Natural Resource Technology

Public Service

Wisconsin Public Service

Completion Report

Former Oshkosh Manufactured Gas Plant
Oshkosh, Wisconsin

WIN000509947

NRT Project No: 1312

NATURAL RESOURCE TECHNOLOGY

COMPLETION REPORT
FORMER OSHKOSH MANUFACTURED GAS PLANT
OSHKOSH, WISCONSIN
USEPA ID: WIN000509947

Project No: 1312

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ACROYNMS

AOC	Administrative Order on Consent
Bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
BaP	benzo(a)pyrene
BbF	benzo(b)fluoranthene
C3	C3 Environmental Limited
City	City of Oshkosh
CERCLA	Comprehensive Environmental Response Compensation, and Liability Act
Cm/sec	centimeters per second
COCs	constituents of concern
CQA	construction quality assurance
CSM	conceptual site model
DO	dissolved oxygen
EDI	EDI Engineering & Science, Inc.
ES	Enforcement Standard
ft/ft	feet per foot
ft3	cubic feet
ft/min	feet per minute
GCL	geocomposite liner
GIS	geographic information system
gpm	gallons per minute
Hp	horsepower
HSI	Simon Hydro-Search
LL	liquid limit
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MGP	manufactured gas plant
MCL	Maximum contaminant level
NCP	National Contingency Plan
ND	non-detectable
NGVD	national geodetic vertical datum
NRT	Natural Resource Technology, Inc.
OM&M	operation, maintenance and groundwater monitoring
ORP	oxidation/reduction potential

PAH	polynuclear aromatic hydrocarbons
PAL	Preventive Action Limit
Park	Riverside Park

ACRONYMS (CONT'D)

PID	photoionization detector
PLC	Programmable Logic Controller
ppm	parts per million
psi	pounds per square inch
PVOC	petroleum volatile organic compounds
RAOs	Remedial Action Objectives
RCLs	Residual Contaminant Levels
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation / Feasibility Study
ROD	record of decision
ROW	right-of-way
SARA	Superfund Amendments and Reauthorization Act
SOW	Statement of Work
SPT	standard penetration test
SSL	Soil Screening Levels
TCLP	toxicity characteristic leachate procedure
TCT	Twin City Testing Corporation
TOC	Total Organic Carbon
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USCS	Unified Soil Classification System
UU	undrained unconsolidated
VOC	volatile organic compound
WDNR	Wisconsin Department of Natural Resources
WGNHS	Wisconsin Geological and Natural History Survey
WKG2	Wagner Komurka Geotechnical Group, Inc.
WPDES	Wisconsin Pollutant Discharge Elimination System
WPSC	Wisconsin Public Service Corporation
WWTP	Wastewater Treatment Plant

1 INTRODUCTION

Pursuant to the Administrative Order on Consent (AOC) and associated Statement of Work (SOW) executed between the U.S. Environmental Protection Agency (USEPA) and WPSC on May 5, 2006, a completion report is to be prepared for the former Manufactured Gas Plant (MGP) Site (Site), located in Oshkosh, Wisconsin (Figure 1) to summarize environmental investigation and remediation activities undertaken at the Site. Natural Resource Technology, Inc. (NRT), on behalf of Wisconsin Public Service Corporation (WPSC), prepared this Completion Report.

The purpose of this Completion Report is to:

- Summarize the previous work performed at the Site prior to the effective date of the AOC;
- Assess the environmental effectiveness of the remedial actions undertaken to date;
- Document whether the areas where further remedial measures and/or other response actions are necessary;
- Summarize the on-going monitoring results, and
- Determine, based on current site information, areas that pose a potential risk to human health and/or the environment, and may warrant additional investigation.

The report is divided into the following sections:

- Section 2: Pre-Remedial Upland Investigations;
- Section 3: Sediment Investigation and Results;
- Section 4: Remedial Actions Performed;
- Section 5: Post-Remedial Upland Investigations;
- Section 6: Post-Remedial Performance Monitoring Results;

- Section 7: Identified Pathways and Conclusions; and
- Section 8: References (Record File).

1.1 General Site Information

Owner:	City of Oshkosh Contact: Mr. Jackson Kinney 215 Church Avenue P.O. Box 1130 Oshkosh, WI 53903
Former MGP Operator:	Wisconsin Public Service Corporation Contact: Mr. Brian Bartoszek (920-433-2643) 700 North Adams Street, P.O. Box 19002 Green Bay, WI 54307-9002
Facility Location:	T18N, R16E, Section 24 305 Ceape Avenue Oshkosh, Wisconsin Winnebago County
USEPA ID:	WIN000509947
WDNR BRRTS #:	02 71 000256

The former MGP property encompasses approximately 7.6 acres and is bounded on the north by Ceape Avenue, on the east by Broad Street, on the west by Court Street and on the South by the Fox River (Figure 2).

1.2 History of Site Use

The Oshkosh Gas Works owned and operated the Oshkosh MGP from 1869 until 1922. In 1922, a number of existing utility companies merged to form WPSC and the MGP became a WPSC facility. Numerous companies owned portions of the former MGP property. Sanborn maps show Banderob & Chase Furniture Factory owned the eastern portion of the property between the 1890 and 1950s for furniture making and lumber storage. Based on the Sanborn maps, WPSC purchased the eastern portion of the property from Banderob & Chase between 1949 and 1957.

The former MGP facility was constructed in 1869 and initially utilized the retort coal gas production method, which involved heating the coal in an airtight chamber (retort) which produced coke and gases containing a variety of volatilized organic constituents. The process also produced tar, which was sold for roofing, wood treatment, and paving roads. The gas was passed through purifiers to remove impurities such as sulfur, carbon dioxide, cyanide, and ammonia. Dry purifiers contained lime or hydrated iron oxide mixed with wood chips. The gas was then stored in large holders on the property prior to distribution for lighting and heating.

In 1914, the production method was converted to a carbureted water gas process, which involved passing air and steam over the incandescent coal in a brick-filled vessel to form a combustible gas, which was then enriched by injecting a fine mist of oil over the bricks. The gas was then purified and stored in holders prior to distribution. The Oshkosh MGP ceased operations in 1946 when propane was introduced as a fuel. Based on MGP property site plan drawings provided by WPSC, which cover the years 1915 to 1966, former MGP-related structures (Appendix A1, Sheet C020) included the following:

- Boiler, retort, condenser, scrubber, vaporizer and purifier houses;
- Two gas holders with capacities of 200,000 cubic feet and 500,000 cubic feet;
- One aboveground oil storage tank approximately 24 feet in diameter;
- Four tar wells;
- Three tar separator tanks and one tar still;
- Two water supply wells;
- Steam plant; and
- Coal and coke storage.

Based on review of Sanborn maps, the shoreline of the Fox River has shifted considerably from 1890 to 1911 to its present day position (Appendix A1, Sheet C020). The source of the fill material is not known.

In 1985, the City of Oshkosh constructed a pump station on property purchased from WPSC on the eastern edge of the property near the WPSC electrical substation. Also installed at that time were two force mains each 36 and 16 inches in diameter, respectively, that traverse across and beneath the Fox River to the City's treatment facility located south of the former MGP. WPSC retained ownership of the central and western portions of the property and operated a natural gas regulating station located along Court Street. Gas regulation operations were housed in an aboveground building that was formerly part of the MGP operations and ceased in 2002 as part of the upland remedial action.

In December 2003, following WPSC upland remedial construction activities, the City of Oshkosh purchased the WPSC property to expand its existing park located west of Court Street along the Fox River (Figure 2). WPSC retains ownership of the electrical substation adjacent to the pump station on the eastern portion of the former property and the groundwater treatment building which houses the gradient control system equipment and control panel.

