipated that MNA monitoring will be performed for approximately 8 years to document a stable and reducing plume condition. Institutional controls would be required at time of closure due to the presence of any residual soil and groundwater impacts.

Technical Feasibility

This alternative is considered technically feasibility and is effective to be effective in achieving the remedial objectives and goal of risk reduction within a reasonable time period. Excavation is highly effective at eliminate the direct contact pathway. The LNAPL and source area excavations will reduce contaminant mass and loading to groundwater. Under this alternative, soil in excess migration to groundwater pathway RCLs will remain at the KEP and may require special handling/disposal if disturbed during future site redevelopment activities.

Treatment of source area impacted saturated soil and groundwater will help to reduce the contaminant mass, reduce the potential for further migration of impacts to groundwater, and should allow natural attenuation to occur much more rapidly than the other Alternatives previously discussed that include only minimal source area groundwater treatment. ISCO and MNA will help to reduce contaminant toxicity and volume of identified impacts. Additionally, due the decrease in contaminant mass, it is anticipated that MNA will be able to maintain and reduce residual groundwater conditions.

Overall this alternative is effective in the short-term with minimal potential for exposure to contaminants during cap installation and long-term groundwater monitoring activities. The short-term potential exposure to contaminants could be higher during performance of the LNAPL and more extensive excavation activities, ISCO implementation or during future site redevelopment activities if not properly managed by following health and safety procedures and performing the necessary vapor mitigation and monitoring activities. Additionally there is the potential for worker exposure to ISCO related chemical if proper handling procedures are not implemented.

From an administrative/regulatory feasibility point of view, this alternative is acceptable as the remedy is anticipated to meet short-term remedial objectives (elimination of direct contact pathyway and hot spot remedy of soil and groundwater impact) and long-term objectives (decreased groundwater contamination and groundwater migration control). Permits would be required as part of the remedial design and planning phases. This alternative will have some impact on the community during implementation due to the use of heavy equipment (excavators, loaders), increased truck traffic, and potential for dust generation. These potential impacts can be mitigated by implementing a project-specific health and safety plan, keeping excavation areas properly wetted (dust control), planning truck routes to minimize disturbances to the surrounding community, and other construction best-management practices.

The time required for implementation this alternative is relatively short. Post remediation monitoring will be required to demonstrate effective completion of the remedial objectives. It is anticipated that the increased level of source removal and/or treatment will greatly reduce the time required to achieve regulatory closure. Listing of the KEP on the WDNR GIS registry and the associated continuing obligations would be required in perpetuity.

Economic Feasibility

Considering the required work associated with implementing this alternative (from design through remedial action completion, including excavation, backfill, disposal, confirmation sampling, capping, ISCO, and groundwater monitoring), the present worth cost for this alternative is estimated to range from $ 24,120,000 to $51,680,000. Conceptual costs are presented on Table 6. This conceptual estimate is based on a 10-year operational time period.

Sustainability

This alternative will have a large carbon footprint during implementation; however there are no long-term energy inputs required as part of this remedial option. Fossil fuel consumption would be high due to the off-site transportation of excavated materials to a local Subtitle D facility and trucking associated with transporting clean fill material to the site. The potential for the use of clean on-site soils as backfill material could help to reduce this impact and should be evaluated during the remedial design phase. Water and chemical use will take place during implementation and waste will be generated as part of the excavation activities. ISCO laboratory treatability testing will help establish the appropriate dosing to help minimize chemical and water usage while also achieving the desired level of treatment.

5.6 Alternative 5: Extensive Soil Removal and Groundwater Treatment

Under Alternative 5, the following remedial technologies have been identified to address soil and groundwater impacts at the KEP.

Soil
- Excavation

Groundwater
- ISCO
- ERD
- MNA
- Institutional Controls

The conceptual layout for Alternative 5 is illustrated on Figure 19.

Description of Alternative

Alternative 5 would include excavation of virtually the entire property to removal soil impacts and subsurface structures. Excavation depths would be extended to an average of 8 feet bgs in CS2 through CS10. Excavation depths will be extended to 12 feet bgs in those areas were LNAPL is present or soil sample analytical data is indicative of significant concentrations within the unsaturated zone. Additionally CS11 and CS12 will excavated to a depth of 4 feet bgs and the berm would be removed from CS1. It is estimated that a total of approximately 1,195,000 cubic yards of impacted soil and debris would be excavated under this Alternative. Excavated soil would be transported off-site for treatment/disposal at a Subtitle D landfill. The excavation would be backfilled with clean soil obtained from an on-site or off-site source and graded to match the surrounding topography.

ISCO and/or ERD will be utilized to treat saturated soil and groundwater in-situ identified in CS3, CS4, CS5, and CS10. The goal of this in-situ treatment is to significantly reduce saturated contaminant mass such that MNA is able to achieve stable or receding groundwater conditions in a short period of time. The off-site impacts identified on the Jockey International property would also be treated in-situ using either ISCO or ERD as part of this alternative. It is estimated that approximately 490,000 cubic yards of impacted material will be treated in-situ as part of this Alternative. Laboratory treatability study would be conducted during the remedial design phase to identify oxidant types and dosing best suited for the impacts identified at the KEP. Due to the varying contaminant types, concentrations, and distribution, soil and groundwater samples would be collected from several locations within the identified remediation areas and submitted for testing. The results of the treatability testing will be utilized to design field scale pilot testing that can be conducted prior to full scale implementation. For the purposes of this evaluation, it is assumed that direct push injection would be utilized to deliver the oxidant to the sub-surface. The number and spacing of injection points will be determined following completion of the field scale pilot testing. Follow-up injections may be required to achieve remedial goals.

Groundwater monitoring will be required to evaluate the effectiveness of ISCO. It is anticipated that MNA monitoring will be performed for approximately two years to document a stable and reducing plume condition. Institutional controls would be required at time of closure due to the presence of any residual groundwater impacts.

Technical Feasibility

This alternative is considered technically feasibility and is effective in achieving the remedial objectives and goal of risk reduction within a reasonable time period. Excavation is highly effective at eliminating the direct contact pathway and contaminant mass. Additionally the extensive excavation will also remove soils in excess of migration to groundwater pathway RCL and subsurface structures. There will be very few impediments to site redevelopment under this scenario.

Treatment of source area impacted saturated soil and groundwater across the majority of the impacted groundwater footprint will significantly reduce the contaminant mass, reduce the potential for further migration of impacts to groundwater, and should allow natural attenuation to occur much more rapidly than the other. ISCO and MNA will help to reduce contaminant toxicity and volume of identified impacts. Additionally, due the extensive contaminant mass removal, it is anticipated that MNA will be able to maintain and reduce residual groundwater conditions within a reasonably short period of time.

Overall this alternative is effective in the short-term at achieving the remediation goals. There is a large potential for short-term potential exposure to contaminants during performance of the extensive excavation activities and ISCO implementation if not properly managed by following health and safety procedures and performing the necessary vapor mitigation and monitoring activities. Additionally there is the potential for worker exposure to ISCO related chemical is properly handling procedures are not implemented.

From an administrative/regulatory feasibility point of view, this alternative is acceptable as the remedy is anticipated to meet short-term remedial objectives (elimination of soil and groundwater impact) and long-term objectives (decreased groundwater contamination and groundwater migration control). Permits would be required as part of the remedial design and planning phases. This alternative will have some impact on the community during implementation due to the use of heavy equipment (excavators, loaders), increased truck traffic, and potential for dust generation during an extended period of time. These potential impacts can be mitigated by implementing a project-specific health and safety plan, keeping excavation areas properly wetted (dust control), planning truck routes to minimize disturbances to the surrounding community, and other construction best-management practices.

The time required for implementation this alternative is relatively short compared to other alternatives. Post remediation monitoring will be required to demonstrate effective completion of the remedial objectives. It is anticipated that the extensive soil removal and groundwater treatment will greatly reduce the time required to achieve regulatory closure. Listing of the KEP on the WDNR GIS registry and the associated continuing obligations would be required in perpetuity to address any residual groundwater impacts.

Economic Feasibility

Considering the required work associated with implementing this alternative (from design through remedial action completion, including excavation, backfill, disposal, confirmation sampling, ISCO, and groundwater monitoring), the present worth cost for this alternative is estimated to range from $ 134,360,000 to $287,920,000. Conceptual costs are presented on Table 6. This conceptual estimate is based on a 5-year operational time period.

Sustainability

This alternative will have a large carbon footprint during implementation; however there are no long-term energy inputs required as part of this remedial option. Fossil fuel consumption would be very high due to the off-site transportation of a large volume of excavated materials to a local Subtitle D facility and trucking associated with transporting clean fill material to the site. The potential for the use of clean on-site soils as backfill material could help to reduce this impact and should be evaluated during the remedial design phase. Water and chemical use will be significant during implementation and a large volume of waste will be generated as part of the excavation activities. ISCO laboratory treatability testing will help establish the appropriate dosing to help minimize chemical and water usage while also achieving the desired level of treatment.

5.7 Comparison of Remedial Alternatives

5.7.1 Introduction

Remedial alternatives for the KEP were developed in Section 4.3 following an initial screening of technologies for soil and groundwater. The assembled alternatives were then evaluated on an individual basis against the criteria specified in NR 722, as described in Section 5.0. The following section enhances this evaluation by comparing the advantages and limitations of the alternatives relative to each other. The comparative analysis uses EPAs criteria: Threshold Criteria (overall protection of human health and the environment and compliance with ARARs), Primary Balancing Criteria (long-term effectiveness; short-term effectiveness; reduction of toxicity, mobility or volume; implementability; and relative cost). The green and sustainable aspects of each alternative are also considered when comparing the alternatives. The two EPA Modifying Criteria (state/support agency acceptance; and community acceptance) are not included in this evaluation as they will be assessed following completion of a public comment period and/or regulatory review.

5.7.2 Comparative Analysis

The comparative analysis of the alternatives is presented on Table 7. Based on this analysis, the alternatives were scored with respect to each of the EPA criteria. For the two threshold criteria, the alternatives were evaluated on the basis of whether they can be reasonably expected to pass or fail the criteria. For primary balancing and additional criteria, the alternatives were scored on scale of 1 to 5, with lower values representing the less-favorable alternatives and higher values representing the more-favorable alternatives.

The no action alternative did not pass the initial threshold criteria (overall protection of human health and the environment and compliance with ARARs) and was therefore not screened against the remaining primary balancing and modifying criteria.

5.7.3 Ranking of Remedial Alternatives

The alternatives that can be reasonably expected to “pass” the threshold criteria were then ranked based on their cumulative scores for each of the EPA criteria in the order of most favorable (1) to least favorable (4). The results of the scoring/ranking are provided in Table 7 and the results are summarized below with the most favorable being listed first:

Alternative 4: Soil and Groundwater Source Control

Alternative 3: Limited Active Source Groundwater Treatment with PRB

Alternative 2: Continued Groundwater Recovery/ Treatment

Alternative 5: Extensive Soil Removal and Groundwater Treatment

Based on this evaluation, Alternative 4 (Soil and Groundwater Source Control) appears to be the most technically and economically feasible alternative for implementation at the KEP. This alternative provides for soil and groundwater source control and is considered protective of human health and the environment. Pre-design data collection and testing (laboratory treatability and field scale) is necessary to confirm the anticipated effectiveness of in-situ chemical reduction (ISCO and ERD) for the KEP and to gather the information needed to complete the remedial design. Costing assumptions made as part of the remedial action options evaluation can be verified and modified as needed.

6.0 Conclusions and Recommendations

A range of alternatives for remediating impacted soil and groundwater at the KEP based on the chemicals present, the nature and extent of the contaminated media, site characteristics, and future redevelopment impacts were evaluated in general accordance with NR 722. Based on this evaluation, Alternative 4 (Soil and Groundwater Source Control) appears to be the most technically and economically feasible alternative for implementation at the KEP. This remedy includes a combination of excavation, capping, and in-situ treatment using ISCO and/or ERD. The selected approach addresses the remediation goals and objectives for site-wide management of residual soil and groundwater impacts, focusing on protection of human health and the environment while considering potential redeveloped site uses and available funding for remediation.

As referenced previously, additional pre-design data is needed to verify selection and implementation methods for ISCO and ERD. ISCO laboratory treatability testing is recommended to aid in the selection of the appropriate treatment chemistry and to establish site specific dosing needed to meet the remedial objectives. A properly designed ISCO dosing strategy can mitigate the over use of chemicals and water resources during field implementation. Based on the results of the treatability testing, field scale pilot testing will likely be recommended to assess effectiveness in the field and to refine critical parameters needed for full scale design (delivery method, spacing, and dosages). Similarly, additional data is needed to support the selection and design for the ERD component of the remedial design, including possible field scale testing.

7.0 References

AECOM, March 2011, *Phase I Environmental Site Assessment*, Chrysler Kenosha Engine Plant

AECOM, March 2011, *Review of Groundwater Remediation Systems*, Chrysler Kenosha Engine Plant

AECOM, April 2011, *Off-Site Impacts Assessment Report – South and West*, Former Chrysler Kenosha Engine Plant

AECOM, April 2011, *Off-Site Impacts Assessment Report – North and East*, Former Chrysler Kenosha Engine Plant

AECOM, September 2011, *Interim Investigation at the former Chrysler Kenosha Engine Plant*

AECOM, October 2011, *Phase II Environmental Site Assessment CS11– Chrysler Kenosha Engine Plant*

AECOM, October 2011, *Phase II Environmental Site Assessment CS12– Chrysler Kenosha Engine Plant*

AECOM, December 2011, *Phase II Environmental Site Assessment CS1– Chrysler Kenosha Engine Plant*

AECOM, August 2012, *Phase II Environmental Site Assessment CS2 – Chrysler Kenosha Engine Plant*

AECOM, August 2012, *Phase II Environmental Site Assessment CS3– Chrysler Kenosha Engine Plant*

AECOM, April 2012, *Phase II Environmental Site Assessment CS4– Chrysler Kenosha Engine Plant*

AECOM, May 2012, *Phase II Environmental Site Assessment CS5– Chrysler Kenosha Engine Plant*

AECOM, May 2012, *Phase II Environmental Site Assessment CS7– Chrysler Kenosha Engine Plant*

AECOM, May 2012, *Phase II Environmental Site Assessment CS8– Chrysler Kenosha Engine Plant*

AECOM, July 2012, *Phase II Environmental Site Assessment CS6– Chrysler Kenosha Engine Plant*

AECOM, July 2012, *Interim Action Investigation, Petroleum-Impacted UST Area at the Kenosha Engine Plant*

AECOM, August 2012, *Phase II Environmental Site Assessment CS9– Chrysler Kenosha Engine Plant*

AECOM, November 2012, *Site Investigation Work Plan*, Former Kenosha Engine Plant Site

AECOM, December 2012, *Phase II Environmental Site Assessment CS10– Chrysler Kenosha Engine Plant*

AECOM, December 2012, *Site Assessment for Underground Storage Tank Closure in Parcel CS4*

AECOM, December 2012, *Interim Action Report – UST and Soil Removal in CS4*

AECOM, May 2013, *Site Investigation Work Plan-Revision 1*, Former Kenosha Engine Plant Site

AECOM, October, 2014, *Remedial Action Cost Engineering and Requirements* (RACER), remedial cost estimating software, version 11.2.

AECOM February 2015, *Site Investigation Report*, Former Kenosha Engine Plant

DaimlerChrysler, December 1999, Internal memorandum regarding lead impacted foundry sand.

GZA GeoEnvironmental, Inc, April 2002, *Coolant Release Update and Work Plan* Daimler Chrysler Corporation 5555 30th Avenue, Kenosha, Wisconsin

GZA GeoEnvironmental, Inc, *Remediation Performance and Monitoring Progress Report, Fourth Quarter, 2013*, Capstone Advisory Group, LLC and Old Carco Liquidation Trust, Kenosha Engine Plant, Kenosha, Wisconsin

Triad, January 1994, Soil Vapor Extraction System Installation Summary, Letter to Chrysler Corporation.

Triad, March1998, *Operation and Maintenance Manual Area 3 Groundwater Recovery and Treatment Systems and Soil Vapor Extraction Systems*, Kenosha Main Plant, Kenosha, Wisconsin.

Triad, May 1998, *Operation and Maintenance Manual Area 6 Groundwater Recovery and Treatment Systems and Soil Vapor Extraction System*, Kenosha Main Plant, Kenosha, Wisconsin.

Triad, August 1998, *Site Investigation Report* Chrysler Corporation Kenosha Engine Plant 5555 30th Avenue Kenosha, Wisconsin.