1.3 Current Site Use

The former MGP facility now known as Riverside Park has an amphitheatre, parking lot, concession buildings, restroom facilities, landscaped lawn, and paved walkways (Figure 2). The Park currently extends from the Fox River on the south to State Street on the west, to Ceape Avenue on the north, and to Broad Street right-of-way on the east. The Park footprint includes the former MGP property and about 200 feet of the southern portion of former Court Street right-of-way.

An asphalt parking lot is located on the north side of the Park, with access from Court Street and Ceape Avenue. WPSC's groundwater treatment building is located adjacent to Broad Street right-of-way and the City of Oshkosh pump station (Figure 2). At the southwest corner of Court Street and Ceape Avenue is a building owned by a law firm. East of the Park are residential homes and commercial buildings.

1.4 Overview of Site Conditions

WPSC provided a summary of Site conditions to the USEPA in October 2005. The summary included information pertaining to: (1) the upland remediation work; and, (2) on-going monitoring. In addition a list of documents pertaining to the Site was included. An overview of Site conditions is presented below.

1.4.1 Site Status Summary

1.4.1.1 Overview of Work Performed

- WPSC performed upland remediation work in 2002, including source area excavation and thermal treatment (23,500 tons), installation of a containment barrier wall and gradient control system, and construction of a surface cap.

- Operation, maintenance, and groundwater monitoring (OM&M) is in progress. WPSC submitted *2006 Annual Operation, Maintenance, and Monitoring Report* on February 7, 2007 to document OM&M activities. This Completion Report includes the 2007 OM&M activities (Section 6).

- The City purchased the property for park redevelopment in December 2003. Park construction began in 2004 and was substantially completed in June 2005.

- Assessment of groundwater quality in the bedrock aquifer was performed in 2005.

- River sediment quality assessments were performed in 1996 and 2001.

1.4.1.2 Status of Site Conditions & Monitoring

- The depth to groundwater ranges from approximately 4 to 10 feet below existing ground surface. Shallow groundwater outside of the containment zone flows south toward the Fox River. Shallow bedrock flow is to the north, away from the river.

- Post-remediation residual concentrations of BTEX, trimethylbenzenes, PAH, and cyanide are present in soil and/or groundwater, as described in the project reports of record.

- Monitoring data indicates the existing gradient control system adequately captures the shallow/water table zone. The system discharges to City WWTP at average flow rates of 5 to 10 gpm with an "up" time of more than 90 percent since start-up. The discharge complies with the WWTP limits.

- Shallow groundwater quality is close to or below the maximum contaminant level (MCL) or NR140 ES at perimeter wells (outside of the containment system). Bedrock water quality exceeds the MCL or NR140 ES adjacent to the Fox River (upgradient), and is at or below MCL or NR140 ES off-site to the east (side gradient). Bedrock water quality is at or below MCL or NR140 PAL to the north (down gradient).

- Water depths in the Fox River vary from about 6 to 7 feet adjacent to the former MGP at the sheet pile wall, increasing to as much as 30 feet near the center of the river channel. Soft sediment thickness based on poling, core samples, and borings varies from <1 foot to about 6 feet.

- Residual tar, sheens and PAH are present in sediments. Soft sediments containing MGP residuals occur near shore in thin, discrete deposits within the river channel. Underlying the soft sediment is consolidated sediments. Tar was observed within the consolidated sediments generally confined to the sand seams within the clay, and the gravel deposits.

- Total PAH concentrations in sediment samples are highest in sample T107-C (0 to 2 feet composite) at 30,710 mg/kg, located near mid-channel. Other sediment samples adjacent to the former MGP vary from ND to 12,710 mg/kg total PAHs. Samples slightly upstream of the former MGP ranged from ND to 7.6 mg/kg. Samples from near the railroad bridge and downstream ranged from ND to 17 mg/kg.

2 PRE-REMEDIAL UPLAND INVESTIGATIONS

2.1 Overview

This section summarizes pre-remedial soil and groundwater investigations performed in the upland portions of the Site. Most soil samples collected and analyzed were obtained during pre-remedial investigations. The soil quality issues were largely addressed through soil excavation and treatment, containment of MGP residuals by construction of the vertical barrier wall and earthen cap, and operation of the hydraulic gradient control system. Post-remedial soil sampling was limited to excavation side wall samples and post-treatment samples collected from the thermally-treated material prior to use as backfill.

Pre-remedial groundwater investigations focused on determining the magnitude and extent of groundwater contamination at the former MGP property. Groundwater analytical results collected during these pre-remedial investigations were compared to WDNR NR140 regulatory standards. These data, while of historical interest, are not reflective of current conditions due to the remedial work performed to-date. Potential exposure pathways that may continue to pose a risk to human health and/or the environment are discussed in Section 7.

2.2 Investigation Chronology

As outlined below, site investigation efforts began in 1985 at the former MGP by WPSC. Concentrations of BTEX, PAHs, and total cyanide in groundwater samples collected from monitoring wells OW-1, OW-2 and OW-3 suggested that these constituents were present at elevated levels in groundwater beneath the former MGP property. In November 1991, HGM Architecture, Inc. retained Twin City Testing Corporation (TCT), on behalf of the City of Oshkosh, to perform geotechnical borings on the property to the west of Court Street as part of the City of Oshkosh senior center construction. TCT encountered black oily material and odorous wood chips suggesting the presence of subsurface contamination.

WDNR requested that both the City of Oshkosh and WPSC conduct investigations of their respective properties. WPSC coordinated and conducted further investigations on both properties under a Consent Order entered into with WDNR on October 22, 1993.

WPSC performed additional soil investigations between 1985 and 1996 to evaluate the magnitude and extent of MGP contamination. In 1998, pre-design data was collected to prepare the upland remedial action alternative described in Section 4.

Detailed information regarding the soil investigation activities and results (including soil boring logs and monitoring well construction forms) is contained in the following documents:

- EDI Engineering & Science, Inc., January 1986. *Site Investigation, Former Coal Gas Manufacturing Plant, Ceape Avenue, Oshkosh, Wisconsin*;

- Simon Hydro-Search (HSI), June 23, 1994. *Phase II Investigation Report – Environmental Investigation of Former Manufactured Gas Plant Facility, Oshkosh, Wisconsin*;

- Natural Resource Technology, Inc. (NRT), October 2, 1996, Letter to James Reyburn, Wisconsin Department of Natural Resources, *Phase II Addendum Investigation Results, Former Oshkosh Manufactured Gas Plant (MGP) Site, Oshkosh, Wisconsin*; and

- Natural Resource Technology, Inc., April 27, 2000, *Remedial Design Report, Former Manufactured Gas Plant Site, Oshkosh, Wisconsin*.

The investigations consisted of the following:

- EDI 1985 Site Investigation included an analysis of ten surface soil samples (two at five locations, SS-1 through SS-5), sampling of two soil borings (SB-1 and SB-2), installing and sampling of four monitoring wells (OW-1 through OW-4), and six ambient air samples (AS-1 through AS-6; four on-and two off the MGP property) (refer to EDI, 1986); A potable well search was performed for the area within a ¼ -mile radius of the property, including an assessment of the municipal water source; however a more recent potable well search was completed in 2005 (August 31, 2005, NRT), as discussed in Section 5;

- In 1991 and 1992, the City of Oshkosh investigations included sampling of twenty soil borings (B-1, B-2, BX-1 through BX-6, and BZ-1 through BZ-12), installing and sampling of five monitoring wells (GW-1 through GW-5) and three piezometers (P-2 through P-4) (refer to HSI, 1994) to define the extent and magnitude of affected groundwater west of the former WPSC property;

- A 1993 Phase II Investigation by HSI included sampling 19 test pits (TP-101 through TP-118, and TP-105A), four surface soil samples (SS-101 through SS-104), seven soil borings (B-101 through B-107), five HydroPunch™ soil and groundwater samples (HP-101 through HP-105), four monitoring wells (MW-101 through MW-104), and three piezometers (P-101 through P-103) (refer to HSI, 1994) to define the extent and magnitude of groundwater and soil contamination at the former MGP property;

- A 1996 Phase II Addendum Investigation by NRT included drilling of seven soil borings (SB-101 through SB-107) and sampling three piezometers (P-104 through P-106) (refer to NRT, 1996);

- A 1998 Pre-Remedial Design Investigation by NRT included installing and sampling four monitoring wells (MW-105 through MW-108) and a groundwater recovery well which was used to perform a pump test, installation of 13 geotechnical borings (SB-109 through SB-111, SB-113 through SB-119, SB-121, SB-123 and SB-124), and analysis of nine composite soil samples (refer to NRT, 2000); and

- In February 2001, as requested by WDNR (December 2000, WDNR), monitoring well MW-109 and piezometer P-107 were installed to define the affects on groundwater to the east. Based on the results of February 2001 groundwater investigation, monitoring well MW-110 and piezometer P-108 were installed in the Broad Street right-of-way to evaluate the extent of the plume east of MW-109/P-107 well nest in October 2001 (refer to NRT, November 2001).

All soil sample locations from the various investigations are shown in Appendix A1 on Plate 1. Soil analytical results are provided in Appendix A2. Monitoring well and piezometer locations from the pre-remedial investigations are shown on Figures 7 and 8 in Appendix B1. Groundwater analytical results are summarized in Table 2 and 3.

2.3 Regional Geology

Olcott (1968)[1] mapped the Oshkosh area within the Eastern Lake Plain and Moraine geographic province. Unlithified materials largely consist of silt and clay, deposited as glacial ground moraine and lake-plain sediments. The thickness of the unlithified deposits is less than 100 feet, except in a bedrock valley that is roughly parallel to, and north of, the Fox River, where thickness can reach 200 feet (Olcott 1968; Appendix E1, Figure 1). This valley slopes to the west towards a major preglacial river valley that likely

[1] Olcott, Perry G., 1968, Water Resources of Wisconsin Fox-Wolf River Basin, Hydrologic Investigations Atlas HA-321, University of Wisconsin Geological and Natural History Survey in Cooperation with the United States Department of the Interior Geological Survey.

flowed to the southwest and discharged to the Wisconsin River. The unlithified deposits are underlain by dolomite bedrock of the Ordovician Age Sinnipee Group, also known as the Galena Platteville Formation. Dolomite thickness on the former MGP property is 42 feet. St. Peter Sandstone underlies the dolomite, and is the area's primary aquifer for high capacity potable wells (Olcott 1966).[2]

2.4 Site Geology and Hydrogeology

Surficial soil at the former MGP property consisted of 2 to 12 feet of an inconsistent mixture of fine sands, silts, and clay mixed with ash/cinder, glass, bricks, concrete, and wood. In general, the fill was between 2 and 5 feet thick near Ceape Avenue and thickened to 6 to 12 feet bgs near the river. On the south portion of the former MGP property, the fill is underlain by an organic soil layer ranging in thickness from 1 to 11 feet that decreases in thickness to the north, away from the river and is absent in the vicinity of P-109 on the north portion of the former MGP property. The fill and organic rich deposits are underlain by a lean clay, that ranges in thickness from 10 to 30 feet where present and externals to depths of 20 to 30 feet bgs and is absent on the northwest portion of the former MGP property in the vicinity of P-104 and P-109. The origin of this lean clay is likely alluvial (prior to development of the former MGP property) and clay fill material (during and subsequent to development of the former MGP property). A gravelly lean clay, interpreted as a clay-rich till, is present beneath the lean clay on the majority of the former MGP property and is thickest, 25 to 45 feet at P-104, P-109, and P-111 on the north portion of the former MGP property and north of the property, thins to the south (PW-A and SB-123), and is absent near and adjacent to the river (P-105 and T108-D). The till, where present, directly overlies the dolomite bedrock, with sporadic thin sand or gravel lenses at the bedrock interface (e.g., P-104). The dolomite bedrock interface occurs at elevations ranging 706 feet (P-107) on the southeast portion of the property to greater than 720 feet adjacent to the river on the southwest portion of the site and at 674 feet on the north portion of the former MGP property (P-109), within the bedrock valley.

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[2] Olcott, Perry G., 1966, Geology and Water Resources of Winnebago County, Wisconsin, United States Department of the Interior Geological Survey in Cooperation with The University of Wisconsin Geological and Natural History Survey.

Cross sections (Appendix E2, Plate 1 and 2) based on pre-remedial, sediment, and post-remedial geologic borings illustrate three hydrostratigraphic units:

- Shallow: Unit consists of fill and alluvium from depths of zero to 16 feet bgs.
- Intermediate: Unit consists of confining lean clay and till (gravelly lean clay) between depths of 20 and 35 feet bgs, with the exception of the north portion of the property where units extends at least 80 feet below ground surface, within the bedrock valley.
- Bedrock: Unit consists of fractured dolomite bedrock and sandy units directly overlying and in contact with the bedrock.

2.5 Soil Investigation Results

Soil samples were analyzed for MGP constituents of concern (COCs), including volatile organic compounds (VOCs); benzene, toluene, ethylbenzene and xylenes (BTEX); polynuclear aromatic hydrocarbons (PAHs); total phenols; total, amenable and weak acid dissociable cyanide; and RCRA metals. Soil analytical data are provided in Appendix A2.

2.5.1 Former MGP Property

The area with elevated PAHs generally coincided with a portion of the area where elevated benzene concentrations were present (see Figure 2 in Appendix A3).

In the central portion of the former MGP property, the contaminated area was associated with the former 500,000 ft^3 gas holder. Based on soil borings and test pits performed in this area, affected soil extended to 6 feet bgs in the vicinity of the former gas holder and was relatively localized. Field observations indicated that a sheen and strong odor (and possibly tar) was present between 4 to 6 feet bgs from the south edge of the holder to approximately 25 feet south of the former gas holder.

Soil contamination on the northwestern side of the former MGP property was located in the vicinity of the former tar wells and 200,000-ft^3 gas holder. Laboratory analytical results showed the presence of BTEX and PAHs throughout this area. Field observations indicated that tar was present in the vicinity of two of the tar wells and the gas holders. Coal tar was also observed in the fractures of the clay with sand at MW-104 (depth 10.9 to 11.4 feet).

Elevated levels of cyanide were detected during the pre-remedial investigations. Field observations indicated stained wood chips located primarily in the vicinity of the tar wells, tar separator and scattered on the north-central part of the property (Figure 3, Appendix A3). The highest concentration of total cyanide (1,727 mg/kg) was encountered in the former 25,000 gallon tar well at 1.5 feet bgs. The total cyanide concentration at TP-107, below the former tar separator, was 496 mg/kg at a depth of 4.5 feet bgs. Total cyanide concentrations from all other samples collected were less than 100 mg/kg.