List of Tables

Table 1
Initial Technologies Screening - Soil
former Kenosha Engine Plant
Kenosha, Wisconsin

Technology	Technology Description	Effectiveness	Implementability	Relative Cost	Retained
NO ACTION	No action is taken to remediate site.	No action would not be effective due to the degree and nature of impacts at the KEP.	Easy to implement as no action would be required, but would likely not be acceptable to the WDNR given soil impacts at the site.	Low	Yes
INSTITUTIONAL CONTROLS	Institutional controls involve public (ordinances) or private (deed instruments including listing site on WDNR GIS Registry) restrictions on property use as a means to limit the potential for unacceptable exposure to impacts on-site.	Institutional controls provide long term reduction in potential exposure to impacts. However, institutional controls alone provide no reduction in toxicity, mobility, or volume.	Generally considered easy to implement and would but would likely not be acceptable to the WDNR as a stand alone remedy due to the nature and extent of impacts at the KEP.	Low	Yes
SURFACE CAP	Areas of identified soil contamination exceeding direct contact and/or groundwater protection standards would be rendered inaccessible by capping with an engineered barrier. Typical engineered barriers consist of asphalt, concrete pavement and/or geomembrane liners. Earthen and/or landscaped cap may be suitable in some situations.	Effective in eliminating the direct contact exposure pathway and reducing infiltration of water through impacted soil. Can affect the direction and magnitude of groundwater flow if capping area is extensive. Will not reduce mass of contaminants, which may significantly increase time for either active groundwater treatment or Monitored Natural Attenuation (MNA) if no source removal action is performed.	Capping alone likely not acceptable to WDNR given soil concentrations and groundwater impacts. Can be installed in a short period of time with minimal disruption to the Site and surrounding properties. Can be integrated into future site redevelopment plans. Will require permits, DNR approval, and long-term maintenance & monitoring.	Low	Yes
EXCAVATION AND TREATMENT/DISPOSAL OF IMPACTED SOIL	Directly remove and treat impacted soil to address accessible RCL exceedances. Treatment may take place at site and/or prior to landfilling at an approved/permitted off-site disposal facility. Clean backfill is used if soil is taken off-site for treatment.	Remediation can be accomplished in a relatively short period of time. Will address dermal contact and ingestion direct contact exposure pathways. Impacted soil may be left in place if it is deemed inaccessible.	Excavation will only address accessible soil. This alternative may be difficult to implement in some areas due to buried construction debris, foundations etc. Requires permitting to treat and/or dispose of soil. Monitoring and control of fugitive dust and vapors will need to be considered.	Moderate to High	Yes
SOIL MIXING	Soil mixing is a supplementary remedial approach that uses physical disruption of the soil matrix to enable access to low permeability soil zones. This can greatly enhance the performance of other soil remediation technologies, including *in-situ* chemical oxidation or stabilization, or soil vapor extraction.	Soil mixing alone would not achieve the remedial objectives to the nature and degree of soil contamination. Soil mixing would be effective in enhancing SVE or chemical treatment technologies by exposing highly impacted soil that is bound in low permeability soil, thereby promoting remediation.	Implementation of this alternative would be restricted in areas where existing infrastructure (utilities, building foundation systems, etc.) make it difficult to access impacted soils for mixing.	Moderate	No
SOIL VAPOR EXTRACTION (SVE)	SVE addresses VOC impacts in the vadose zone. Air is extracted through subsurface soil from vapor extraction wells creating a pressure gradient that induces flow of air through contaminated soil. CVOCs volatilize into the vapor phase from contaminated soil and are subsequently captured by the vapor extraction wells. The CVOCs can then be treated using activated carbon or other technology, or discharged directly to the atmosphere under an air discharge permit. Fine grained soil with a high degree of saturation requires higher vacuums and closer well spacing, which reduces the efficiency of the SVE system. SVE systems are most effective in removing CVOCs from granular soil. SVE systems require routine maintenance and monitoring and are typically placed inside a protective building near the treatment area.	SVE is effective in removing substantial amounts of VOC mass from soil, particularly granular soil, in a relatively short period of time. SVE is also effective in controlling vapor migration and indoor vapor intrusion. The effectiveness can be diminished when fine-grained soils are present. Fine-grained soil can act as a reservoir that retains VOC mass and slowly release contaminants after coarse grained soils have been remediated.	A pilot study would likely be needed to collect design parameters for full-scale implementation. Additionally the subgrade structures (utilities, foundations, etc.) would limit the implementability of this technology. Exhaust from an SVE system will likely require treatment to comply with air discharge requirements. SVE system can be constructed subgrade to minimize site disruption for future tenants or land owners but may have some impact on site redevelopment activities	Moderate	No

Table 1
Initial Technologies Screening - Soil
former Kenosha Engine Plant
Kenosha, Wisconsin

Technology	Technology Description	Effectiveness	Implementability	Relative Cost	Retained
THERMALLY ENHANCED SVE	Thermally enhanced SVE is essentially an SVE system the is supplemented through the use of heated air injection to increase the volatilization rate of volatiles and semi-volatiles as well as promote drying of fine grained soil layers. Combined, these actions can substantially facilitate and enhance extraction of volatile and semi-volatile contaminants. The process is otherwise similar to standard SVE but requires heat resistant extraction wells. Heated air or steam is injected below or within the contaminated zone to increase the temperature of the contaminated soil. The heating enhances the release of contaminants from soil matrix. As with standard SVE the released volatile and semi-volatile contaminants are stripped from the contaminated zone and brought to the surface through vapor extraction. If properly designed, thermally enhanced SVE can use extraction points as locations for heated air injection. This has the advantage of not only heating the contaminant source, but also modifying the air pressure gradients and hence air flow direction through the contaminated source.	Thermally enhanced SVE is more effective than SVE alone and can remediate VOC's in shorter time frames depending upon the amount of mass required to be treated. Thermally enhanced SVE also has the capability to treat VOC in finer-grained soils due to the increased volatilization component from heating. A thermal source, typically either treated SVE system exhaust or steam will be required and will need to be generated thus adding equipment requirements to the system.	A pilot study would likely be needed to collect design parameters for full-scale implementation. Additionally the subgrade structures (utilities, foundations, etc.) would limit the implementability of this technology. Exhaust from an SVE system will likely require treatment to comply with air discharge requirements. SVE system can be constructed subgrade to minimize site disruption for future tenants or land owners but may have some impact on site redevelopment activities	Moderate	No
ELECTRICAL RESISTANCE HEATING	Electrical resistance heating uses an electrical current to heat low permeable soils such as clays and fine-grained sediments to temperatures above the vaporization potential of the CVOCs that are sorbed to the soil matrix. This results in vaporization of the CVOCs and allows them to be readily captured by vacuum extraction. Electrodes are placed directly into the low permeable soil matrix and activated. This results in an electrical current passing through the soil. Resistance to the current in the soil matrix generates heat, which warms the soil and CVOCs. The heat also dries the soil causing it to fracture, and thereby increasing secondary porosity and making the soil more permeable which improves the vapor extraction efficiency.	This technology is effective in treating VOC's in fine-grained soil and can achieve remediation goals in a short period of time. Electrical resistive heating increases the mobility of CVOCs in fine grained soil by vaporizing the VOCs that are sorbed to the soil matrix. When coupled with SVE, to capture the vaporized VOCs, the combined system is very effective in reducing the volume mass.	Electrical resistive heating requires substantial electrical energy source near the site. Numerous electrodes and SVE wells will be installed over the impacted area. Subsurface obstructions at the site, may complicate installations, and could impact the ability to generate electrical current. Exhaust from the SVE system would likely need to be treated prior to discharge. A pilot test for design may be needed and the system would require equipment to be protected in a structure along with frequent O&M.	Moderate	No
IN-SITU CHEMICAL OXICATION	In-situ chemical oxidation (ISCO) uses chemical oxidants (Fenton's Reagent, permanganate, persulfate, ozone, etc.) to transform organic contaminants (typically through oxidation) into less harmful chemical compounds. This technology is typically applied through injections or mixing at the source of contaminant and as a result is considered an *in-situ* remedial approach. Catalysts are often used to accelerate or enhance the degree of oxidation.	Short-term effectiveness is high as complete destruction of VOCs in permeable portions of the source area. Effectiveness generally relies on the ability for the oxidant to come in contact with the impacted soil. Oxidant selection is also critical. Effectiveness of this alternative would be evaluated following treatment. Supplemental or focused additional ISCO treatments may be needed to reach desired treatment level.	Implementation of this alternative would require treatability testing to select the most appropriate oxidant to address site contaminants. A pilot test at the site would also be required to determine how readily chemical oxidation can reach impacted source area soil. Subsurface obstructions at the site, may complicate installations, and could impact the ability to achieve adequate oxidant distribution.	Moderate	Yes

Table 1
Initial Technologies Screening - Soil
former Kenosha Engine Plant
Kenosha, Wisconsin

Technology	Technology Description	Effectiveness	Implementability	Relative Cost	Retained
IN-SITU SOLIDIFICATION/STABILIZATION	In situ soil solidification/stabilization involves mixing a binding reagent into the contaminated media or waste using jet grout injection, augers, of backhoe to solidify and/or stabilize organic and inorganic waste constituents. Cement-based mix designs are most commonly used for solidification/stabilization treatment; however, a variety of additives such as fly ash, hydrated lime, bentonite-cement grout can also used to meet specific project requirements.	Soil stabilization/solidification is effective in permanently treating soil with high concentrations of constituents. It reduces the potential for the material to act as a continuing source to groundwater and also eliminates the threat to direct contact as the technology can be applied from the ground surface to depths of 30 feet or more over a relatively short period of time. Nearby cement plants are typically advantageous to effectively and economically utilize this technology as large volumes of material are often required. The solidification agent and application method would be determined during the design phase and would likely require bench scale treatability testing and field scale pilot testing activities.	Field testing programs are required to determine the proper reagent addition and equipment operation necessary to produce a homogeneous mix and to determine a workable grout mix ratio (water to solids ratio) that would satisfy the project requirements. Auger mixing methods are anticipated to be the most suitable for the Site however it would be complicated by the presence of subsurface structures and utilities. The time frame to complete the is relatively short. Redevelopment potential of solidified area is significantly limited in areas treated.	Moderate to High	No
COSOLVENT/ALCOHOL FLOODING	Cosolvent flushing involves the injection of alcohols such as methanol, ethanol, and propanols. These compounds enhance the solubility of many contaminants and are mutually miscible in both water and NAPL and when added to the flushing system can bring about changes in the bulk properties of the contaminated zone. When larger amounts of alcohol are used, the alcohol may partition into both the NAPL and water phases and can result in the reduction of the NAPL-water interfacial tension making it go to zero which facilitates the mobilization of the NAPL. Cosolvent flushing is typically used in conjunction with a hydraulic containment system.	Under permeable conditions with an underlying confining clay layer cosolvent flushing can be effective in transporting NAPL to a pump and treat system. However, since cosolvent flushing releases substantial amounts of bound VOCs, there is a increase in the volume of material that needs to be treated.	Implementation of this approach would require careful evaluation of the specific source areas to ensure that all mobilized NAPL could be readily captured. An extensive treatment system would need to be constructed, operated, and maintained. The existing hydraulic containment system would need to be evaluated to ensure there was no potential for losing capture during the flushing operations. Unidentified subsurface obstructions could complicate this work.	Moderate	No
SURFACTANT FLUSHING	Surfactant flushing is similar to cosolvent/alcohol flooding and involves the injection of surfactants, typically water based chemicals, which alter the properties of NAPLs by either increasing their solubility or reducing the NAPL-water interfacial tension. This reduction results in a decrease of capillary forces thus allowing the NAPL to readily migrate with the surfactant material. Surfactant flushing typically involves pumping surfactant into a NAPL source area and then extracting it, often in a recirculation system. Surfactant system typically require construction of a treatment system to remove the NAPL material from the surfactant for disposal or further treatment.	Under permeable conditions with an underlying confining clay layer cosolvent flushing can be effective in transporting NAPL to a pump and treat system. However, since cosolvent flushing releases substantial amounts of bound VOCs, there is a increase in the volume of material that needs to be treated.	Implementation of this approach would require careful evaluation of the specific source areas to ensure that all mobilized NAPL could be readily captured. An extensive treatment system would need to be constructed, operated, and maintained. The existing hydraulic containment system would need to be evaluated to ensure there was no potential for losing capture during the flushing operations. Unidentified subsurface obstructions could complicate this work.	Moderate	No
PHYTOREMEDIATION	Phytoremediation uses plants along with their associated microorganisms to stabilize or reduce contamination in soil and limit infiltration of precipitation to the water table. It can be an effective long term remedial strategy on a variety of contaminants especially for site with low concentrations of contaminants over a large area and are at shallow depths. Poplar and willow trees have been successful in treating CVOCs.	Due to the high concentrations present is some areas of the KEP, phytoremediation alone would not be effective alone in reducing soil contaminant mass. It could however be part of an effective long term remedial strategy in areas with lower concentrations or following initial source treatment.	Implementation of this technology is easy to implement, but would need to be incorporated into a long term development plan for the KEP as trees may need to be removed as site development progresses. Long term maintenance of the trees would be required.	Low	No

Table 2
Initial Technologies Screening - Groundwater
Former Kenosha Engine Plant
Kenosha, Wisconsin

Technology	Technology Description	Effectiveness	Implementability	Relative Cost	Retained
NO ACTION	No action is taken to remediate site.	No action would not be effective due to the degree and nature of impacts at the KEP.	Easy to implement as no action would be required, but would likely not be acceptable to the WDNR given soil impacts at the site.	Low	No
INSTITUTIONAL CONTROLS	Institutional controls involve public (ordinances) or private (deed instruments including listing site on WDNR GIS Registry) restrictions on property use as a means to limit the potential for unacceptable exposure to impacts on-site.	Institutional controls provide long term reduction in potential exposure to impacts. However, institutional controls alone provide no reduction in toxicity, mobility, or volume.	Generally considered easy to implement and would but would likely not be acceptable to the WDNR as a stand alone remedy due to the nature and extent of impacts at the KEP.	Low	Yes
MONITORED NATURAL ATTENUATION	Monitored Natural Attenuation (MNA) uses natural physical, chemical, and/or biological processes (e.g., volatilization, sorption, dispersion, dilution; and chemical or biologic stabilization, transformation, or destruction) to reduce and attenuate contaminant mass, toxicity, mobility, volume, or concentration to acceptable levels. Rate of reduction is monitored through groundwater sampling to document progress. This option may require modeling and evaluation of contaminant degradation rates and pathways and predicting contaminant concentration at down gradient receptor points.	MNA would have limited effectiveness as a stand alone remedy at KEP. However, if another remedy is applied to reduce concentrations at the site, MNA could work as a supplemental remedy to provide long-term degradation of impacts.	MNA could be easily implemented at KEP through the evaluation of existing conditions and development of a monitoring plan that could evaluate the rate of reduction of contaminant concentrations. This would result in a long-term groundwater monitoring program during which sampling of monitoring wells on a semi-annual or annual basis.	Low	Yes
GROUNDWATER RECOVERY/TREATMENT	Groundwater recovery wells are placed to intercept the plume on-site (source) and/or at downgradient (barrier) locations. Pumping of groundwater creates a depression in the groundwater table thus controlling the direction and rate of groundwater flow. Rates of VOC mass removal from groundwater pumping systems are minimal and do not function efficiently to remove contaminant mass. Recovered groundwater is treated on-site by air stripping and/or by carbon adsorption. Treated groundwater can be released to the local POTW, to surface water, or re-injected.	Groundwater pump-and-treat systems do not efficiently remove contaminant mass from groundwater. They are usually very effective in controlling contaminant migration; however, they often require frequent maintenance to keep the system operating and functioning to meet design requirements. Operation of a P&T system can result in a stable and/or receding groundwater plume; however, contaminants concentration rebounding following operation can result from contaminants being sorbed onto soil particles.	Installation of P&T systems are intensive and require proper planning and permitting to be installed correctly. Treatment systems will require placement of a temporary structure to protect the equipment. Recovery wells and distribution piping can be installed below grade however it may have some impact on site redevelopment. Operation of P&T systems usually occur over long periods of time and require routine and sometimes major maintenance such as pump replacement, well rehabilitation, and treatment system cleaning.	Moderate to High	Yes
PERMEABLE REACTIVE BARRIER (PRB)	Permeable reactive barriers (PRB) are in-situ remedial systems designed to limit plume migration by forcing impacted groundwater to flow through the PRB, usually under natural gradients. PRBs are constructed in the aquifer, perpendicular to groundwater flow, and filled with media, typically a mixture of zero valent iron and sand, to create an environment in which contaminants are degraded and/or destroyed. Aquifers with minimal anisotropy and a lower confining unit that that can be keyed into are suitable candidates for this treatment technology. PRBs typically have greater treatment longevity than other in-situ alternatives and require minimal maintenance. PRBs are often used to treat chlorinated VOC contamination.	PRBs have long term effectiveness in treating dissolved phase VOC impacts with minimal maintenance provided the system is properly designed and constructed. The PRB truncates the plume of contaminated groundwater flowing away from the source zone and stops the migration of contaminated groundwater beyond the property boundary. PRBs are not typically installed within the source area. Groundwater monitoring is used to evaluate the PRB system performance.	Implementation of PRBs can require substantial field, laboratory and design work. Substantial field work is often needed characterize aquifer heterogeneities and the geometry of the underlying confining layer that the PRB is keyed into. Bench scale testing is used to design the media mixture in the barrier wall. PRB installation is typically a significant construction project involving large scale trenching equipment.	Moderate to High	Yes
IN-SITU CHEMICAL REDUCTION (ENHANCED REDUCTIVE DECHLORINATION)	Nutrients and food sources (substrate) are injected into the groundwater aquifer to enhance conditions for indigenous microbes to degrade VOC to less harmful by-products. Reduction of CVOC follows a sequential breakdown process in which TCE is degraded to DCE and then VC and then to ethene to complete the process. The presence of the correct conditions are required for the process to work efficiently and effectively i.e, reducing groundwater conditions and low dissolved oxygen concentrations. Treatment process can take up to several years to complete and can require numerous substrate injections to keep conditions favorable for efficient contaminant depletion.	Although this alternative targets CVOC's, it is a process that can take many years to fully degrade all the way down to ethene.	Implementation of this alternative would require a pilot test at the site to determine how easily a reducing zone can be reached and maintained throughout the entire process. Regular monitoring would need to be conducted to determine if degradation is taking place or if the process is stalling at a certain level.	Moderate to High	Yes

Table 2
Initial Technologies Screening - Groundwater
Former Kenosha Engine Plant
Kenosha, Wisconsin