2.5.2 Adjacent Properties

Soil samples collected by the City's consultant, Twin City Testing Corp. (TCT), and NRT indicated the presence of MGP residuals. These MGP residuals are mostly located along the southern end of Court Street and adjacent to the Fox River (Figure 2, Appendix A3). Laboratory analytical results indicate that BTEX and PAHs are present in soils throughout this area (southern end of Court Street and adjacent to the Fox River at GW-4, BZ-8 and BZ-1); generally below the water table, which may be related to groundwater migration and do not necessarily indicate presence of potential source areas. Coal tar was observed in the fractures of the native clay with sand at boring B-105 in Court Street from 6 to 10 feet bgs. Geotechnical soil borings installed in Court Street by NRT in 1998 indicated that fill material and hydrocarbon staining was present in soils to a depth of approximately 4 to 6 feet bgs.

2.6 Groundwater Flow

Depth to groundwater measurements were collected during pre-remedial investigation activities from the monitoring wells and piezometers and are summarized in Table 1.

2.6.1 Shallow Groundwater Flow

Pre-remedial shallow groundwater elevations ranged from 746 to 748 feet[3] (4 to 8 feet bgs). Shallow groundwater flows were south-southwest towards the Fox River (Appendix B1 Figure 7). River elevations were similar to or slightly lower than groundwater elevations. Horizontal gradients, based on

[3] NAVD88 - Elevations in this report will be noted as feet only and are referenced to the new North American Vertical Datum of 1988 (NAVD88)

September 2001 data (Appendix B1, Figure 7), were approximately 0.007 to the south (toward the Fox River).

Hydraulic conductivity values calculated from 1993 baildown/recovery test methods ranged from $1.5x10^{-2}$ to $1.3x10^{-7}$ cm/sec. The highest hydraulic conductivity values occurred in well-graded gravel layers and in the coarse-grained fill material. Low hydraulic conductivity values occurred in the wells screened in lean clay with sand and within the fine-grained fill (HSI, 1994).

The higher velocities were influenced by higher hydraulic conductivities calculated for monitoring wells screened in fill, and the lower velocities represent wells screening the shallow lean clay. The mean flow velocity in the fill, using a geometric mean hydraulic conductivity value of 2.0×10^{-3} cm/s ranged from 20 to 50 ft/yr.

2.6.2 Bedrock Groundwater Flow

Pre- and post-remedial bedrock groundwater elevations ranged between 742 to 748 feet NAVD based on piezometers P-104 through P-108 and indicated groundwater flow is north with a slight westerly component. Horizontal hydraulic gradients have ranged from were 0.001 to 0.005 to the northwest/west (away from the Fox River).

2.6.3 Vertical Hydraulic Gradients

The shallow and bedrock groundwater flow systems are independent of each other (See Section 5). As such, vertical hydraulic gradient data presented in the pre-remedial site investigation reports are not helpful in interpreting vertical groundwater flow.

2.7 Groundwater Quality

Groundwater samples collected from the monitoring wells and piezometers from 1985 through March 2002 were analyzed for BTEX; trimethylbenzenes; total, weak acid dissociable and amenable cyanides; and PAHs. Groundwater quality data are summarized in Tables 2 and 3, and presented on Figure 9 in Appendix B1.

2.7.1 Shallow

The highest concentrations of BTEX (520 to 9,700 micrograms per liter (µg/L) benzene) and PAH (510 to 41,000 µg/L naphthalene) compounds were detected in the south central portion of the former MGP property at GW-2, MW-102 and MW-101. Concentrations decreased to the east and west (<0.13 to 2.2 µg/L benzene and <0.056 to 280 µg/L naphthalene), toward the park and the Broad Street right-of-way.

The upgradient extent of MGP-related constituents in groundwater was delineated by OW-1, where BTEX and PAHs concentrations were slightly above or at NR 140 Preventive Action Limits (PAL).

2.7.2 Intermediate

MGP-related constituents present in groundwater samples collected from piezometers screened within the intermediate silt/clay zone (P-2, P-4, P-101 and P-102) were attributed to historical activities and the alignment of historic shorelines at the former MGP property before these areas were backfilled to current surface grade (Appendix A1, Sheet C020).

2.7.3 Bedrock

MGP-related constituents in bedrock piezometers were mostly below NR140 ES with the exception of P-103, P-107, and P-108, located adjacent to the Fox River. P-103 and P-107 are screened in gravel above bedrock. P-108 is screened in silt above bedrock with a sand pack that is hydraulically connected to bedrock. All three piezometers (P-103, P-107, and P-108) are hydraulically upgradient of the former MGP operations area and other piezometers (Appendix B1, Figure 10).

2.8 Summary of Findings

The pre-remedial upland investigations identified and delineated soil and groundwater contamination associated with operation of the former manufactured gas plant. Most contamination occurred within the shallow alluvium and fill unit. Section 4 describes the remedial actions designed to treat and contain the contamination.

Results of pre-remedial investigations include the following:

- Shallow groundwater flows south-southwest toward the Fox River and bedrock groundwater flows north-northwest;

- Shallow groundwater was affected by MGP residuals on the former MGP property. The groundwater data at MW-103 and MW-108 did not indicate significant MGP residual concentrations migrating to the east;

- Historical activities and the alignment of historic shorelines influenced the intermediate groundwater quality;

- Bedrock monitoring wells near the river (P-103, P-107, and P-108) had higher concentrations of BTEX and PAH compounds than the downgradient bedrock wells north of the river (P-104 and P-106);

- Oxide box wastes consisting primarily of blue stained wood chips were visually identified near the former MGP tar separator located northwest of the former 500,000 gas holder and in surficial soils (less than one foot bgs) in various portions of the former MGP property; and

- The fill materials are primarily an inconsistent mixture of fine sands, silts and clay mixed with ash/cinder. These fill materials contain MGP residual constituents consisting primarily of BETX and PAHs. MGP residuals are also present in the fill materials within and in the vicinity of the former gas holders and tar wells.

3 SEDIMENT INVESTIGATION AND RESULTS

3.1 Investigation Chronology

Sediment investigations were performed in the Upper Fox River, adjacent to the former MGP. Detailed information of the surface water investigation activities and results are discussed in the following letter reports, listed in chronological order:

- *WPSC Oshkosh Former Manufactured Gas Plant Site Fox River Sediment Sampling Results*, (August 1994, Simon Hydro-Search, Inc.);
- *Sediment Sampling Work Plan, Former Manufactured Gas Plant Site - Oshkosh, Wisconsin* (April 1995, NRT);
- *Sediment Investigation Report, Former Manufactured Gas Plant Site - Oshkosh, Wisconsin* (October 1996, NRT);
- *Sediment Sampling and Analysis Plan (SAP) for the former Oshkosh Manufactured Gas Plant (MGP) Site, Oshkosh, Wisconsin* (June 2001, NRT); and
- *(Revised) Sediment Investigation Report Former Oshkosh Manufactured Gas Plant Site Oshkosh, Wisconsin* (August 22, 2005, NRT).

Two types of material are observed at the bottom of the Fox River: unconsolidated soft sediments and consolidated sediments. The soft sediments are composed of organic silt/clay to organic sand with debris and fine-grained material (lean clay and silt) with varying amounts of coarse-grained material (sand and gravel). Underlying the soft sediment are consolidated deposits comprised of clay and silt with thin, localized sand and fine gravel layers. These consolidated deposits were previously identified, during 1994 through 2002 sediment investigation, as gravelly lean clay till deposits. Evaluation of data during upland geology as part of the former MGP bedrock assessment activities in 2005 (Section 5), indicate these consolidated materials do not correlate to gravelly lean clay, which are interpreted as till deposits, identified north and south of the Fox River (Appendix E: Plates 1 and 2). Additionally, the sediment and bedrock assessment activities indicate some of the consolidated deposits encountered are weathered bedrock. For purposes of this completion report, the upper debris layer will be referred to as “soft sediment” and the lower consolidated material with be referred to as “consolidated sediment”, which includes the lean clay, silt, localized sand and gravel layers, and the potential weathered bedrock.