Technology	Technology Description	Effectiveness	Implementability	Relative Cost	Retained
IN-SITU CHEMICAL OXIDATION	Injection of oxidizing chemicals to groundwater to chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. Oxidant delivery systems often employ vertical injection wells and sparge points with forced advection to rapidly move the oxidant into the groundwater zone.	Effectiveness depends on the amount of oxidant that comes in contact with the contaminants. Difficulty injecting and dispersing the oxidant is typically encountered in fine-grained soils and often requires pilot testing to determine its effectiveness. Subsequent injections are required in areas that may not have been exposed to the oxidant. Oxidation of VOCs occurs at a relatively rapid rate and remediation goals can typically be achieved in a relatively short period of time.	Treating groundwater in "hot-spot" locations is feasible. Treatment of the entire groundwater plume would require vast amounts of oxidizing chemicals to be successful. Multiple injections may be required based on oxidant distribution and mass of contaminants required to be treated to meet remedial goals. Pilot study would be required to determine the quantity and type of oxidant required.	Moderate to High	Yes
COSOLVENT/ALCOHOL FLOODING	Cosolvent flushing involves the injection of alcohols such as methanol, ethanol, and propanols. These compounds enhance the solubility of many contaminants and are mutually miscible in both water and NAPL and when added to the flushing system can bring about changes in the bulk properties of the contaminated zone. When larger amounts of alcohol are used, the alcohol may partition into both the NAPL and water phases and can result in the reduction of the NAPL-water interfacial tension making it go to zero which facilitates the mobilization of the NAPL. Usually used in conjunction with a pump and treat system.	Under permeable conditions with an underlying confining clay layer cosolvent flushing can be effective in transporting NAPL to a pump and treat system. However, since cosolvent flushing releases substantial amounts of bound VOCs, there is a increase in the volume of material that needs to be treated.	Implementation of this approach would require careful evaluation of the specific source areas to ensure that all mobilized NAPL could be readily captured. An extensive treatment system would need to be constructed, operated, and maintained. The existing hydraulic containment system would need to be evaluated to ensure there was no potential for losing capture during the flushing operations. Unidentified subsurface obstructions could complicate this work.	Moderate	No
SURFACTANT FLUSHING	Surfactant flushing, very similar to cosolvent/alcohol flooding, involves the injection of surfactants, which are chemicals that alter the properties of solution interfaces. Use of a surfactant can either increase the NAPL's solubility or reduce the NAPL-water interfacial tension. This reduction results in a decrease of capillary forces thus allowing the contaminant to move more easily. Usually used in conjunction with a pump and treat system.	Under permeable conditions with an underlying confining clay layer cosolvent flushing can be effective in transporting NAPL to a pump and treat system. However, since cosolvent flushing releases substantial amounts of bound VOCs, there is a increase in the volume of material that needs to be treated.	Implementation of this approach would require careful evaluation of the specific source areas to ensure that all mobilized NAPL could be readily captured. An extensive treatment system would need to be constructed, operated, and maintained. The existing hydraulic containment system would need to be evaluated to ensure there was no potential for losing capture during the flushing operations. Unidentified subsurface obstructions could complicate this work.	Moderate	No
AIR SPARGING	Air sparging consists of injecting compressed air at controlled pressures and volumes into water-saturated soils. It is applicable to sites having volatile and /or aerobically biodegradable organic contaminants present in water-saturated zones, under relatively permeable conditions. Contaminant mass removal occurs via in-situ air stripping of dissolved VOCs, volatilization of trapped and adsorbed phase contamination present below the water table and in the capillary fringe, and aerobic biodegradation of both dissolved and adsorbed phase contaminants. Process is conducted in-situ by injection of compressed air into wells screened below the water table. This technology uses vacuum extraction systems (SVE) to remove stripped contaminants.	Under permeable conditions, air sparging is effective in reducing the mass of contaminants in groundwater and can meet remediation goals in a reasonable period of time. Air sparging can remove large amounts of mass in groundwater resulting in the overall reduction of groundwater contaminant concentrations. Placement of wells, the volume of air injected, and the distribution of air throughout the water table are key factors in maximizing contaminant mass removal. Air sparging systems can be designed to treat entire plumes, treat "hot spots", or placed as a treatment curtain to cut-off plume migration. Effective mass removal will require the use of an SVE system.	Pilot testing is necessary to obtain required design information. Operation of the system requires routine maintenance; however, air sparging systems are fairly reliable due to minimal amounts of equipment as compared to other in-situ technologies. Treatment of the SVE effluent stream using catalytic oxidation or activated carbon may be required depending on contaminant mass and removal rates. Construction of the system can be completed sub-grade, however it could potentially make site redevelopment difficult is some areas. Equipment would be placed in a temporary building located near the treatment area. Numerous wells would be needed for a system that is designed to treat the entire plume. Local permitting may be required to construct and operate the system.	Moderate	No
PHYTOREMEDIATION	Phytoremediation is the use of plants along with their associated microorganisms to stabilize or reduce contamination in shallow groundwater. It can be an effective remediation method on a variety of contaminants especially for site with low concentrations of contaminants over a large area and are at shallow depths. Hybrid poplar and willow trees have been successful in treating CVOC's.	Due to the high concentrations present is some areas of the KEP, phytoremediation alone would not be effective alone in reducing groundwater contaminant mass. It could however be part of an effective long term remedial strategy in areas with lower concentrations or following initial source treatment or to provide some degree of hydraulic groundwater gradient control	Implementation of this technology is easy to implement, but would need to be incorporated into a long term development plan for the KEP as trees may need to be removed as site development progresses. Long term maintenance of the trees would be required.	Low to moderate	Yes

Table 3
Retained Technologies Evaluation - Soil
Former Kenosha Engine Plant
Kenosha, Wisconsin

		Threshold Criteria		Balancing Criteria					Modifying Criteria	
Retained Technology	**Technology/Alternative Description**	**Overall Protection of Human Health and the Environment**	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility or Volume**	**Short-term Effectiveness**	**Implementability**	**Cost**	**State/Support Agency Acceptance**	**Community Acceptance**
NO ACTION	No action is taken to remediate site.	Does not protect human health or the environment as this site has concentrations that exceed risk-based levels.	This alternative would not comply with the ARAR's.	Implementing No Action at KEP would be ineffective as soil impacts would remain in place. Soil impacts would continue to leach to groundwater leading to greater/expanding impact and likelihood of unacceptable exposure.	There would be no reduction of toxicity and volume of impacted soil. In addition, impacted groundwater would expand with this alternative.	Implementing No Action at site would result in minimal impact in the short term.	No Action alternative would be very implementable.	There would be no cost.	The WDNR would find this alternative unacceptable.	It is very likely that the community would not accept this alternative.
INSTITUTIONAL CONTROLS	Institutional controls involve public (ordinances) or private (deed instruments including listing site on WDNR GIS Registry) restrictions on property use as a means to limit the potential for unacceptable exposure to impacts on-site.	This alternative offers protection through administrative rules to limit potential exposure to contaminants, but does not affect the toxicity, mobility or volume of contamination.	This alternative alone will not comply with the ARAR's, but may be used in conjunction with other technologies to achieve regulatory compliance and enable redevelopment of KEP.	Institutional controls provide long term reduction in potential exposure to impacts. However, institutional controls alone provide no reduction in toxicity, mobility, or volume.	Institutional controls offer no reduction of toxicity, mobility, or volume of contaminants.	Short term effectiveness is limited to reduction in potential for exposure to impact. Given that no remediation is conducted, there is no effective reduction in contamination.	Alternative can be implemented with deed instruments, listing of the property on the WDNR GIS registry or local ordinances.	Cost for this alternative are low as they are limited to implementation of land use controls. There are no costs associated with remedial actions or operations and maintenance.	It is very likely that the WDNR would not accept this alternative as a stand alone action. However, the WDNR would likely accept this as part of a remedial strategy to enable redevelopment of KEP.	The community would likely not accept this alternative as a stand alone action. However, it would likely be viewed favorably as part of a remedial strategy to enable redevelopment of KEP.
SURFACE CAP	Areas of identified soil contamination exceeding direct contact and groundwater protection standards would be rendered inaccessible by capping with an engineered barrier. Typical engineered barriers consist of asphalt, concrete pavement and/or geomembrane liners. Earthen and/or landscaped cap may be suitable in some situations..	This alternative would prevent direct contact with impacted soil while slowing down the migration of contaminants from soil to groundwater.	A surface cap alone will likely not comply with all ARARs.	Effective in eliminating the direct contact exposure pathway and reducing infiltration of water through impacted soil. Placement of an impermeable barrier could affect the migration of vapors and expand the extent of soil impacts. The cap would need to be maintained. Can affect the direction and magnitude of groundwater flow if capping area can be extensive. Capping alone would not reduce mass of contaminants, which will significantly increase time for effective groundwater treatment	There would be no reduction of toxicity or volume of contamination. However, the mobility of contamination may be reduced based on the reduced amount of infiltration in the source area.	A surface cap would be effective in the short term by reducing infiltration of precipitation through contaminated soil. This will result in a lower flux of impacted groundwater flowing from the source area.	This alternative could be readily implemented but may limit some potential site redevelopment activities.	Costs for installation of a cap are generally considered relatively low relative to other remedial technologies. The cost would be dependent on the size of the capped area and the amount of debris that would need to be removed before a cap could be installed.	It is unlikely that the WDNR would accept this alternative as a stand alone action. However, the WDNR would likely accept this as part of a remedial strategy to enable redevelopment of KEP.	The community would likely not accept this alternative as a stand alone action. However, it would likely be viewed favorably as part of a remedial strategy to enable redevelopment of KEP.
EXCAVATION AND TREATMENT/DISPOSAL OF IMPACTED SOIL	Directly remove and treat impacted soil to address accessible RCL exceedances. Treatment may take place at site and/or prior to landfilling at an approved/permitted off-site disposal facility. Clean backfill is used if soil is taken off-site for treatment.	The overall protection of human health is high with this alternative as impacted soil would be removed from the KEP and treated/disposed of at a landfill that is properly designed/controlled.	This alternative would comply with the ARAR's.	Long term effectiveness is very high with this alternative because the contamination is being removed and properly disposed of.	This alternative reduces the volume of contaminated soil through removal and disposal. Potential exists for leaving residual contamination from soil that would not be accessed.	This alternative would have a high degree of short-term effectiveness through the removal and disposal of impacted soil, however there is the potential for exposure to impacted soil and dust during implementation. These short term risks are manageable.	This alternative may be difficult to implement because of all of the buried construction debris.	The cost of this alternative would be dependent on the size of the excavated area. However, it is expected that the cost would likely range from high to very high given the size of the source area(s) at KEP and the likelihood of encountering buried obstructions that would need to be addressed.	The WDNR would likely accept this alternative because it completely remediates the contaminated area.	The community would likely look favorably on this alternative, although temporary disruptions associated with excavation activities could interfere with typical neighborhood activities. On the whole, it is expected that the community would likely view the excavation alternative favorably.
IN-SITU CHEMICAL OXICATION	In-situ chemical oxidation (ISCO) uses chemical oxidants (Fenton's Reagent, permanganate, persulfate, ozone, etc.) to transform organic contaminants (typically through oxidation) into less harmful chemical compounds. This technology is typically applied through injections at the source of contaminant and as a result is considered an *in-situ* remedial approach. Catalysts are often used to accelerate or enhance the degree of oxidation.	This technology will destroy CVOCs, but if not properly applied, can result in release of chemicals to subsurface utilities. It can also have the added benefit of altering soil structure to make other remedial measures more suitable (e.g., soil vapor extraction). This technology will also oxidize other organic carbon in the soil/groundwater matrix. This can make it difficult to switch to biologically mediated remedial methods (Enhanced Reductive Dechlorination) in the future.	This alternative could comply with ARARs if properly implemented.	Effectiveness of this alternative would be evaluated following treatment. Rebound of CVOC concentrations is often observed with ISCO. As a result, supplemental or focused additional ISCO injections may be needed. ISCO addresses CVOC impacts in the source area. Downgradient plume(s) of VOCs are not addressed through ISCO and would need to be addressed with another technology or allowed to flush through the aquifer before RCLs are achieved.	ISCO will reduce the volume of contaminant and thereby toxicity. However, mobility of residual contaminant that is not addressed by initial ISCO application can be increased as the level of organic carbon in soil and groundwater is reduced resulting in reduced attenuative capacity.	Short-term effectiveness is high as complete destruction of CVOCs in permeable portions of the source area will result in very low to none detect concentrations in the shallow aquifer.	Implementation of this alternative would require treatability testing to select the most appropriate oxidant to address site contaminants. A pilot test at the site would also be required to determine how readily chemical oxidation can reach impacted source area soil.	Cost for this alternative would be moderate. There would be an initial cost for the treatability and pilot testing prior to full scale implementation. Multiple applications may be warranted to achieve treatment to desired RCLs	The WDNR would likely accept this alternative as part of an overall remedy strategy. Permits would be required for pilot testing and full scale implementation of this remedy	It is likely that the community would accept this alternative as part of a remedial approach that would reduce levels of VOC impact in soil to acceptable risk-based criteria. The community may have concerns about materials injected into the subsurface.
PHYTOREMEDIATION	Phytoremediation uses plants along with their associated microorganisms to stabilize or reduce contamination in soil and limit infiltration of precipitation to the water table. It can be an effective long term remedial strategy on a variety of contaminants especially for site with low concentrations of contaminants over a large area and are at shallow depths. Poplar and willow trees have been successful in treating CVOCs.	Protection of human health by phytoremediation at KEP would be low. Contaminant concentrations at KEP are high and phytoremediation would not address these conditions.	This alternative alone would not comply with the ARAR's.	Long-term effectiveness of this alternative is low for KEP. Phytoremediation can be used for smaller concentrations or residual concentrations but is not suitable for the elevated concentrations at KEP. In addition, the limited growing season at KEP would reduce overall effectiveness.	Phytoremediation can reduce contaminant concentrations at low to moderate levels. However, this alternative would have limited ability to reduce toxicity, mobility, or volume given the elevated concentrations found at KEP.	Short-term effectiveness of phytoremediation is low. Little effectiveness would be expected over the first several years following planting of the phytoremediation system.	Phytoremediation would be difficult to implement. Planting associated with this option would likely cover much of the KEP property, thereby limiting redevelopment options. The presence of numerous subsurface obstructions, and need to maintain and impermeable cap over the source area(s) at KEP.	The cost of this alternative is low. Installation costs are limited to planting of trees or other vegetation. O&M costs are limited to thinning and replanting of trees as well as MNA monitoring. .	The WDNR would not likely accept this alternative because the site is mostly concrete and would not be feasible or cost effective to implement this alternative at the vast majority of the site.	The community would not likely accept this alternatives a stand alone mea because it would not be adequately protective of human health and the environment and would limit redevelopment of the site.

ARAR=Applicable or Relevant and Appropriate Requirements

Table 4
Retained Technology Evaluation - Groundwater
Former Kenosha Engine Plant
Kenosha, Wisconsin