3.1.1 Simon Hydro-Search, Inc. (HSI), August 1994

An initial sediment investigation was performed by HSI to evaluate the presence or absence of compounds in sediments that might be associated with the former MGP property. This investigation consisted of collecting ten sediment cores from approximately 6 to 60 feet from shore and ranging in length from 1 to 2.2 feet (Appendix C1, Figure 2). Following unsuccessful attempts to obtain sediment samples from conventional coring devices (likely due to gravel and shell or other debris), a diver collected samples using a hand-held coring device.

HSI indicated that surficial sediments consisted of dark gray to black silty sand and gravel ranging in thickness from 0.1 to 1.2 feet. Sediments beneath this layer to the bottom of the cores consisted of dark grayish brown to dark gray silt and silty clay, with varying amounts of organic material. Bivalve shells and snail shells were observed in the silty sand. Shells were also noted in the deeper organic silt sediments.

The HSI analytical data summary is provided in Appendix C1, Table 1. Appendix C2, Sheet 1 provides the sampling locations with the distribution of BTEX and total PAHs. Phenol was not detected at any sampling location.

3.1.2 Natural Resource Technology, October 1996

NRT performed a subsequent sediment investigation using a HSA drill rig and a barge in December 1995. Six transects (T101 through T106; Appendix C1, Figure 2) were extended out from shore approximately 150 feet and divided into approximately 50-foot long sections. One sediment borehole was completed per 50-foot section. Each borehole was completed to refusal.

A 2-foot split spoon sampler was used to collect continuous samples, which were containerized for field screening and laboratory analysis. Sediment samples were visually inspected for physical characteristics, including color, odor, texture, structure and presence of oily sheens or visible tar/oils. The sediments were then screened for the presence of volatile organic compounds (VOCs) using the headspace method and a PID. Select sediment core subsamples were submitted for laboratory analysis of BTEX, PAHs, total cyanide, total phenol, grain size, TOC, and oil and grease.

Sediment boring logs indicated the presence of a soft sediment layer typically one to two feet thick, consisting of broken bivalve shells, gray clay marl, wood, and organic detritus. Underlying the soft sediment was a dense clay unit (consolidated sediment). This unit extended from approximately 1to 2 feet beneath the sediment surface to the terminus of most boreholes. Borings advanced closer to the shore generally contained thicker units of clay. The clay was firm to stiff with varying plasticity and fissures and blow counts range between 40 to 80 blows or more per 12-inches of sample collection. The clay was relatively continuous and consistent across the site. Intervals of localized silt, fine sand, and fine gravel layers were present. A sandy gravel layer was observed above weathered bedrock, which may be five to ten feet in thickness (Olcott 1966) in boreholes that approached the center of the channel.

Intervals in near-shore boreholes from transects T101, T102, T104, and T105 exhibited tar, sheen, or tar-like odors. The analytical data summary is provided in Appendix C1, Tables 4-2 and 4-3. Sheet 1 (Appendix C2) provides the sampling locations along with the distribution of BTEX and total PAHs.

3.1.3 Natural Resource Technology, (2001 Sampling Activities)

The sampling activities completed in 2001 followed the procedures outlined in Sediment Sampling and Analysis Plan for the former Oshkosh MGP Site (June 2001, NRT). The 2001 sediment sampling locations are plotted in Appendix C2, Figure 3.

3.1.3.1 River Bathymetry

The hydrographic surveys indicate that the river water depth ranges from approximately 7 feet to over 37 feet within the study area. The water is deepest in an apparent scour area to the east, immediately downstream of the railroad bridge pier and shallower along the shoreline. Based on the United States Geological Survey (USGS) topographic quadrangle water elevation at the mouth of the Fox River, the water elevation, during sediment investigations, was assumed to be 746.9 feet[4]. The river bottom

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[4] NAVD - Elevations in this report will be noted as feet only and are referenced to the new North American Vertical Datum of 1988 (NAVD).

elevation ranges from approximately 710 to 740 feet (Appendix C4). Field poling measurements indicate that the river water depth ranges from approximately 6.5 to 32 feet within the study area. The deepest and shallowest portions of the water correspond to the areas identified in the hydrographic surveys (Appendix C3, Tables 1 and 2). The top of sediment elevations obtained from the hydrographic surveys are generally comparable to the elevations from the field poling measurements.

The multi-beam sonar survey of the river bottom indicates varying channel configurations likely due to changes in general flow patterns resulting from the bridge piers immediately downstream of the former MGP (Appendix C4). West (upstream) of the former MGP, there is an approximately 250-foot wide channel located in the central portion of the river. The elevation of this channel ranges from about 716 to 720 feet (Appendix C4). Along the east side of the site (just upstream of the railroad bridge), the river is shallower, up to elevation 736 feet , suggesting this is an area of sediment accumulation.

Downstream of the railroad bridge there appear to be two separate channels, which are likely related to the influence of the bridge piers on water flow. The base of the channel, located on the southern side of the river, indicates an area of sediment scouring with elevation ranges between 710 and 714 feet, while the base of the channel on the north side ranges from 720 to 724 feet (Appendix C4). Separating these two channels is a mound in the center of the river with a base elevation above 728 feet. The channels become shallower and converge into a single channel at the point where the river enters Lake Winnebago.

3.1.3.2 Sediment Thickness

Sediment thickness maps of the river bottom immediately adjacent to the former MGP were developed from the hydrographic survey results and the sediment poling results (Appendix C3, Table 1 and Appendix C4). In areas where the soft sediment is underlain by consolidated sediments composed of soft, saturated clay soils, determining sediment thickness can be somewhat arbitrary using either method. Visual observations at some of these locations confirmed that soft clays underlay the sediment as this material was smeared onto the pole (Appendix C3, Table 1).

The soft sediment layer present immediately adjacent to the former MGP is generally thin and uneven ranging from 0 to 4 feet of sediments along the eastern end of the site (Appendix C4). Boring logs indicate sediment up to 7-feet within 40 feet from the shoreline on the western end of the study area (Appendix C4, Soft Sediment and Debris Thickness map, location T101-D). Sediments are generally thin and discontinuous in the channel areas ranging from 0 to 0.5 feet (Appendix C4). In general, the near-shore sediments are less than two feet thick over much of this area although some areas had no measurable sediments. Sediment thickness increases downgradient of the railroad bridge.

3.1.3.3 Side Scan Sonar

The side scan sonar images as documented in the *Revised Sediment Investigation Report* (August 22, 2005, NRT) show the continuous presence of debris along the dock wall and adjacent steeper slope of the north side of the channel. The dock wall is well defined in the side scan sonar images with the exception of where Court Street appears to intersect the river. Historically, this was the location of a former slip extending into Court Street that was subsequently filled in (Appendix A1, Sheet C020). Since the time of the side scan sonar survey was conducted, a vertical barrier wall has been installed along the shoreline as part of the upland remedial action, as discussed in Section 4, (Appendix C2, Sheet 2).

The side scan sonar detected two probable pipeline trenches extending across the river channel from the former MGP property. In addition, a pipe or cable is particularly well defined immediately upstream of the railroad bridge. No other recognizable large scale objects were discernable within the river channel, however, other obstacles (e.g., submarine electric lines) may limit future sampling activities.

3.1.3.4 Fox River Hydraulic Characteristics

The Upper Fox River at Oshkosh is approximately 3.2 miles long as it flows out of Lake Butte des Morts into Lake Winnebago. The upstream area drained by the river at this location is approximately 5,310 square miles. The USGS has an Acoustical Velocity Meter (AVM) stream gauge system (Hydrologic Unit 04030201) located approximately 1,500 feet upstream from the former Oshkosh MGP. The AVM gauge is located on the right bank of the river, about 400 feet downstream from US Highway 45 and State Highway 26 bridge, in the SW ¼, SW ¼, Sec.24, T18N, R16E, Winnebago County, the same section in which the site is located. According to previous conversations with Mr. Peter Hughes (USGS, 1996[5]), the AVM gauge was installed at the beginning of water year 1992 (October 1991 to September 1992). The USGS information for the period of record from 1992 to 2000 is summarized on

[5] Hughes, Peter. (U.S. Geological Survey, Madison, WI). Personal communication, April 16, 1996.

Appendix C3, Table 7. Updated USGS information will be evaluated as part of the remedial investigations/feasibility study (RI/FS). Annual discharge from the river during this time period ranges between 104 billion cubic feet (cf) to 228 billion cf, with an average discharge of 139 billion cf.

The average daily flow rate for the period of record is approximately 4,420 cubic feet per second (cfs), while the daily mean flow rates range from -6,270 cfs (November 1, 1992) to 18,600 (June 25, 1993). Negative daily flow rate values indicate that the water flow is sometimes reversed and water flows from Lake Winnebago into Lake Butte des Morts. During the period of record, reversed stream flow occurred on 89 of 3,288 days (2.7% of total days). Over 65% of these reversed flow events occurred between the months of September and November, with October having the highest reversed flow days of any month.

The U.S. Army Corps of Engineers (USACE) controls the water level in Lake Winnebago. During the navigation season (from mid-May to through mid-October; USACE 2002[6]), target water levels in Lake Winnebago are strictly controlled (a seasonal range of less than 3.5 feet) to maintain navigation in the Lower Fox River, downstream of the lake. Therefore, during relatively dry years, less water is released through the dams at Neenah-Menasha, and there is a higher chance for storm events to add sufficient water to the lake over a relatively short period of time to cause a flow reversal near the former MGP property. According to stream flow records, 59 days with negative flow (over 66%) were observed during the four water years (1995, 1998, 1999, and 2000) where the average daily discharge was less than 4,000 cfs. This suggests that decreased discharge and low water levels in Lake Winnebago result in conditions favorable for reversed stream flow near the former MGP.

Based on the bathymetry plot generated as part of the hydrographic survey (Appendix C4), the cross sectional area of the river at the downstream end of the site (i.e., just upstream of the railroad bridge) is approximately 10,800 ft^2. Using this area and the discharge data, the average daily discharge of 4,420 cfs translates to an average water velocity of 0.41 ft/sec (0.12 meters per second [m/s]). Actual water velocities will be higher than the average near the center of the river channel and lower near the shoreline.

[6] USACE. The Lake Winnebago Facts Book Home Page. Retrieved May 16, 2002. http://huron.lre.usace.army.mil/COASTAL/lwfacts.html

Previous modeling efforts completed within the Lower Fox River (EWI Engineering Associates 1991[7]) report critical flow velocities just downstream of Lake Winnebago were generally around 0.3 ft/s (0.09 m/s). Sediment was deposited and accumulated in areas where the flow velocity was less than 0.3 ft/s (0.09 m/s), while significant sediment deposits were not present in areas where the velocity exceeded 0.3 ft/s (0.09 m/s).

3.1.3.5 River Bottom Geology

Geologic cross sections are presented on Appendix C2, Sheet 2 (cross sections A-A' through E-E'). Cross sections A-A', B-B', and D-D' run perpendicular from the shoreline into the river. Cross sections C-C' and E-E' run parallel to shore.

As shown on all of the cross sections, the surficial layer of the Fox River bottom generally consists of two types of material–soft sediments with debris and gravelly material. A soft sediment, typically found in locations approaching the center of the channel (cross section E-E'), consists of, organic silt/clay units to organic sands that overlie diamictons. These soft sediments are primarily black to dark brown silt and clay intermixed with fine sands, which exhibit no consistent layering. Also present within these soft sediments is gyttja, which consists of organic materials such as decayed vegetation, broken bivalve shells and other fine materials. Soft sediments are generally thin and discontinuous in the channel areas. In some areas, soft sediments are absent or too thin to effectively measure.

As sample locations approach the shoreline, as in cross section C-C' the surficial layer is dominated by "debris" which includes wood, brick, glass, and other fill material. In several locations, the surficial sediments exhibited odors, sheen, and trace tar to viscous coal tar, as described in Section 3.1.3.6 and summarized on Tables 1 and 2 in Appendix C3.

Underlying the soft sediments are consolidated sediments, generally comprised of clay and silt soils with thin, localized and intermixed silt, fine sand, and fine gravel layers. The clay soils range from very firm to hard or very soft. The consolidated sediment is relatively continuous and consistent across the study area near the shore as shown on cross section C-C', ranging in thickness from 12 feet (T106-B) to 29 feet

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[7] EWI, 1991. Deposit A – Technical Memo: Task 3: Sediment Transport LLBdM. Project No. 15605.00.

(T106-D). This consolidated sediment is likely to be resistant to erosion during average river flow. As shown in cross section A-A', B-B', and E-E' the consolidated sediment layer decreases in thickness approaching the center of the channel and is not observed in all locations (cross section B-B', T107-B and T107-C). In these locations, a thin layer of soft sediment may be present over gravel, grading to weathered dolomite bedrock and competent dolomite bedrock. Based on the completed cores, the top of bedrock ranges from approximately 707 feet to 718 feet (Appendix E1, Figure 7). However, these elevations are based on auger refusal using HSA drilling methods and may represent the top of weathered bedrock. The actual top of competent bedrock may be five to ten feet deeper (Olcott, 1966). The gravels encountered in the subsurface may represent a mixture of consolidated sediment and weathered bedrock and are likely hydraulically connected to the bedrock, as discussed in Section 5.

3.1.3.6 Occurrence of MGP Residuals

Sampling and poling locations were evaluated for the presence of MGP residuals based on the presence of sheen or coal tar as summarized in Appendix C3, Tables 1 and 2. Olfactory observations are also included on Tables 1 and 2 in Appendix C3. The estimated extent of MGP residuals in the soft sediments is shown in Appendix C2, Figure 4. Estimated extent of MGP residuals in consolidated sediments is shown in Appendix C2, Figure 5. The occurrence of MGP residuals is also noted in the cross sections on Sheet 2 in Appendix C2.

The extent of MGP residuals in soft sediment is sporadic over the study area. The vast majority of the MGP residuals are within 0 to 1-foot from the top of sediment. Trace tar (not readily visible with coal tar-like odor) was observed in one boring (T101-D, NRT 2005) up to 7-feet below the top of sediment.

The extent of MGP residuals in consolidated sediment is disconnected and in some locations, common to the location of soft sediment MGP residuals. However, the presence of MGP residuals within the consolidated sediment is more extensive and is often observed in locations without soft sediment MGP residuals. This is evident when comparing the occurrence of MGP residuals in soft sediments (Appendix C2, Figure 4) and consolidated sediments (Appendix C2, Figure 5). The approximate volume of MGP residuals in sediment was estimated in the revised sediment report (August 22, 2005, NRT) and will be further evaluated during future RI/FS activities.