		Threshold Criteria		Balancing Criteria					Modifying Criteria	
Retained Technology	**Technology/Alternative Description**	**Overall Protection of Human Health and the Environment**	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility or Volume**	**Short-term Effectiveness**	**Implementability**	**Cost**	**State/Support Agency Acceptance**	**Community Acceptance**
NO ACTION	No action is taken to remediate site.	This alternative does not protect human health or the environment. Groundwater impacts would migrate off-site, resulting in an expansion of the area affected.	This alternative would not comply with ARARs for KEP.	Implementing No Action at site would not be effective long term as there would be no action taken.	There would be no reduction of toxicity, mobility with this alternative. Volume of impacted groundwater would increase after hydraulic containment systems are shut down.	Implementing No Action at site would not be effective short term as there would be no action taken.	The No Action alternative could be easily implemented through shutting down of hydraulic containment system.	Cost associated with this alternative would be very low.	The WDNR would not accept this alternative.	Although community acceptance would be determined following a public meeting, it is very unlikely that the community would accept this alternative.
INSTITUTIONAL CONTROLS	Institutional controls involve public (ordinances) or private (deed instruments) restrictions on property use as a means to limit the potential for unacceptable exposure to impacts on-site.	Institutional controls (ICs) provide human health and environmental protection by legal or institutional isolation of contaminants. Institutional controls can be effective when combined with other alternatives but, as a stand alone alternative, it is not effective in addressing contamination.	This alternative, by itself, would not comply with ARAR's.	ICs can provide long term effective isolation of contamination if properly designed and implemented. However, this alternative is ineffective in addressing contaminant mass. As a result, it is considered an ineffective alternative as a stand alone remedy.	ICs provide no reduction in toxicity, mobility, or volume of contamination.	ICs can provide short term isolation of contamination if properly designed and implemented. However, this alternative is not considered to be effective unless combined with other remedies to reduce contaminant mass.	ICs are easily implementable, but require concurrence with the WDNR and local community.	Costs associated with ICs are would be low since there are no costs associated implementing an active remedy, operations and maintenance, or monitoring.	It is unlikely that the WDNR would accept ICs as a stand alone alternative. However, the WDNR would likely accept this alternative if it were used in conjunction with other, more aggressive alternative(s) that would reduce contaminant toxicity, mobility, or volume.	This would be determined following a public meeting. It is unlikely that the community would accept ICs as a stand alone alternative. The community may accept ICs in conjunction with other, more aggressive remedial alternatives.
MONITORED NATURAL ATTENUATION	Monitored Natural Attenuation (MNA) uses natural physical, chemical, and/or biological processes (e.g., volatilization, sorption, dispersion, dilution; and chemical or biologic stabilization, transformation, or destruction) to reduce and attenuate contaminant mass, toxicity, mobility, volume, or concentration to acceptable levels. Rate of reduction is monitored through groundwater sampling to document progress. This option may require modeling and evaluation of contaminant degradation rates and pathways and predicting contaminant concentration at down gradient receptor points.	MNA, as a stand alone remedy, offers a low level of protection to human health and the environment. This is due to the high concentrations of VOCs at KEP. MNA may offer adequate protection to human health and the environment when combined with other remedies that would lower the overall concentrations of contaminants or eliminate the potential for exposure to contaminants.	This alternative, as a stand alone option would not comply with ARARs.	MNA would have limited effectiveness as a stand alone remedy at KEP. However, if another remedy is applied to reduce concentrations at the site, MNA could work as a supplemental remedy to provide long-term degradation of impacts.	As a stand alone remedy, reduction in toxicity, mobility, and volume would require an unacceptable time frame to meet the risk-based cleanup criteria. However, if elevated concentrations are addressed with a aggressive remedial alternative (e.g., excavation or ERD), MNA could reduce the toxicity, mobility, and volume of VOC impacts over a period of years as the risk-based criteria are reached.	MNA would have limited to no short term effectiveness as the processes used with MNA work over a long period of time.	MNA could be easily implemented at KEP through the evaluation of existing conditions and development of a monitoring plan that could evaluate the rate of reduction of contaminant concentrations. This would result in a long-term groundwater monitoring program during which sampling of monitoring wells on a semi-annual or annual basis.	Short term costs associated with MNA are considered low. However, given the extensive length of time over which monitoring would be conducted, overall costs can be substantial.	MNA as a stand alone remedy would not likely be acceptable by the WDNR. This is based on the extremely long time frame (likely 100s or yrs) that would be required to achieve risk-based concentrations.	MNA, as a stand alone remedy, would not likely be acceptable to the community. However, if combined with other, more aggressive, remedies, it would likely be acceptable to the community.
GROUNDWATER RECOVERY/TREATMENT	Groundwater recovery wells are placed to intercept the plume on-site (source) and/or at downgradient (barrier) locations. Pumping of groundwater creates a depression in the groundwater table thus controlling the direction and rate of groundwater flow. Rates of VOC mass removal from groundwater pumping systems are minimal and do not function efficiently to remove contaminant mass. Recovered groundwater is treated on-site by air stripping and/or by carbon adsorption. Treated groundwater can be released to the local POTW, to surface water, or re-injected.	Groundwater recovery and treatment systems are usually very effective in controlling contaminant migration; but do little to treat source area impacts.	This technology would comply with ARARs provided that it is properly designed and operated.	Effective in controlling off-site migration however long term operation and maintenance would be necessary.	If properly designed, groundwater recovery and treatment systems can limit the mobility of contaminants through gradient control but will have little impact on reducing contaminant volume or toxicity within the plume.	Can be effective in the short-term at controlling migration. Limited exposure to impacts during construction or operation and maintenance of the system.	Installation of P&T systems are intensive and require proper planning and permitting to be installed correctly. Treatment systems will require placement of a temporary structure to protect the equipment. Recovery wells and distribution piping can be installed below grade however it may have some impact on site redevelopment. Operation of P&T systems usually occur over long periods of time and require routine and sometimes major maintenance such as pump replacement, well rehabilitation, and treatment system cleaning.	Costs associated with installation of the groundwater recovery system are considered moderate, however there are significant long term costs associated with operation, maintenance and monitoring activities.	The WDNR has previously accepted groundwater recovery and treatment as a acceptable interim remedial action to control off-site migration, however it is unlikely that this technology alone will meet regulatory requirements as a long term remedy for the site.	This would be determined following a public meeting. It is anticipated that the community may accept this provided that it effectively limits off-site migration of groundwater impacts.
PERMEABLE REACTIVE BARRIER (PRB)	Permeable reactive barriers (PRB) are in-situ remedial systems designed to limit plume migration by forcing impacted groundwater to flow through the PRB, usually under natural gradients. PRBs are constructed in the aquifer, perpendicular to groundwater flow, and filled with media, typically a mixture of zero valent iron and sand, to create an environment in which contaminants are degraded and/or destroyed. Aquifers with minimal anisotropy and a lower confining unit that that can be keyed into are suitable candidates for this treatment technology. PRBs typically have greater treatment longevity than other in-situ alternatives and require minimal maintenance. PRBs are often used to treat chlorinated VOC contamination.	Overall protection of human health and environment would be moderate to high with this alternative. The PRB truncates the plume of contaminated groundwater flowing away from the source zone and stops the migration of contaminated groundwater beyond the property boundary.	This alternative would comply with groundwater ARARs at the property boundary, but would not address ARARs associated with source zone impacts (e.g., direct contact or vapor intrusion).	PRBs have long term effectiveness in treating dissolved phase CVOC impacts with minimal maintenance provided the system is properly designed and constructed. Groundwater monitoring is used to evaluate the PRB system performance.	PRBs are effective in stopping the mobility and reducing the toxicity of dissolved phase contaminants. PRBs have limited ability to reduce the volume of contaminant mass.	PRBs can take some time to design and install and this can limit the short term effectiveness of PRBs. The design and installation requirements can be substantial, particularly if aquifer heterogeneities and a lower confining layers are not well/easily defined.	Implementation of PRBs can require substantial field, laboratory and design work. Substantial field work is often needed characterize aquifer heterogeneities and the geometry of the underlying confining layer that the PRB is keyed into. Bench scale testing is used to design the media mixture in the barrier wall. PRB installation is typically a significant construction project involving large scale trenching equipment.	The cost associated with installing a PRB would be moderate to high. Multiple factors must be considered including length and depth of the barrier, nature of media in the barrier, Construction costs associated with a barrier wall are typically high. Although there is limited maintenance requirements, regular groundwater monitoring would needed to verify its effectiveness.	The WDNR may accept this alternative as a long term treatment option but they would likely require a substantial monitoring program to document its success.	This would be determined following a public meeting. It is anticipated that the community may accept this provided that it effectively limits off-site migration of groundwater impacts.

Table 4
Retained Technology Evaluation - Groundwater
Former Kenosha Engine Plant
Kenosha, Wisconsin

		Threshold Criteria		Balancing Criteria					Modifying Criteria	
Retained Technology	**Technology/Alternative Description**	**Overall Protection of Human Health and the Environment**	**Compliance with ARARs**	**Long-term Effectiveness and Permanence**	**Reduction of Toxicity, Mobility or Volume**	**Short-term Effectiveness**	**Implementability**	**Cost**	**State/Support Agency Acceptance**	**Community Acceptance**
IN-SITU CHEMICAL REDUCTION (ENHANCED REDUCTIVE DECHLORINATION)	Nutrients and food sources (substrate) are injected into the groundwater aquifer to enhance conditions for indigenous microbes to degrade VOC to less harmful by-products. Reduction of CVOC follows a sequential breakdown process in which TCE is degraded to DCE and then VC and then to ethene to complete the process. The presence of the correct conditions are required for the process to work efficiently and effectively i.e., reducing groundwater conditions and low dissolved oxygen concentrations. Treatment process can take up to several years to complete and can require numerous substrate injections to keep conditions favorable for efficient contaminant depletion.	Although this alternative targets CVOC's, it is a process that can take many years to fully degrade all the way down to ethene. Because of this, there is more of a chance that human health could be affected by migrating plumes off site.	This alternative alone would not comply with the ARAR's.	Effectiveness of this treatment alternative is moderate to high due to low levels of dissolved oxygen in groundwater at the site,	This alternative deals with multiple injections over a period of time in order to maintain a reducing atmosphere so that the degradation process can proceed at an acceptable rate.	Short-term effectiveness is low to moderate because of the time frame that the degradation takes place in. As TCE degrades to DCE and as DCE degrades to VC and so on, the daughter product concentrations increase. Which could cause a problem if the process stalls and the levels of VC increase, which is a known carcinogen.	Implementation of this alternative would require a pilot test at the site to determine how easily a reducing zone can be reached and maintained throughout the entire process. Regular monitoring would need to be conducted to determine if degradation is taking place or if the process is stalling at a certain level.	Cost for this alternative would be low to moderate. There would be an initial cost for the pilot test that would need to be done. Following the pilot test there would be the cost associated with the injections and also with the monitoring that would have to take place after each injection.	The WDNR would likely not support this alternative because this alternative alone would not remediate the site to below risk-based levels on its own and would likely have to be paired with one or multiple other alternatives.	It is likely that the community would accept this alternative as part of a remedial approach that would reduce levels of VOC impact in soil to acceptable risk-based criteria. The community may have concerns about materials injected into the subsurface.
IN-SITU CHEMICAL OXIDATION	Injection of oxidizing chemicals to groundwater to chemically convert hazardous contaminants to non-hazardous or less toxic compounds that are more stable, less mobile, and/or inert. The oxidizing agents most commonly used are ozone, hydrogen peroxide, hypochlorites, chlorine, and chlorine dioxide. Oxidant delivery systems often employ vertical injection wells and sparge points with forced advection to rapidly move the oxidant into the groundwater zone.	The overall protection of human health is high with this alternative. Doing a chemical injection at or near the source area will slow the migration of TCE offsite.	This alternative could comply with the ARAR's but it depends on how effective the injection would be which would be determined by a pilot test.	Effectiveness depends on the amount of oxidant that comes in contact with the contaminants. Difficulty injecting and dispersing the oxidant is typically encountered in fine-grained soils and often requires pilot testing to determine its effectiveness. Subsequent injections are required in areas that may not have been exposed to the oxidant. Oxidation of VOCs occurs at a relatively rapid rate and remediation goals can typically be achieved in a relatively short period of time. Can be successful at sites that have low amounts of organic carbon and high groundwater ORP levels. Will reduce concentrations to near groundwater protection standards where implemented.	Oxidation of VOCs occurs at a relatively rapid rate and remediation goals can typically be achieved in a relatively short period of time. Doing an injection at the "hot spot" areas can reduce the amount of daughter products that are further down stream.	Short-term effectiveness is high for this alternative because remediation goals can usually be reached in a very quick manner which translates to less of an impact on the community. During the injection there could be a moderate risk for the workers handling and using chemicals, but that risk is would be addressed through proper planning and implementation.	Treating groundwater in "hot-spot" locations is feasible. Treatment of the entire groundwater plume would require vast amounts of oxidizing chemicals to be successful. Multiple injections may be required based on oxidant distribution and mass of contaminants required to be treated to meet remedial goals. Pilot study would be required to determine the quantity and type of oxidant required. Timeframe for remediation relatively short.	Cost of this alternative would be moderate mostly dependent on how many injections that would need to take place in order to remediate the contaminated groundwater below risk-based levels. There are other factors involved with this such as how well the oxidant distributes through the saturate zone.	The WDNR would likely accept this alternative give the fast remediation time and moderate costs.	It is likely that the community would accept this alternative as part of a remedial approach that would reduce levels of VOC impact in soil to acceptable risk-based criteria. The community may have concerns about materials injected into the subsurface.
PHYTOREMEDIATION	Phytoremediation is the use of plants along with their associated microorganisms to stabilize or reduce contamination in shallow groundwater. It can be an effective remediation method on a variety of contaminants especially for site with low concentrations of contaminants over a large area and are at shallow depths. Hybrid poplar and willow trees have been successful in treating CVOC's.	Protection of human health by phytoremediation is low because the site has high concentrations of CVOC's migrating offsite.	This alternative alone would not comply with the ARAR's.	Long-term effectiveness of this alternative is moderate because it is can be used for smaller concentrations or residual concentrations from another form of remediation. But the growing season would cause a problem because of the cold temperatures during the winter.	This alternative has good reduction rates over an extended time but requires substantial area. It does not effectively remediate sites with high contaminate concentrations.	Short-term effectiveness of phytoremediation is moderate because there is no impacts on the environment but if there are contaminants migrating offsite then there could possibly be a problem with the community.	Phytoremediation is very implementable as the main source of the remediation is the use of trees. Depending on the site concrete and construction debris would have to be removed in order to get the trees planted.	The cost of this alternative is moderate, primarily associated with installation of the trees and long term seasonal O&M.	The WDNR would not likely accept this alternative because the site is mostly concrete and would not be feasible or cost effective to implement this alternative at the vast majority of the site.	MNA, as a stand alone remedy, would not likely be acceptable to the community. However, if combined with other, more aggressive, remedies, it would likely be acceptable to the community.

ARAR=Applicable or Relevant and Appropriate Requirements

Table 5
Treatment Technology Components for the Remedial Alternatives
Former Kenosha Engine Plant
Kenosha, Wisconsin

	Unsaturated Soil (0-12 ft bgs)				Groundwater and Saturated Soil (>12 ft bgs)					
	Institutional Controls	Surface Cap	Excavation/Off-Site Disposal	In-Situ Chemical Oxidation (ISCO)	Institutional Controls	Monitored Natural Attenuation (MNA)	Permeable Reactive Barrier (PRB)	In-Situ Chemical Reduction	Groundwater Extraction	Phytoremediation
Alternative 1: No Further Remedial Action										
Alternative 2: Continued Groundwater Recovery/Treatment	X	X	X		X	X			X	O
Alternative 3: Limited Active Source Groundwater Treatment with PRB	X	X	X		X	X	X	X		O
Alternative 4: Soil and Groundwater Source Control	X	X	X	X	X	X		X		O
Alternative 5: Extensive Soil Removal and Groundwater Treatment	X		X	X	X	X		X		O

Notes:

X	Remedial technology will be implemented as part of this remedy.
O	Remedial technology retained for further consideration after primary remedy is implemented.

In-Situ Chemical Reduction includes Insitu Chemical Oxidation (ISCO) and/or Enhanced Reductive Dechlorination (ERD)

Table 6
Remedial Alternative Cost Comparison
Former Kenosha Engine Plant
Kenosha, Wisconsin

Conceptual Cost Summary	Alternative 1 No Action	Alternative 2 Continued Groundwater Recovery/ Treatment	Alternative 3 Limited Active Source Groundwater Treatment with PRB	Alternative 4 Soil and Groundwater Source Control	Alternative 5 Complete Soil Removal and Groundwater Treatment
Engineering, Design, and Project Coordination	$0	$1,170,000	$2,240,000	$2,820,000	$15,480,000
Implementation					
Site Preparation	$0	$2,300,000	$2,300,000	$2,300,000	$2,300,000
Soil	$0	$4,820,000	$6,090,000	$15,300,000	$146,380,000
Groundwater	$0	$580,000	$16,080,000	$14,050,000	$29,030,000
Operation, Maintenance and/or Monitoring	$0	$5,710,000	$1,240,000	$820,000	$260,000
Subtotal	$0	$14,580,000	$27,950,000	$35,290,000	$193,450,000
Present Worth[1]	**$0**	**$11,785,000**	**$26,829,000**	**$34,410,000**	**$191,948,000**
Present Worth[1] Cost Range	*$0*	*$8,250,000*	*$18,780,000*	*$24,090,000*	*$134,360,000*
Low (-30%) to	*to*	*to*	*to*	*to*	*to*
High (+50%)	*$0*	*$17,680,000*	*$40,240,000*	*$51,620,000*	*$287,920,000*

Notes:

The cost estimates provided above are conceptual and were developed for the purposes of evaluating remedial alternatives. Costs shown above are through completion of corrective action and do not included costs for well abandonment and/or system decommissioning.

Engineering, Design, and Project Coordination estimated at approximately 9% of estimated project costs.

[1] The Total Present Worth Cost is calculated at a discount rate of 7%.

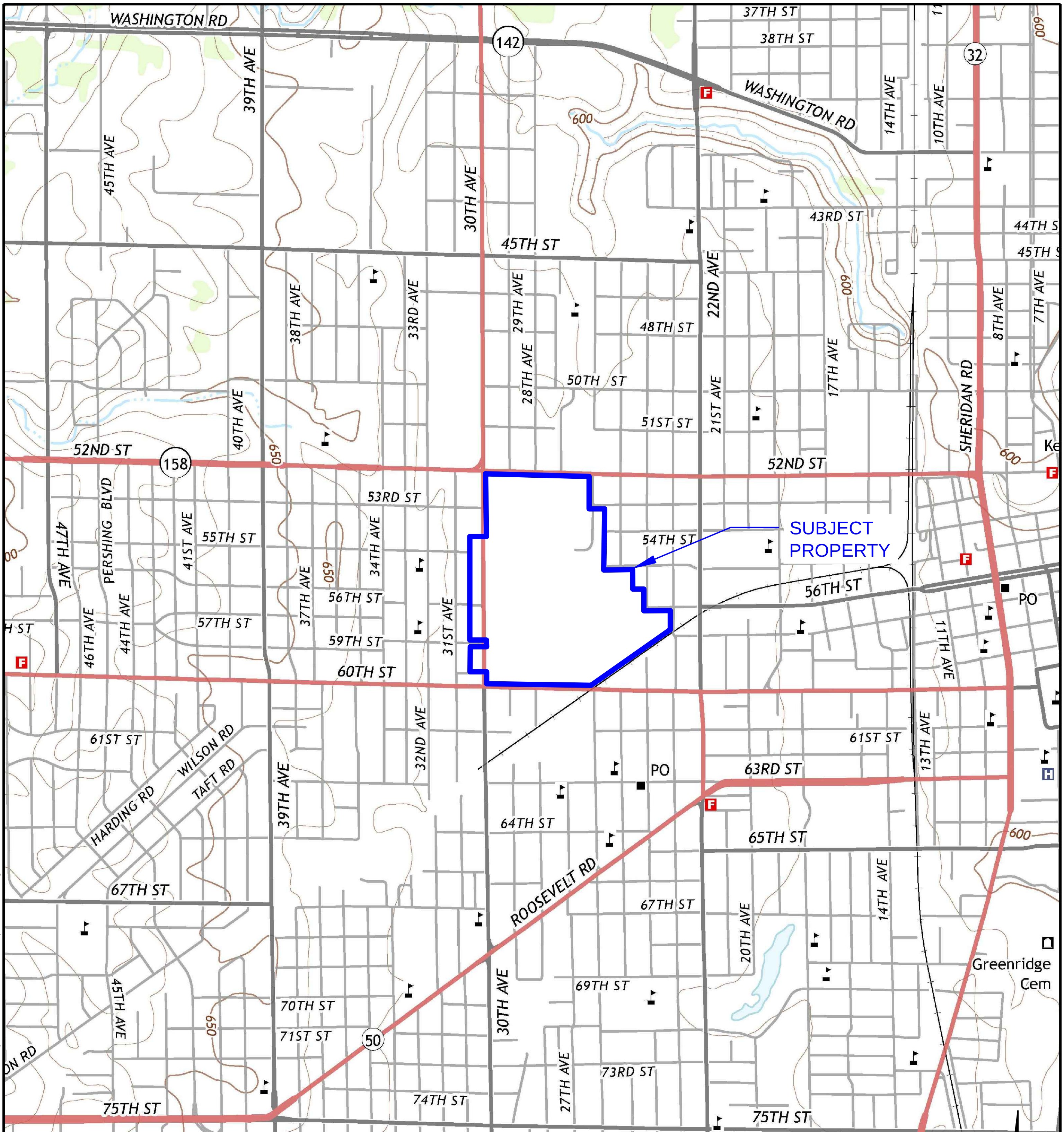
Table 7
Comparative Analysis of Remedial Alternatives
Former Kenosha Engine Plant
Kenosha, Wisconsin