The cross sections (Appendix C2, Sheet 2) further demonstrate that the MGP residuals found in the consolidated sediments are generally not related to affected soft sediment. Rather, the data indicate that migration occurred within consolidated sediment. In T104-E, T104-F, T104-G, T107-A, and T107-D MGP residuals were observed in a gravel and sand unit at a depth of five to ten feet below the top of the riverbed. The occurrence of tar at these locations is likely due to migration through the gravel and sand unit as opposed to deposition directly in the river channel. Potential migration pathways are further discussed in Section 5.

Estimated surface areas for the consolidated sediment with the occurrence of MGP residuals were also estimated in the revised sediment report (August 22, 2005, NRT) and will be further evaluated during future RI/FS activities.

3.1.3.7 Sediment Analytical Results

Distribution of BTEX and total PAHs in sediments is provided on Appendix C2, Sheet 1 and select sample results are provided on the cross sections (Appendix C2, Sheet 2). For screening purposes, PAH data were compared to MacDonald et al. 2000[8] Consensus Based Sediment Quality Guidelines (CBSQGs). Due to the lack of a CBSQG benchmark for ethylbenzene, the total BTEX data were compared to the EPA Ecotox Thresholds[9] for screening purposes.

<u>Soft Sediment (BTEX and PAH)</u>

Soft sediment analytical results are summarized on Table 4 (BTEX) and Table 5 (PAHs) in Appendix C3. The distribution of BTEX and Total PAHs in soft sediment is provided on Figure 6 in Appendix C2. BTEX concentration ranged from 0.196 to 315 mg/kg and PAH concentration ranged from 0.065 to 30,710 mg/kg in soft sediment.

<u>Consolidated Sediment (BTEX and PAH)</u>

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[8] MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. *Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems.* Arch. Environ. Contam. Toxicol. 39:20-31

[9] USEPA. 1996. ECO Update: Ecotox Thresholds. EPA 540/F-95/038. January, 1996.

Analytical results are summarized on Table 4 (BTEX) and Table 5 (PAHs) in Appendix C3. Only one sample (T108A (10.7-12.7)) in the underlying consolidated sediments in which BTEX concentration was detected at 1.7 mg/kg. PAH concentrations ranged from 0.35 to 30.3 mg/kg in the consolidated sediments.

Sample T104-F(33.5) was collected immediately below a gravel layer that exhibited evidence of coal tar to evaluate the vertical extent of MGP residuals. The total BTEX and PAH concentrations were relatively low, reported at 5.9 mg/kg and 7.9 mg/kg, respectively.

Samples T108-B(20.3-22.3), T108-D(28.9-29.9), and T108-E(10.5-12.5) were also collected to evaluate the vertical distribution of MGP residuals. Total BTEX concentrations ranged from non-detect (T108-E) to 1.2 mg/kg (T108-B). Total PAH concentrations ranged from 0.77 mg/kg (T108-D) to 11.8 mg/kg (T108-E).

Cyanide

Cyanide results in sediments are provided on Table 6 in Appendix C3.

Metals, PCBs, Ammonia and TOC

Sediment subsamples collected from transects T104, T107, T108, T109, and Ponar™ grab Points 53, 54 and 80 were analyzed for metals, PCBs, ammonia, and TOC. The results are presented on Table 6 in Appendix C3.

3.1.3.8 River Water Analytical Results

Analytical results for the two river water samples are summarized on Table 7 (BTEX, cyanide, ammonia, TOC, and TSS) and Table 8 (PAHs) in Appendix C3. Distribution of BTEX and total PAHs in the river water samples are provided on Sheet 1 in Appendix C2.

BTEX, total, dissociable, and amenable cyanides, and total PAHs were not detected in either river water sample. Ammonia was detected in the upstream sample between the limit of detection and the limit of quantitation. TOC and TSS were comparable in the upstream and downstream sample locations.

3.1.3.9 Preliminary Benthic Community Survey

The approach, field activities conducted, and results of the preliminary benthic community survey are provided in Appendix C5. This study was conducted to provide a baseline determination of benthic organisms adjacent to the site, as well as upstream and downstream. It was not intended to provide a species-level identification of organisms collected.

3.2 Summary of Sediment Investigations

- Previous sediment studies showed near-shore MGP residuals to be confined within 60 feet of the north shore in the upper sediment layer. The 2001 survey revealed sporadic distribution of MGP residuals that included the near-shore areas identified by (October 15, 1996, NRT) and areas in the channel extending to within 100 feet of the south bank of the Upper Fox River.

- The river depth adjacent to the former MGP property ranges from between approximately 7 to over 37 feet. The river bed exhibits relatively continuous debris along the dock wall. Other obstructions to further investigation and potential remediation include storm sewers (3), gas main (1, abandoned), electric submarine cables (at least 4), and sanitary sewer force mains (2).

- The average daily flow rate for the period of record is approximately 4,420 cfs, while the daily flow rates range from -6,270 cfs (November 1, 1992) to 18,600 (June 25, 1993). Negative daily flow rate values reflect infrequent water flow upstream out of Lake Winnebago during about 3% of the period of record. Reverse flow conditions may account for an upstream component of MGP residual distribution.

- Two types of material are observed at the bottom of the Fox River: unconsolidated soft sediments and consolidated sediments. The soft sediments are composed of organic silt/clay to organic sand with debris and fine-grained material (lean clay and silt) with varying amounts of coarse-grained material (sand and gravel). The soft sediment layer immediately adjacent to the former MGP property is thin and uneven, generally less than two feet thick over much of this area. The areas where affected soft sediments were noted, rather than underlying soils, generally have less than two feet of sediment. In some areas, soft sediments are absent or too thin to effectively measure or sample.

- Underlying the soft sediment are consolidated sediments comprised of clay and silt with thin, localized silt, fine sand, and fine gravel layers. The predominantly clay consolidated sediment range from very firm or very soft in texture and is relatively continuous and consistent across the upland areas of the former MGP property. The consolidated sediment is absent in mid channel areas.

- Where consolidated sediment is absent in the mid-channel areas the river bed consists of a gravel layer that grades to the weathered dolomite bedrock surface (based on upland geologic information). The gravels appear to be mixed with weathered bedrock and are likely hydraulically connected to the bedrock.

- Observable indications of organic constituents present in the soft sediments consisted of sheen and/or the presence of tar. These areas also correspond to elevated levels of BTEX and PAHs.

- The highest concentrations of BTEX and total PAHs are present in soft sediments at locations that exhibited tar. Total PAH concentrations ranged from below detection limit to 30,710 mg/kg (ppm). These locations were found in the middle of the channel.

- In consolidated sediment samples, total PAH concentrations ranged from non-detect to 30.3 mg/kg and BTEX concentrations ranged from non-detect to 5.9 mg/kg.

- BTEX, PAH, and cyanide results for the two river water samples were below detection limits.

- MGP residuals in the channel have likely migrated via preferential pathways from the upland portion of the site as discussed in Section 5.5.4. Primary migration pathways involving direct inputs to river sediments were addressed by upland remedial actions. Evaluation of the occurrence of MGP residuals within gravel/bedrock and potential for dissolved phase migration both north and south of the river is discussed in Section 5.6.

4 REMEDIAL ACTIONS PERFORMED

4.1 Overview

Remedial actions were performed between March and October 2002. The City of Oshkosh purchased the property from WPSC in December 2003 and built the park between 2004 and June 2005.

4.2 Remedial Action Objectives

Remedial action objectives (RAOs) for the site, as presented in the Remedial Work Plan (November 2001, NRT) are summarized as follows:

- Reduce the potential for direct contact exposure to MGP residuals;
- Prevent surficial run-off of MGP residuals from the former MGP property into the river;
- Reduce leaching of MGP residuals to groundwater; and
- Reduce migration of MGP residuals to the river.