EVALUATION CRITERION	Alternative 1 No Action	Alternative 2 Continued Groundwater Recovery/ Treatment	Alternative 3 Limited Active Source Groundwater Treatment with PRB	Alternative 4 Soil and Groundwater Source Control	Alternative 5 Complete Soil Removal and Groundwater Treatment
THRESHOLD CRITERIA					
Overall Protection of Human Health and the Environment	Somewhat protective; prior actions provide a degree of protection and current paved surfaces/fencing limit direct contact with residual impacts. Although natural processes would likely reduce concentrations over time, the groundwater plume would likely expand	Protective	Protective	Protective	Protective
Criterion Score (Pass or Fail)	Fail	Pass	Pass	Pass	Pass
Compliance with ARARs	Does not comply with ARARs	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.	Complies with ARARs.
Criterion Score (Pass or Fail)	Fail	Pass	Pass	Pass	Pass
BALANCING CRITERIA					
Long-Term Effectiveness and Permanence	NA	Effective and Permanent; requires long term system operation/ maintenance/ monitoring and maintenance of capped areas	Effective and Permanent; requires long term monitoring to demonstrate effectiveness and maintenance of capped areas	Effective and Permanent; requires MNA monitoring to document effectiveness and maintenance of capped areas.	Effective and Permanent
Criterion Score (1-5)	-	2	3	3	4
Reduction of Toxicity, Mobility, and Volume (TMV)	NA	Limited reduction in TMV other than areas that are excavated and/or capped. Groundwater recovery/treatment system reduces mobility but does not reduce toxicity or volume.	Provides some additional reductions in TMV due to slight increase in areas identified for removal along with additional source in-situ groundwater source treatment. PRB reduces mobility.	Provides additional reductions in TMV due to increase in areas identified for removal along with additional source in-situ groundwater source treatment.	Provides the greatest degree of reduction in TMV.
Criterion Score (1-5)	-	2	3	4	5

Table 7
Comparative Analysis of Remedial Alternatives
Former Kenosha Engine Plant
Kenosha, Wisconsin

EVALUATION CRITERION	**Alternative 1** No Action	**Alternative 2** Continued Groundwater Recovery/ Treatment	**Alternative 3** Limited Active Source Groundwater Treatment with PRB	**Alternative 4** Soil and Groundwater Source Control	**Alternative 5** Complete Soil Removal and Groundwater Treatment
BALANCING CRITERIA (continued)					
Short-Term Effectiveness	NA	Effective; limited exposure short term removal action.	Effective; limited exposure during short term removal action and installation of PRB.	Effective; limited exposure during short term removal action and exposure to chemicals used for groundwater treatment.	Effective; significant short term risk associated with large removal action and chemicals used for groundwater treatment.
Criterion Score (1-5)	-	4	3	3	2
Implementability	NA	Easy to Moderate	Moderate	Moderate	Moderate to Difficult
Criterion Score (1-5)	-	3	4	4	3
Estimated Future Cost (Present-Worth; exclusive of costs incurred to date)	NA	$12,000,000	$27,000,000	$34,000,000	$192,000,000
Criterion Score (1-5)	-	5	4	4	2
ADDITIONAL CRITERIA					
Green and Sustainable Remediation	NA	Moderately sustainable; small removal action will generate waste; long term utility needs for continued operation of groundwater recovery and treatment system.	Moderately sustainable; small removal actions will generate waste; transportation related emissions.	Moderately sustainable; no additional actions other than maintenance and monitoring, and possible installation of a limited number of monitoring wells.	Not sustainable; large removal action will generate waste and transportation related emissions; large volume of chemicals and water needed for groundwater remediation.
Criterion Score (1-5)	-	4	4	4	2
Alternative Total Score	**-**	**20**	**21**	**22**	**18**
Overall Rank	**-**	**3**	**2**	**1**	**4**

List of Figures



NOTES

1. TOPOGRAPHIC MAP FROM USGS:
   http://store.usgs.gov/b2c_usgs/usgs/maplocator/
   DATED 2013

1000 0 1000 2000

FEET

N

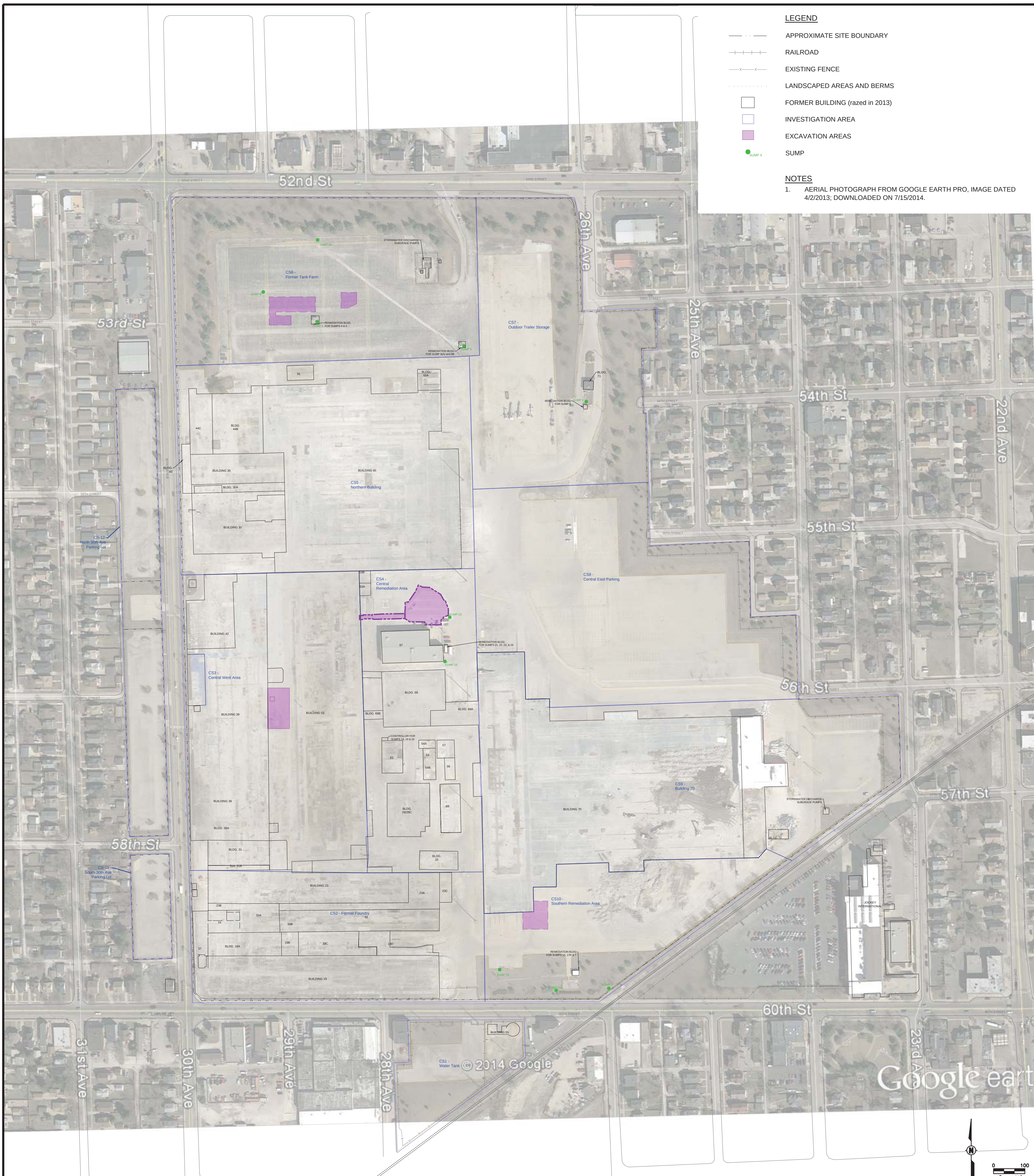
AECOM

1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

USGS TOPOGRAPHIC MAP
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn :	AS	4/7/2015
Checked:	LLA	4/7/2015
Approved:	KWB	4/7/2015
PROJECT NUMBER	60328684	
FIGURE NUMBER	1	

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\Base Map 2015\KEP - base map - 2015.dwg ; 4/6/2015 4:16:36 PM; ENGELHARDT, SARAH; ----

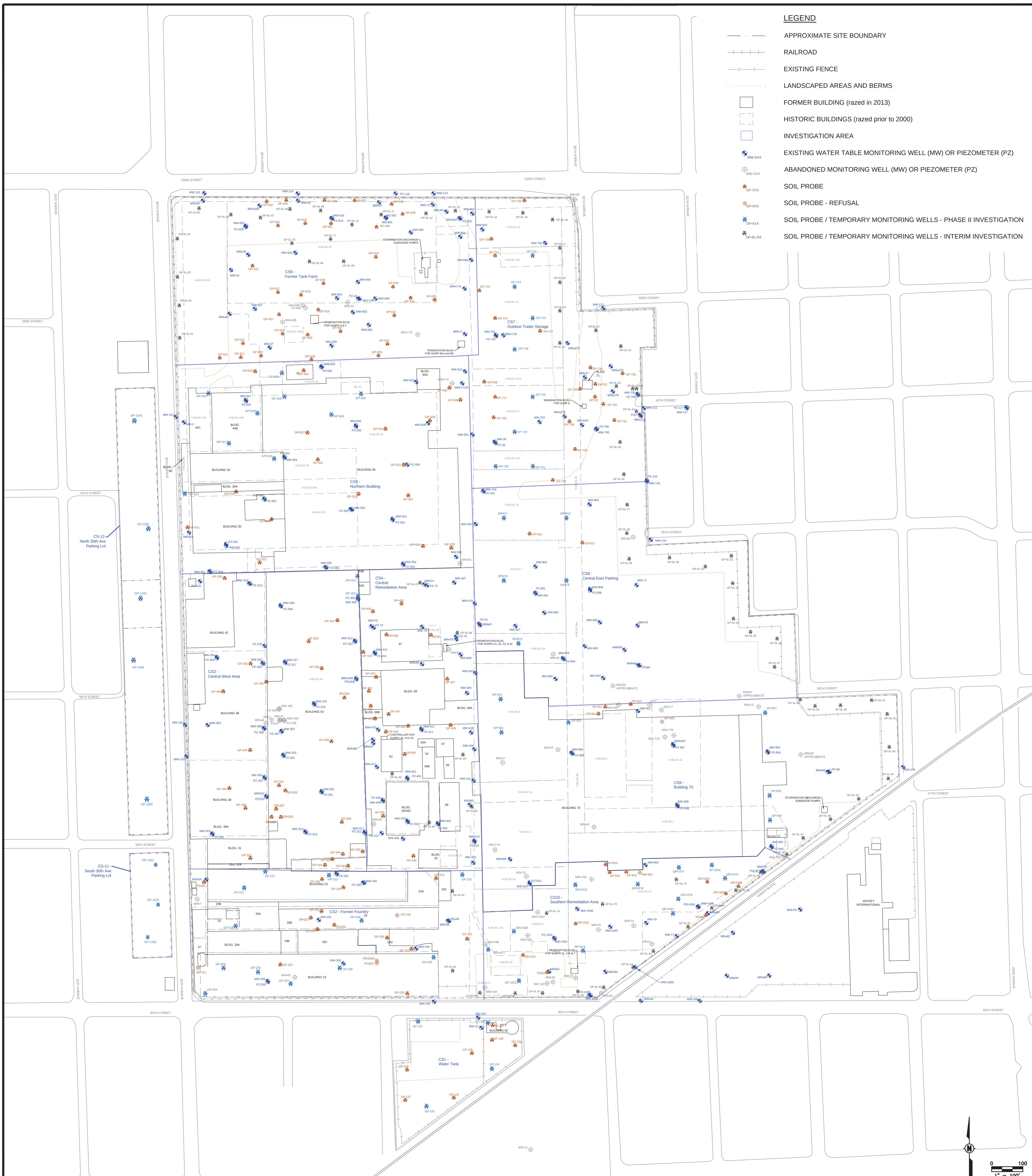


SITE LAYOUT
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn:	SAE 4/6/2015
Checked:	LLA 4/6/2015
Approved:	KWB 4/6/2015
PROJECT NUMBER	60328684
FIGURE NUMBER	2

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\Base Map 2015\KEP - base map - 2015.dwg ; 4/7/2015 11:16:02 AM; ENGELHARDT, SARAH; ----

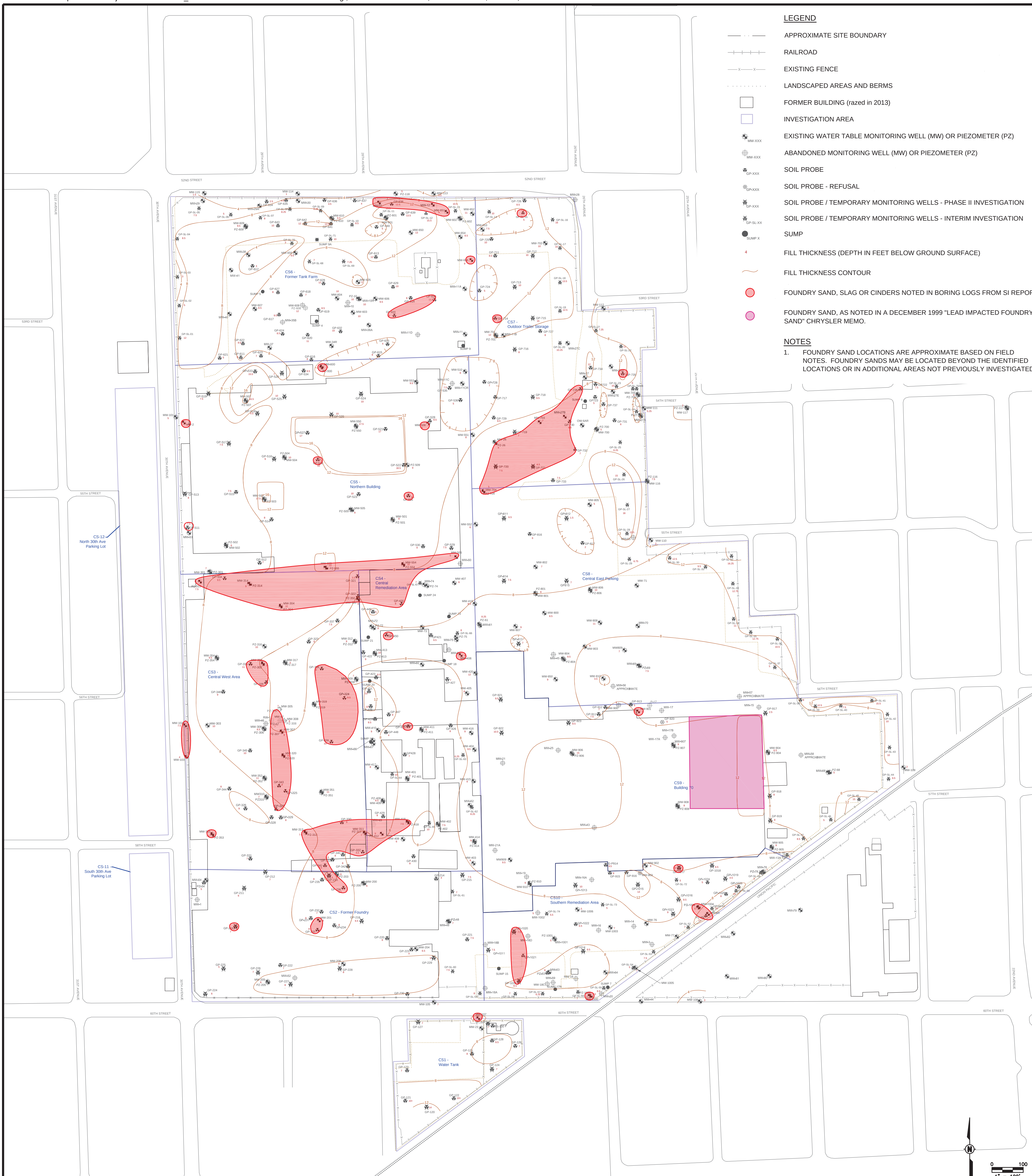


CS AREAS, SOIL PROBE, MONITORING WELL AND PIEZOMETER LOCATION MAP WITH FORMER & HISTORIC BUILDINGS
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn: AS 4/7/2015
Checked: LLA 4/7/2015
Approved: KWB 4/7/2015
PROJECT NUMBER 60328684
FIGURE NUMBER 3

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - Fill Thickness - 2015.dwg ; 4/7/2015 11:23:50 AM; ENGELHARDT, SARAH; ----

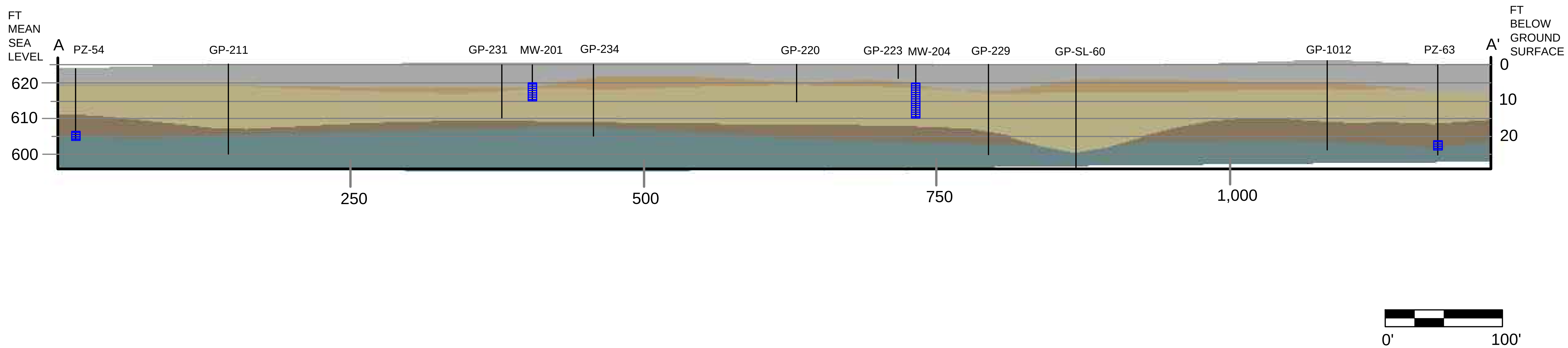


FILL THICKNESS MAP
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn:	SAE 4/7/2015
Checked:	LLA 4/7/2015
Approved:	KWB 4/7/2015
PROJECT NUMBER	60328684
FIGURE NUMBER	4

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

CS2 - FORMER FOUNDRY AREA
LOOKING NORTHEAST

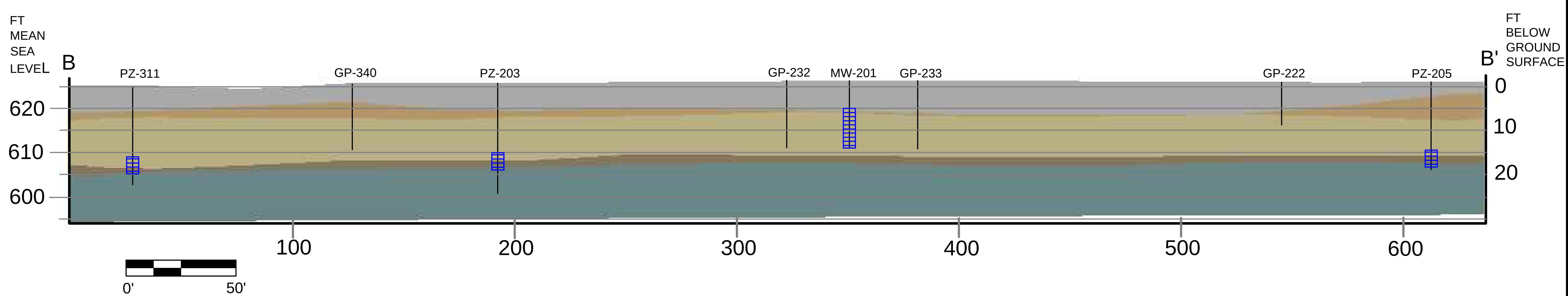


APPROXIMATE HORIZONTAL SCALE
VERTICAL EXAGGERATION 1:3

NOTES:
CROSS SECTION IMAGE IS INTERPOLATED FROM MULTIPLE BORINGS AND INDIVIDUAL THICKNESS OF LAYERS MAY VARY SLIGHTLY FROM THE INDIVIDUAL BORINGS SHOWN HERE.

LEGEND:
FILL
CLAY
SAND
SILT
TILL
PZ-XXX PIEZOMETER
MW-XXX MONITORING WELL
GP-XXX SOIL BORING
SCREEN

CS2 - FORMER FOUNDRY AREA
LOOKING SOUTHEAST



APPROXIMATE HORIZONTAL SCALE
VERTICAL EXAGGERATION 1:2

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

CROSS-SECTIONS A-A' AND B-B'
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

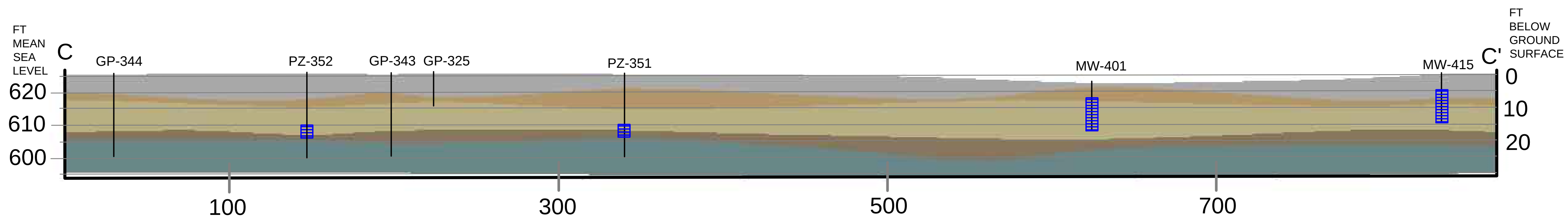
Drawn :	SAE	3/5/2015
Checked:	LLA	3/5/2015
Approved:	KWB	3/5/2015

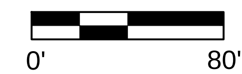
PROJECT NUMBER 60328684

FIGURE NUMBER 5

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CAD\cross sections\Cross Sections.dwg ; 3/5/2015 1:07:57 PM; ENGELHARDT, SARAH; ---

CS3 - BUILDING 53 AREA
LOOKING NORTH



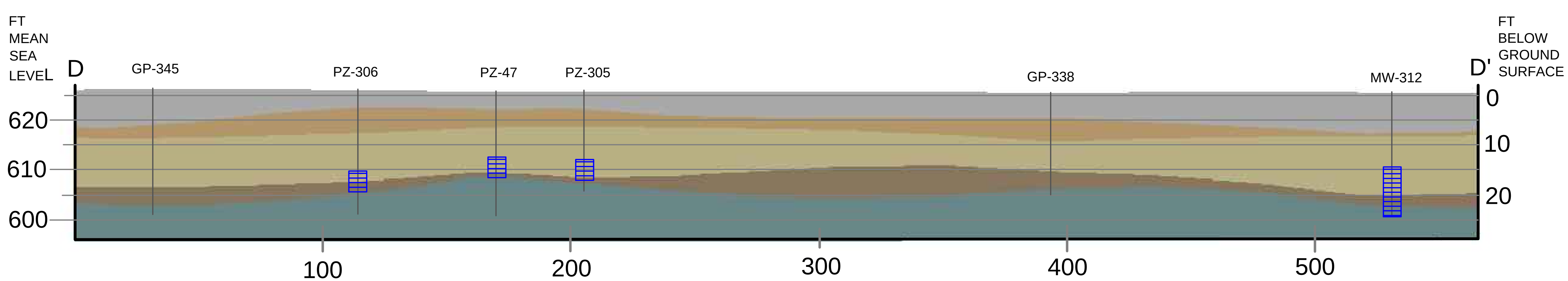


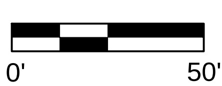
APPROXIMATE HORIZONTAL SCALE
VERTICAL EXAGGERATION 1:2

NOTES:
CROSS SECTION IMAGE IS INTERPOLATED FROM MULTIPLE BORINGS AND INDIVIDUAL THICKNESS OF LAYERS MAY VARY SLIGHTLY FROM THE INDIVIDUAL BORINGS SHOWN HERE.

LEGEND:
FILL
CLAY
SAND
SILT
TILL
PZ-XXX
PIEZOMETER
MW-XXX
MONITORING WELL
GP-XXX
SOIL BORING
SCREEN

CS3 - BUILDING 53 AREA
LOOKING NORTHWEST





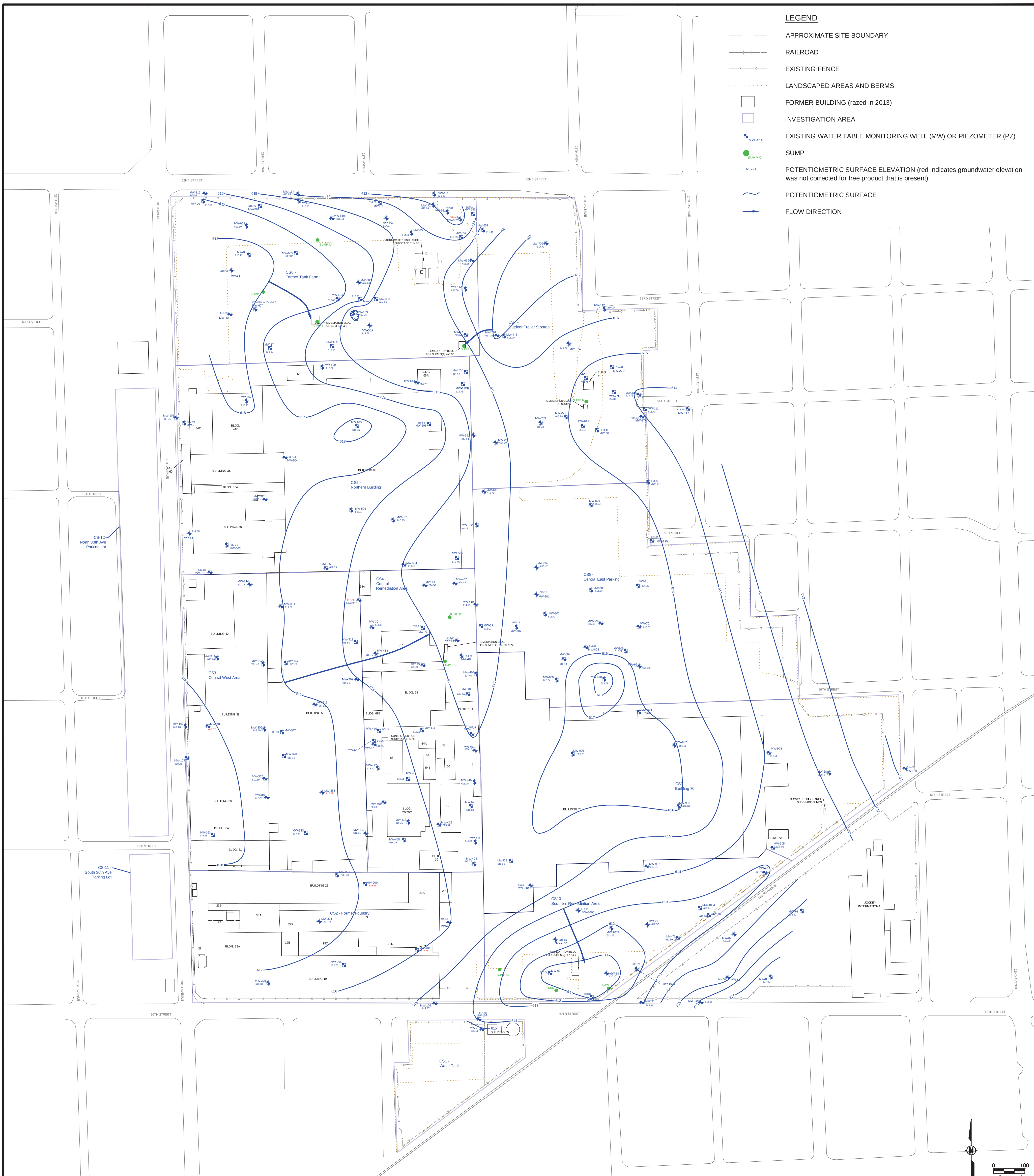
APPROXIMATE HORIZONTAL SCALE
VERTICAL EXAGGERATION 1:2

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

CROSS-SECTIONS C-C' AND D-D'
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn :	SAE	3/5/2015
Checked:	LLA	3/5/2015
Approved:	KWB	3/5/2015
PROJECT NUMBER	60328684	
FIGURE NUMBER	6	

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\cross sections\Cross Sections.dwg ; 3/5/2015 1:08:59 PM; ENGELHARDT, SARAH; ----



WATER TABLE GROUNDWATER CONTOURS - December 2014
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

Drawn :	SAE	4/7/2015
Checked:	LLA	4/7/2015
Approved:	KWB	4/7/2015

PROJECT NUMBER 60328684

FIGURE NUMBER 7

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - GW -12.Dec. Flow and VOCs - 2015.dwg ; 4/7/2015 12:33:15 PM; ENGELHARDT, SARAH; ----

POTENTIOMETRIC SURFACE - KEP PIEZOMETERS - December 2014
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn: SAE 4/7/2015

Checked: LLA 4/7/2015

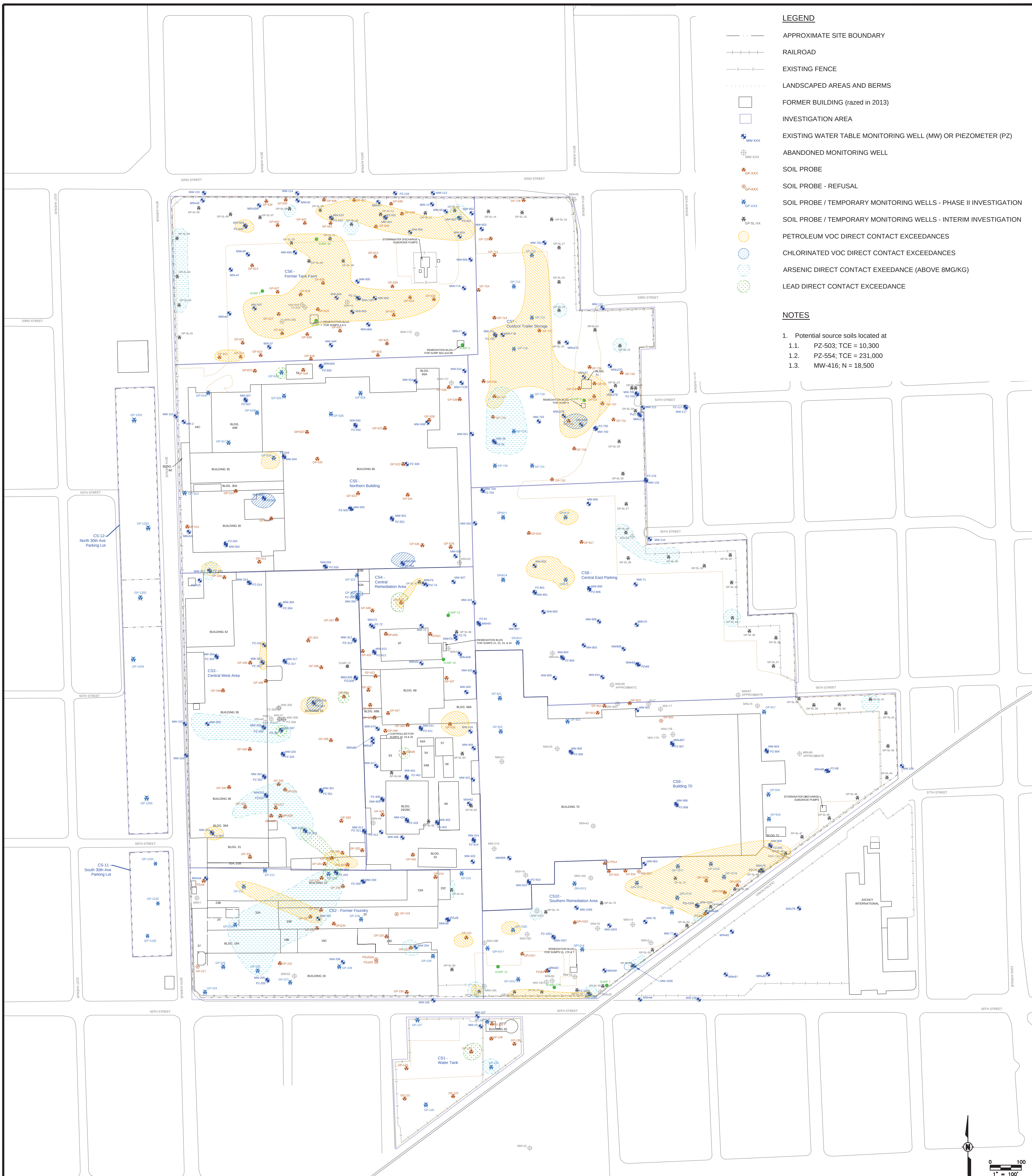
Approved: KWB 4/7/2015

PROJECT NUMBER 60328684

FIGURE NUMBER 8

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - Soil - 2015.dwg ; 4/7/2015 11:35:16 AM; ENGELHARDT, SARAH; ----

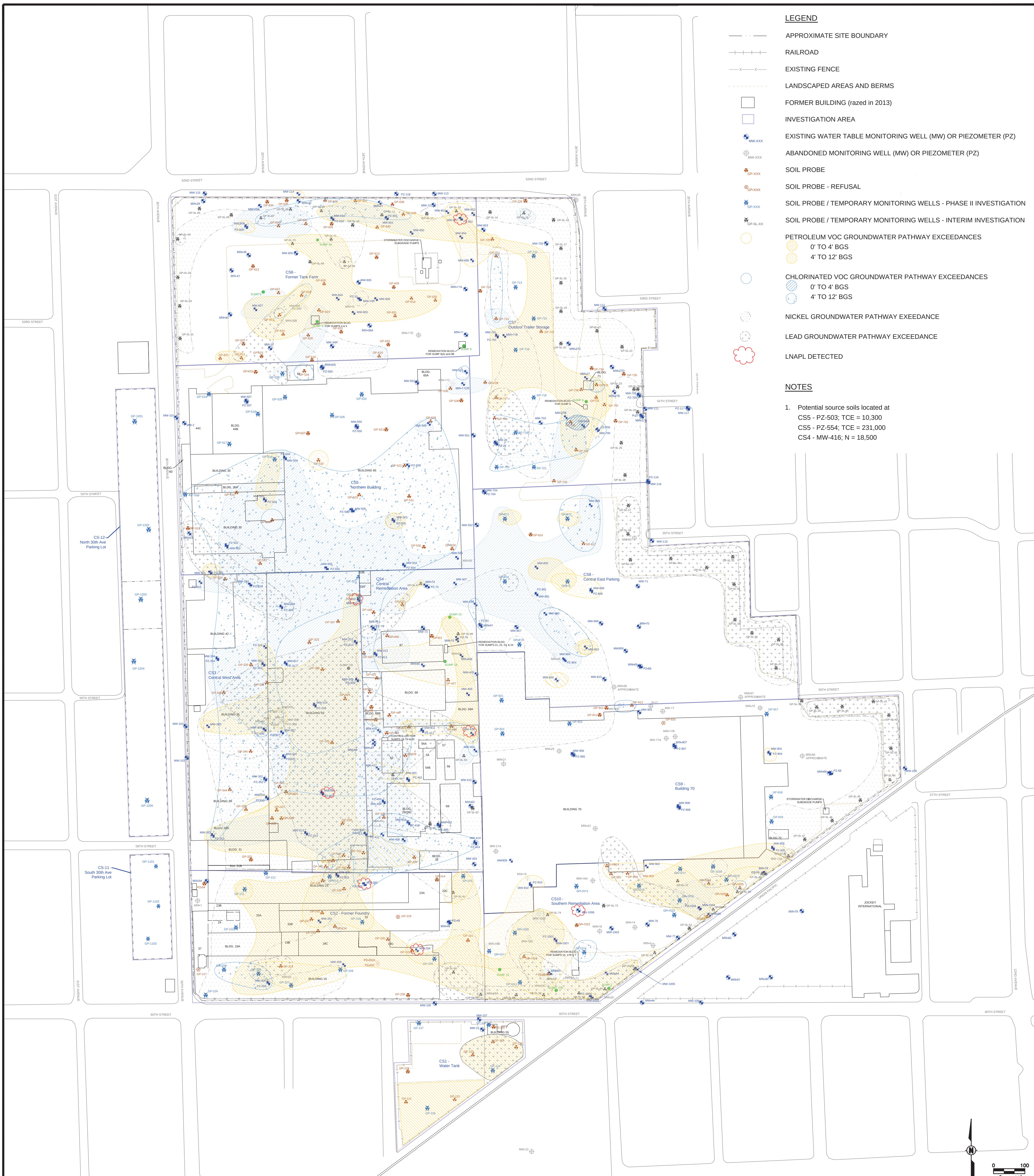


EXTENT OF INDUSTRIAL DIRECT CONTACT EXCEEDANCES IN SOIL
0-4 FEET BELOW GROUND SURFACE
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn: SAE 4/7/2015
Checked: LLA 4/7/2015
Approved: KWB 4/7/2015
PROJECT NUMBER 60328684
FIGURE NUMBER 9

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - Soil - 2015.dwg ; 4/7/2015 11:33:54 AM; ENGELHARDT, SARAH; ----



EXTENT OF GROUNDWATER PATHWAY EXCEEDANCES IN SOIL
0 TO 12 FEET BELOW GROUND SURFACE
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

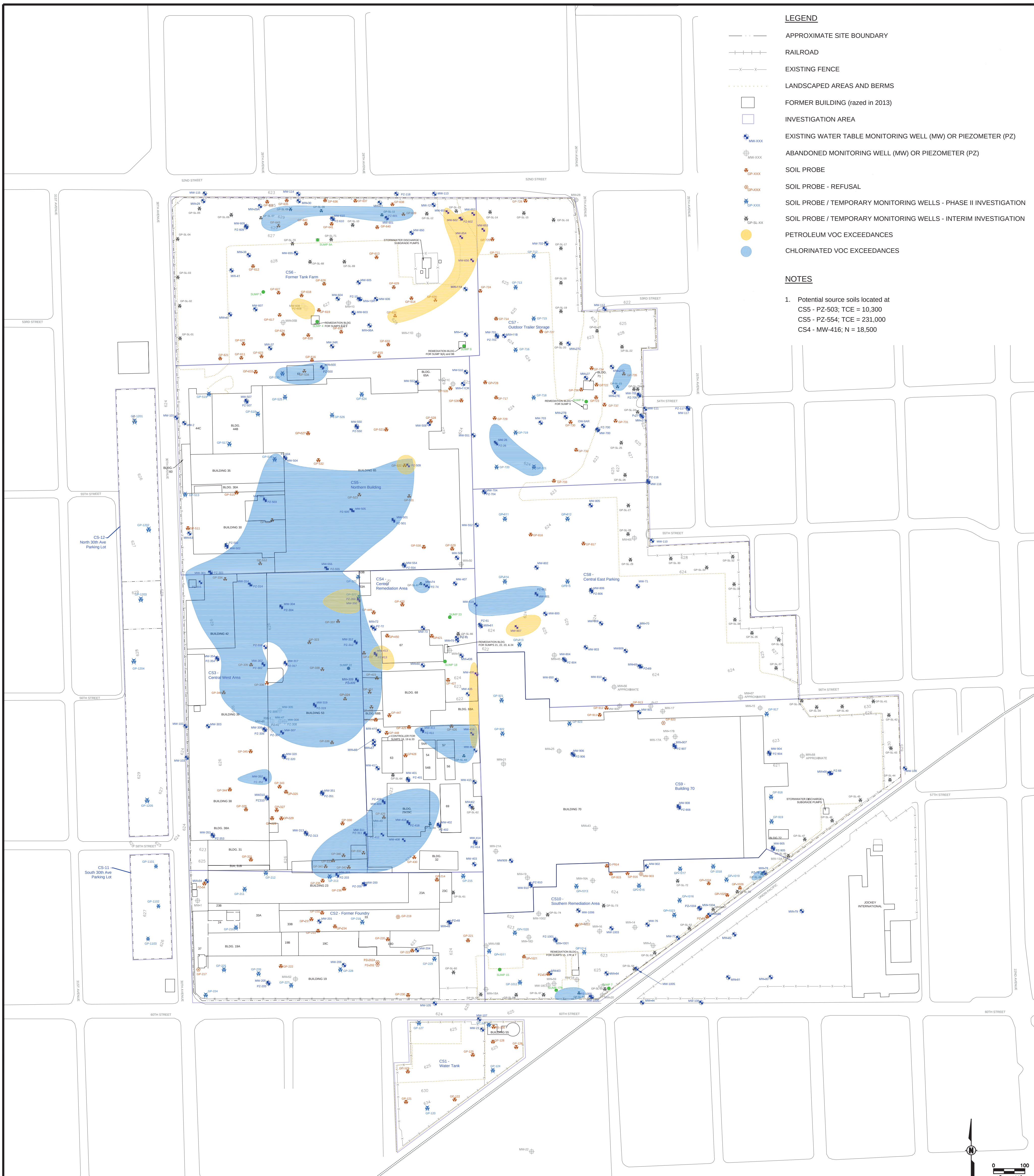
Drawn: SAE 4/7/2015
Checked: LLA 4/7/2015
Approved: KWB 4/7/2015

PROJECT NUMBER 60328684

FIGURE NUMBER 10

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - Soil - 2015.dwg ; 4/7/2015 11:37:26 AM; ENGELHARDT, SARAH; ----



Drawn: SAE 4/7/2015

Checked: LLA 4/7/2015

Approved: KWB 4/7/2015

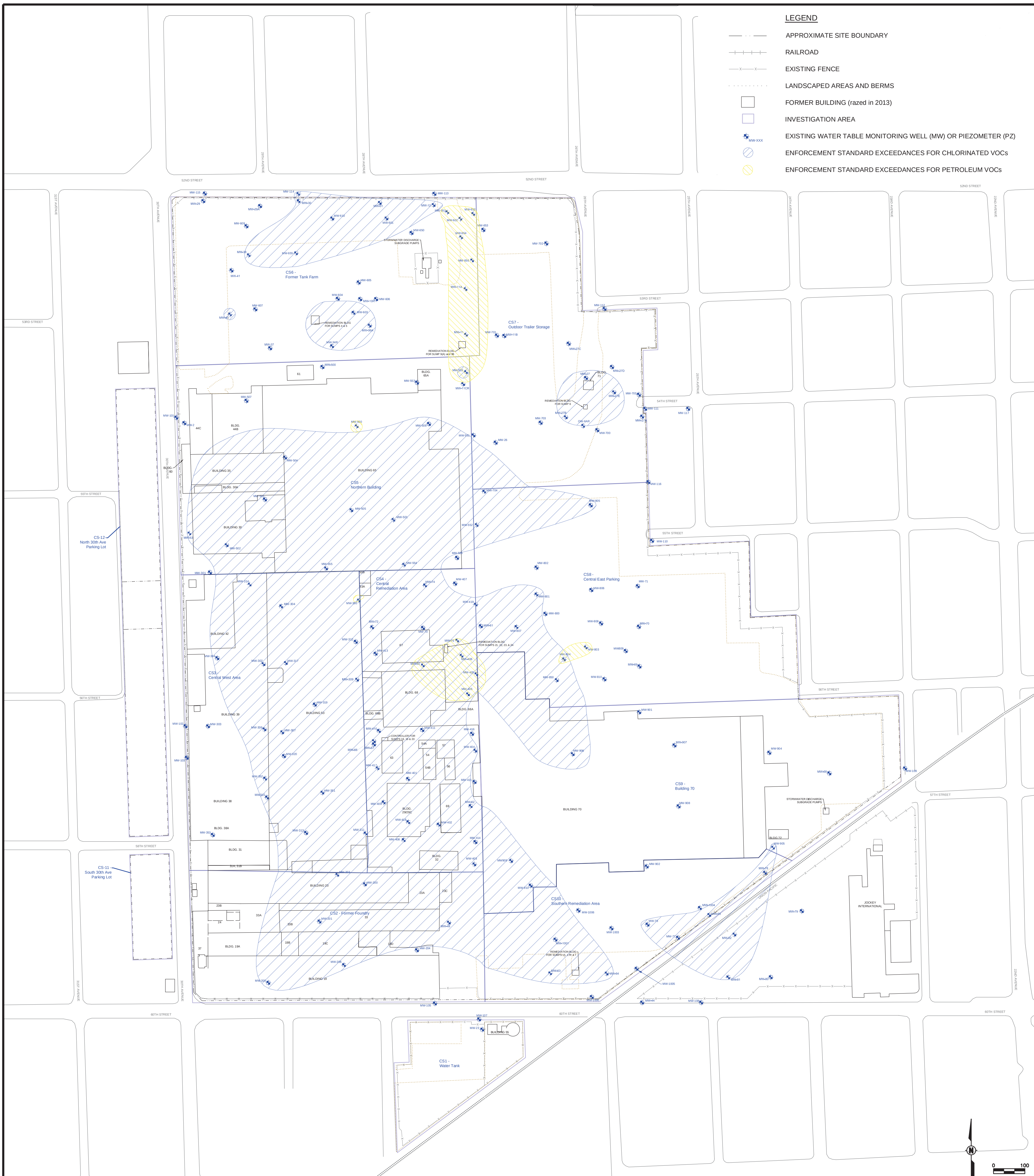
PROJECT NUMBER 60328684

FIGURE NUMBER 11

EXTEND OF RCL EXCEEDANCES IN SATURATED SOIL
GREATER THAN 12 FEET BELOW GROUND SURFACE
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - GW -12.Dec. Flow and VOCs - 2015.dwg ; 3/5/2015 3:44:28 PM; ENGELHARDT, SARAH; ----



AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

EXTENT OF GROUNDWATER ES EXCEEDANCES IN WATER TABLE WELLS, DECEMBER 2014
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn : SAE 3/5/2015
Checked: LLA 3/5/2015
Approved: KWB 3/5/2015

PROJECT NUMBER 60328684

FIGURE NUMBER 12

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

EXTENT OF GROUNDWATER ES EXCEEDANCES IN PIEZOMETERS, DECEMBER 2014
KENOSHA ENGINE PLANT
CITY OF KENOSHA
KENOSHA, WISCONSIN

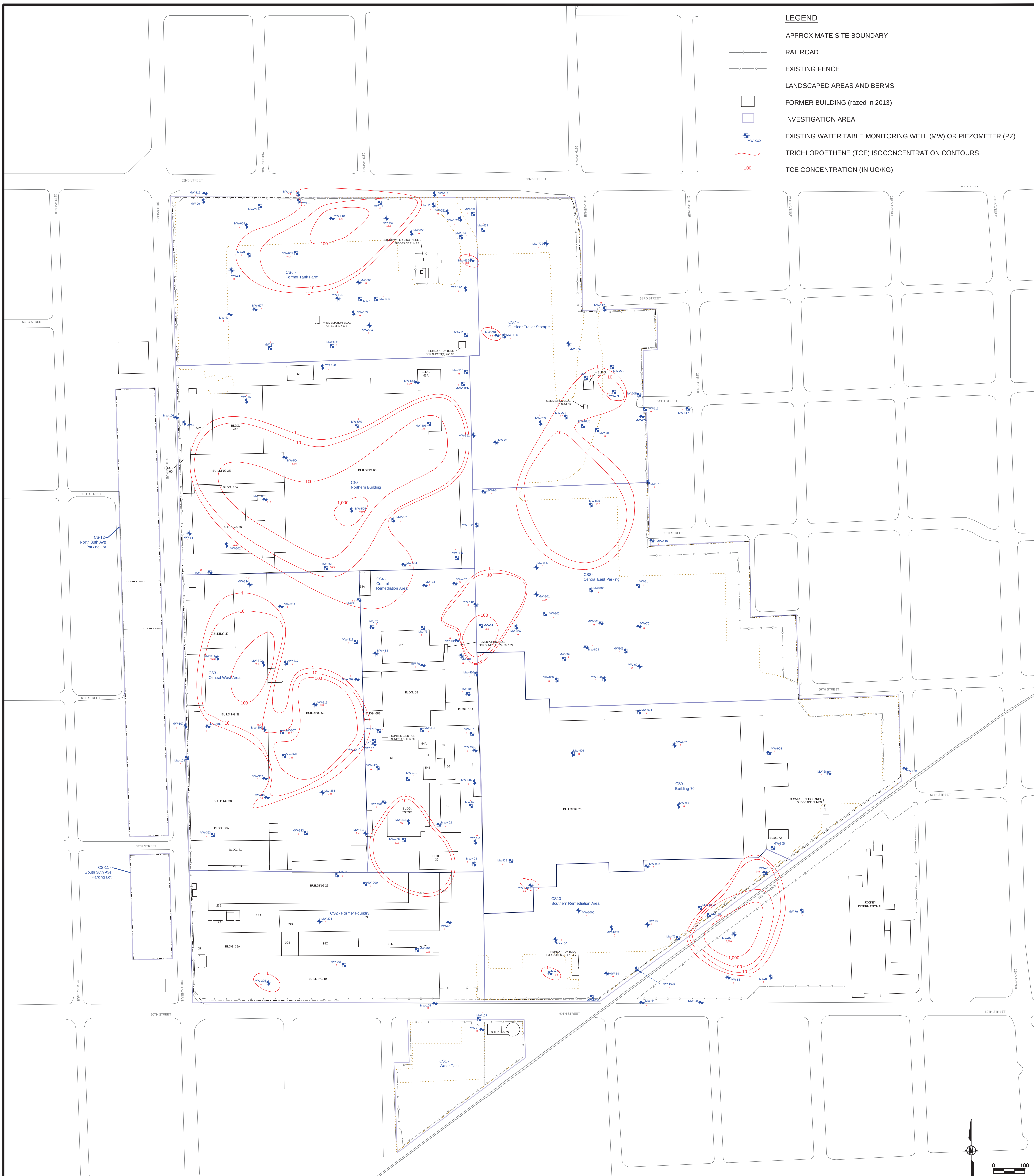
Drawn : SAE 3/5/2015
Checked: LLA 3/5/2015
Approved: KWB 3/5/2015

PROJECT NUMBER 60328684

FIGURE NUMBER 13

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - GW -12.Dec. Flow and VOCs - 2015.dwg ; 3/5/2015 1:47:10 PM; ENGELHARDT, SARAH; ----

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - GW -12.Dec. Flow and VOCs - 2015_recover.dwg ; 3/5/2015 2:38:20 PM; ENGELHARDT, SARAH; ----

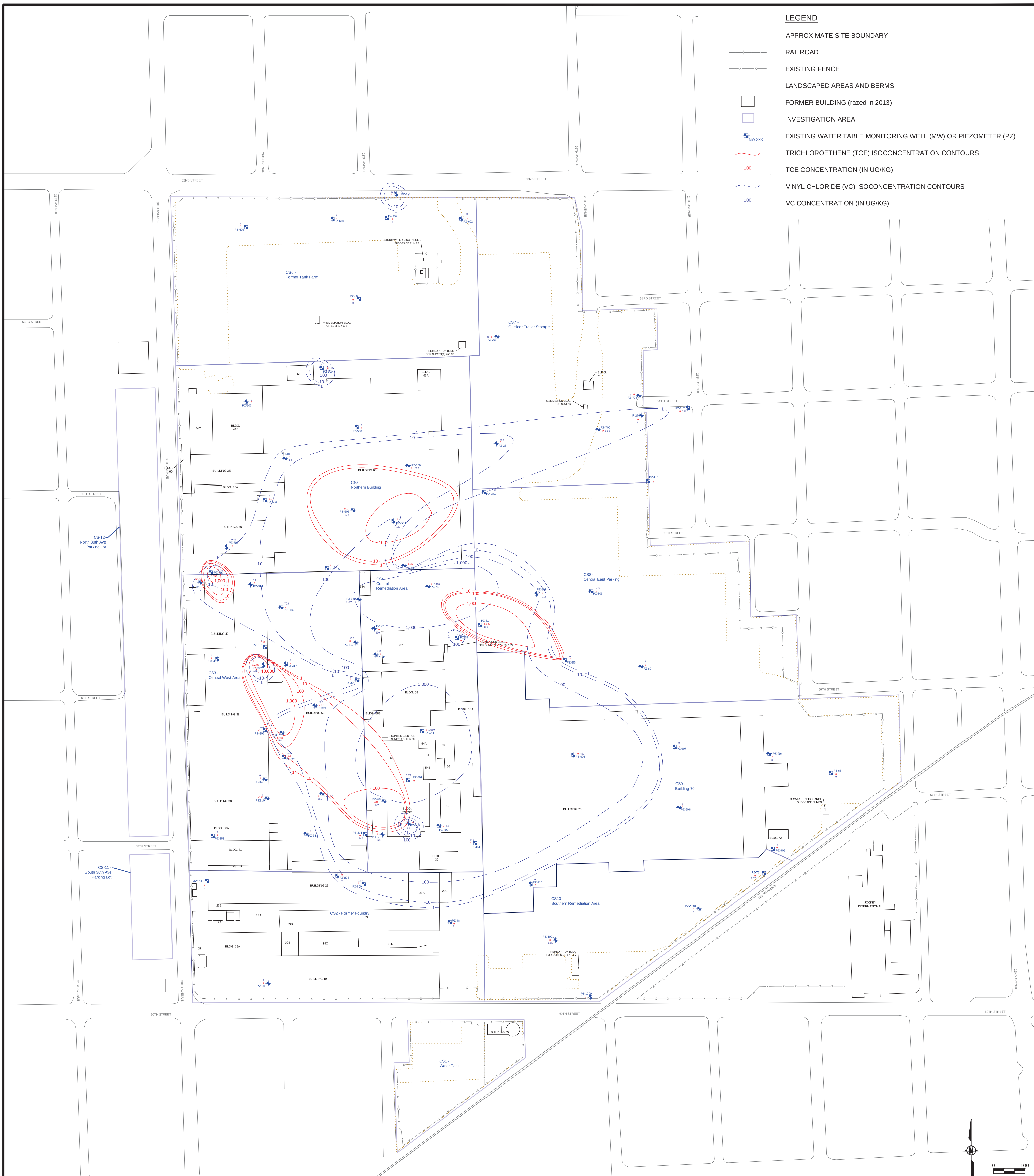


AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

TCE ISOCONCENTRATION CONTOURS IN GROUNDWATER
KENOSHA ENGINE PLANT MONITORING WELLS (DECEMBER 2014)
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn :	SAE	3/5/2015
Checked:	LLA	3/5/2015
Approved:	KWB	3/5/2015
PROJECT NUMBER	60328684	
FIGURE NUMBER	14	

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - GW -12.Dec. Flow and VOCs - 2015.dwg ; 3/12/2015 12:15:31 PM; ENGELHARDT, SARAH; ----



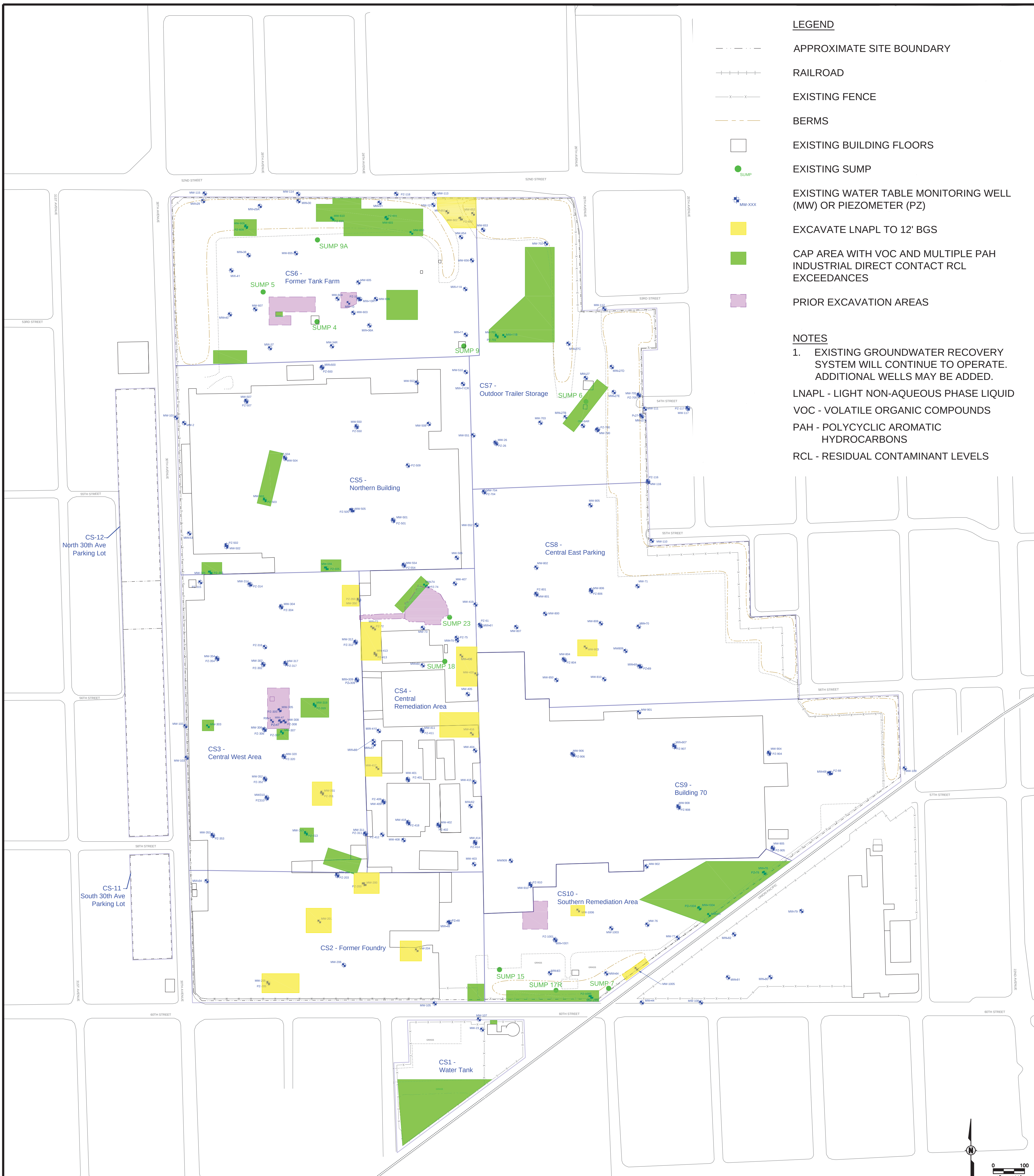
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

TCE AND VC ISOCONCENTRATION CONTOURS IN GROUNDWATER
KENOSHA ENGINE PLANT PIEZOMETERS (DECEMBER 2014)
CITY OF KENOSHA
KENOSHA, WISCONSIN

Drawn :	SAE	3/5/2015
Checked:	LLA	3/5/2015
Approved:	KWB	3/5/2015

PROJECT NUMBER 60328684

FIGURE NUMBER 15

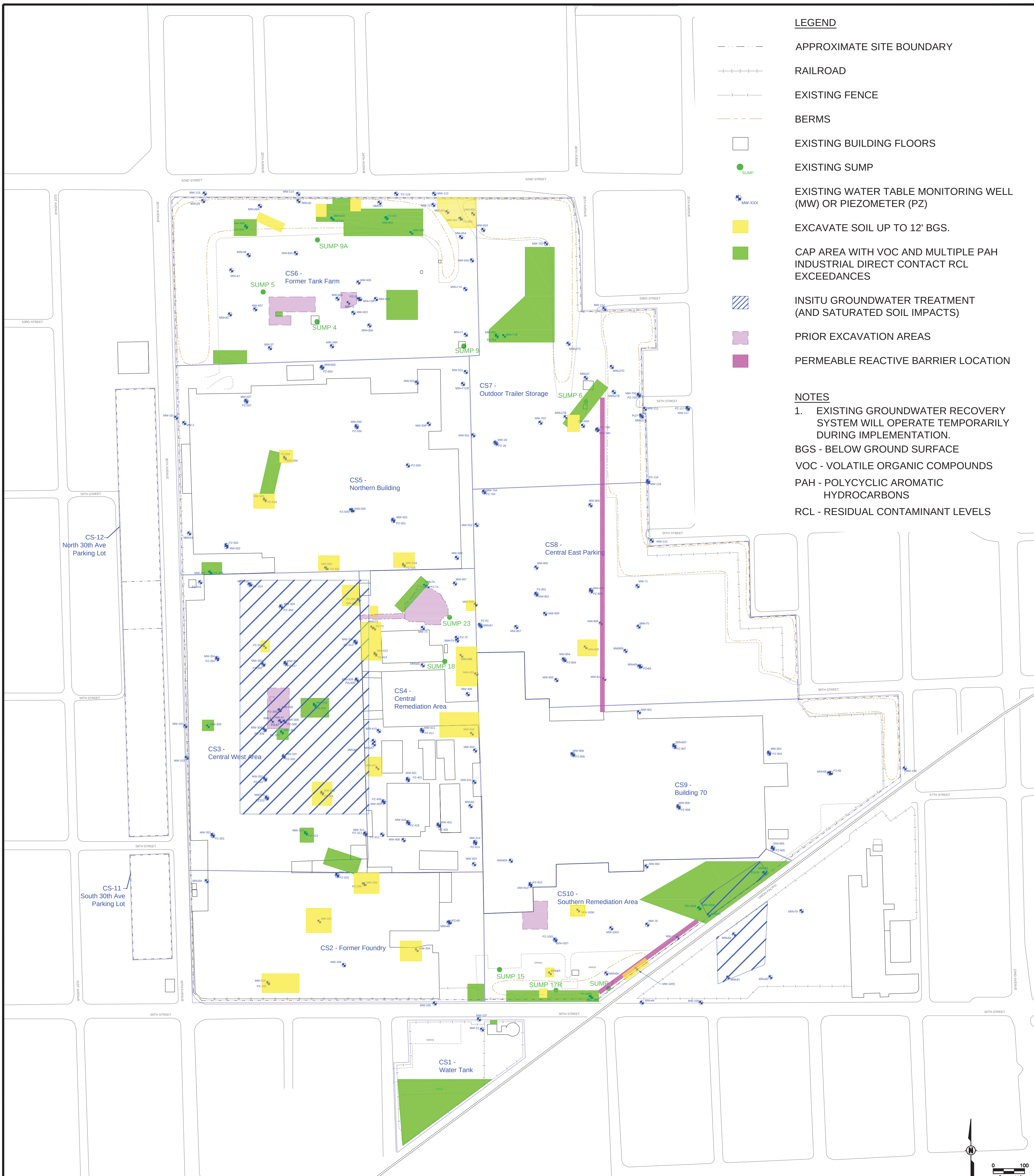


ALTERNATIVE 2 - CONCEPTUAL LAYOUT
CONTINUED GROUNDWATER RECOVERY/TREATMENT
KENOSHA ENGINE PLANT
KENOSHA, WISCONSIN

Drawn: ARS 4/7/2015
Checked: LLA 4/7/2015
Approved: KWB 4/7/2015
PROJECT NUMBER: 60328684
FIGURE NUMBER: 16

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - RAOR FIGURES.dwg ; 4/8/2015 10:21:49 AM; ENGELHARDT, SARAH; ----



ALTERNATIVE 3 - CONCEPTUAL LAYOUT
LIMITED ACTIVE SOURCE GROUNDWATER TREATMENT WITH
PERMEABLE REACTIVE BARRIER
KENOSHA ENGINE PLANT
KENOSHA, WISCONSIN

Drawn: ARS 4/7/2015
Checked: LLA 4/7/2015
Approved: KWB 4/7/2015
PROJECT NUMBER 60328684
FIGURE NUMBER 17

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

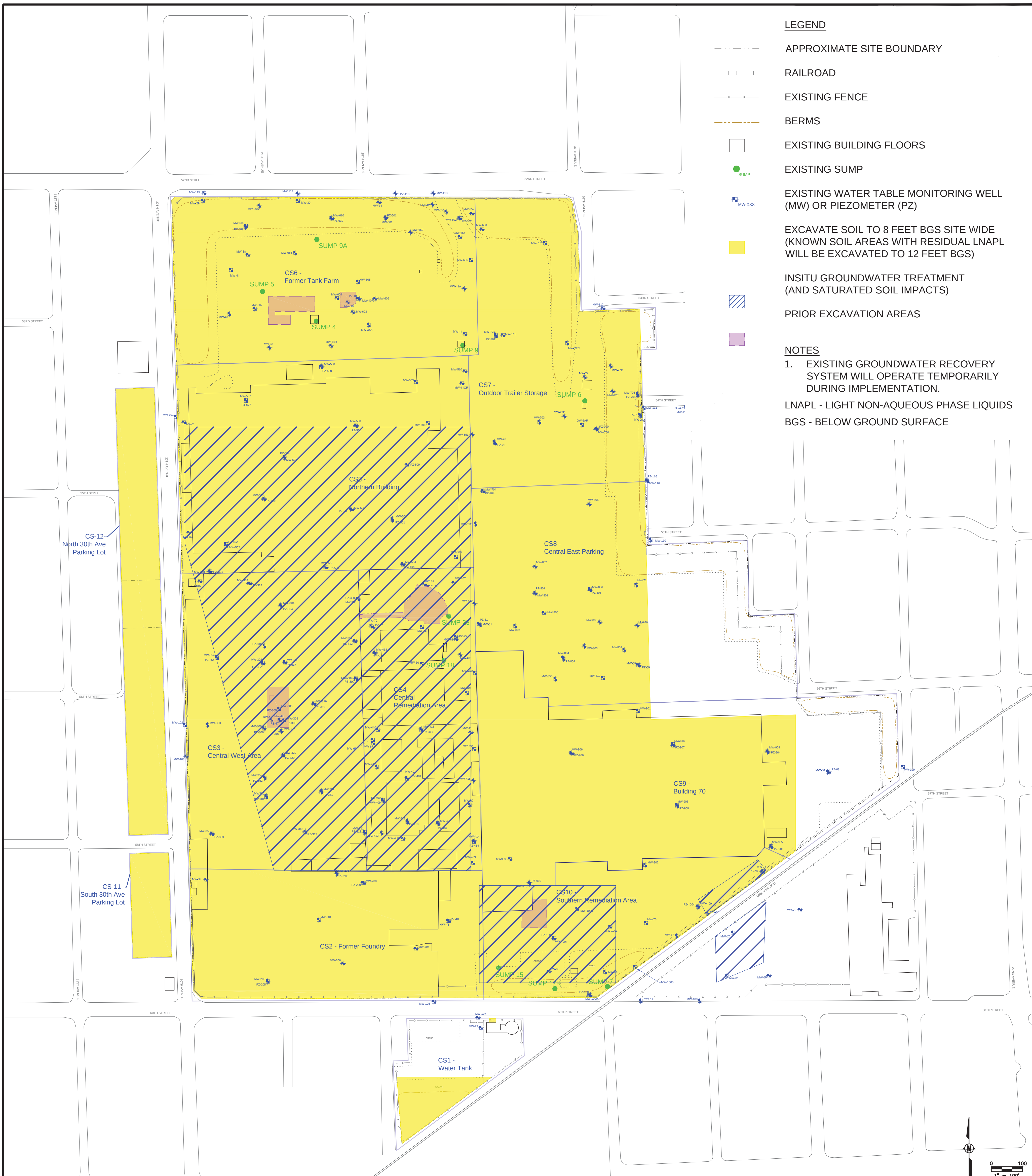
\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - RAOR FIGURES.dwg ; 4/8/2015 10:22:05 AM; ENGELHARDT, SARAH; ----

ALTERNATIVE 4 - CONCEPTUAL LAYOUT
SOIL AND GROUNDWATER SOURCE CONTROL
KENOSHA ENGINE PLANT
KENOSHA, WISCONSIN

Drawn:	ARS	4/7/2015
Checked:	LLA	4/7/2015
Approved:	KWB	4/7/2015
PROJECT NUMBER	60328684	
FIGURE NUMBER	18	

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com

\\USMWK1FS001\prod\Data\Projects\60328684\900_Work\CADD\KEP - RAOR FIGURES.dwg ; 4/8/2015 10:22:20 AM; ENGELHARDT, SARAH; ----



LEGEND

APPROXIMATE SITE BOUNDARY

RAILROAD

EXISTING FENCE

BERMS

EXISTING BUILDING FLOORS

EXISTING SUMP

EXISTING WATER TABLE MONITORING WELL (MW) OR PIEZOMETER (PZ)

EXCAVATE SOIL TO 8 FEET BGS SITE WIDE (KNOWN SOIL AREAS WITH RESIDUAL LNAPL WILL BE EXCAVATED TO 12 FEET BGS)

INSITU GROUNDWATER TREATMENT (AND SATURATED SOIL IMPACTS)

PRIOR EXCAVATION AREAS

NOTES

1. EXISTING GROUNDWATER RECOVERY SYSTEM WILL OPERATE TEMPORARILY DURING IMPLEMENTATION.

LNAPL - LIGHT NON-AQUEOUS PHASE LIQUIDS

BGS - BELOW GROUND SURFACE

1" = 100'

ALTERNATIVE 5 - CONCEPTUAL LAYOUT
EXTENSIVE SOIL REMOVAL AND GROUNDWATER TREATMENT
KENOSHA ENGINE PLANT
KENOSHA, WISCONSIN

Drawn: ARS 4/7/2015
Checked: LLA 4/7/2015
Approved: KWB 4/7/2015
PROJECT NUMBER 60328684
FIGURE NUMBER 19

AECOM
1555 RiverCenter Dr
Milwaukee, WI 53212
414.944.6080
www.aecom.com