4.3 Pre-Remedial Action Activities

4.3.1 Feasibility Study

NRT performed an FS to evaluate remediation alternatives for the property and select a response action as detailed in the *Remedial Action Options Report* (May 1998, NRT). The FS recommended limited excavation and thermal desorption coupled with capping and hydraulic containment. Hydraulic containment would be a combination of groundwater recovery with aboveground treatment and the installation of a vertical hydraulic barrier wall.

A pre-remedial design investigation and supplemental design investigation were conducted in November/December 1998 and fall 2001, respectively.

4.3.2 Design Activities

Pre-design investigative activities included the following:

- Pump Test and Groundwater Treatability: A 48 hour pump test was performed at RW-101. Pump test data is summarized in the *Remedial Design Report* (April 2000, NRT). Based on the pump test results extraction trenches were selected over a well system to achieve the desired gradient control. During the pump testing, influent and effluent groundwater samples were collected and analyzed for treatability evaluation and confirmation that the extracted groundwater met the City of Oshkosh discharge limits to the sanitary sewer system;

- Soil Treatability: Representative composite soil samples were collected from the upper unsaturated zone (approximately zero to four feet bgs) and the lower saturated zone (approximately 4 to 14 feet bgs) for soil treatability evaluations. Soil treatability data are presented on Table 6 in Appendix A2; and

- Geotechnical Laboratory Testing: Undisturbed and disturbed soil samples obtained during the geotechnical drilling program were submitted for geotechnical testing to identify preliminary engineering parameters for a containment wall and/or extraction trench, general excavation and slope stabilization. Laboratory testing included falling head triaxial back pressure permeability, index properties consisting of moisture/density, specific gravity, grain size analysis and Atterberg Limits, and unconsolidated undrained (UU) triaxial testing on selected samples of fill material and glacial till. Geotechnical laboratory test results and data is provided in the *Remedial Design Report* (April 2000, NRT). The test results indicated that the clay till is a suitable key-in-layer with hydraulic conductivity ranging from $1.6x10^{-8}$ to $5.9x10^{-9}$ cm/sec.

4.3.3 Supplemental Design Activities

In addition to the installation of the monitoring wells and piezometers installed in February/October 2001, as mentioned above in Section 2, supplemental design activities included assessment of the existing dock wall (Sheet C010, Appendix D1) and performing additional geotechnical borings (Sheet C020, Appendix A1).

4.3.3.1 Dock Wall Assessment

Test pits TP-201 through TP-205 were excavated to evaluate the subsurface conditions along the pre-existing dock wall, adjacent to the former MGP. Test pit locations are shown on Sheet C020 in Appendix A1. Conclusions of the test pit program and dock wall assessment were as follows:

- The pre-existing dock wall was unstable and beyond repair.
- Due to debris and foundations sheet piles could not be readily advanced through the fill to the desired key depth in a cost effective manner.
- A containment wall/dock wall combination was considered to be the most efficient method of both renovating the existing dock wall and providing an alignment for the containment wall that would minimize the amount of debris.
- The containment wall would need to be installed on the river side of the pre-existing dock wall.

4.3.3.2 Additional Geotechnical Borings

In September/October 2001, five geotechnical borings were advanced in the Fox River and one additional geotechnical soil boring SB-125 was advanced near the northeastern extent of the proposed vertical barrier alignment. The geotechnical borings confirmed the proposed key depth of approximately 732 feet NGVD. An additional flexible wall hydraulic conductivity test at boring T-108B (5.7×10^{-7} cm/sec) indicates similar geotechnical properties from previous investigations of the key-in-layer (clay till).

4.3.4 Remedial Design

The remedial design focused on:

- Decommissioning former MGP structures;
- Eliminating potential migration pathways;
- Excavating MGP affected soils;
- Installing a vertical barrier wall (Waterloo® sheet pile system);

- Installing hydraulic gradient control and groundwater extraction and treatment system;
- Backfilling with thermally treated soil; and
- Constructing an earthen cap.

4.3.5 Permitting and Approvals

Wisconsin Department of Natural Resources (WDNR) approved the *Remedial Work Plan* and directed WPSC to proceed with excavation and thermal treatment of contaminated soil on-site (March 2002, WDNR). WPSC obtained approval from the City of Oshkosh to temporarily use a portion of the park and parking lot west of Court Street for storing equipment and job trailers. In addition, the following permits and approvals were obtained in order to begin operations at the site:

- City of Oshkosh building permit and other municipal permits;
- Approval for temporary dewatering discharge to City of Oshkosh wastewater treatment plant;
- WDNR Chapter 30 permit;
- Army Corps of Engineers general permit;
- Storm Water discharge permit;
- Notification of demolition;
- Plan of Operation for Thermal Treatment approval letter; and
- Notification to Treat or Dispose of Petroleum Contaminated Soil (Form 4500-168).

The thermal treatment contractor was responsible for meeting air emission standards including emission rates for particulates, volatile organic compounds, and visible emissions as set forth in the facility operating permit.

4.4 Soil Remediation

Waste characterization of each former MGP structure was conducted prior to hauling contaminated debris to Valley Trial landfill in Berlin, Wisconsin. Test pits were advanced and representative samples were collected within the structures to characterize the debris and soil for off-site disposal, as shown on Sheet C040 in Appendix D1. A summary of the analytical results are on Table 1 in Appendix D2.

4.4.1 Excavation and Grading

The following structures and areas were excavated, in accordance with the *Remedial Work Plan* (November 2001, NRT) as shown on Sheet C040 in Appendix D1:

Structure Excavated	Material Description
500,000 cubic foot gas holder	Fill, black with rubble/concrete, odor
200,000 cubic foot gas holder	Fill, rubble, solidified coal tar
9,000 gallon tar well area*	Clay, fill, odor
25,0000 gallon tar well	Fill, coal tar
18,000 gallon tar well	Fill, coal tar
200,000 gallon tar well	Fill, coal tar
Two small unknown structures	Fill, coal tar
One tar separator	Water, coal tar, sludge
Two USTs	Sandy fill, petroleum odor

* 9,000 gallon tar well from historic plans was not encountered during exploratory excavation of the area. Surrounding soil excavated to 3 to 4 feet.

Excavation began at the 500,000 cubic foot gas holder in order to use the base as a staging area for post-treatment material. The concrete base of the large gas holder was found to be approximately five feet below existing ground surface (bgs), with no side walls intact. After soils above the gas holder base were removed and stockpiled for thermal desorption, the concrete base was used for stockpiling post-treated material.

Following the large gas holder excavation, the tar separator located west of the thermal desorption unit (TDU) concrete pad was excavated due to its proximity to the TDU, as shown on Sheet C040. The tar separator consisted of four chambers constructed of steel, concrete and wood. There was approximately five feet of tar and tar sludge at the bottom of the four chambers with approximately 1.5 feet of perched water. All material was removed from the tar well to its base at approximately 8 feet bgs and was consolidated with excavated material from other areas for thermal treatment (See Appendix D3). The separator was backfilled with imported clay. The tar separator adjacent to the 200,000 cubic foot gas holder was not encountered during exploratory excavation.

The 18,000 gallon and 25,000 gallon tar wells were excavated to the bottom of each tar well. The base was left in-place, but the sidewalls were removed to at or below elevation 747 feet. Two additional subsurface structures were encountered while excavating surrounding soils east of the tar wells, as shown on Sheet C040 in Appendix D1. One structure approximately 10 feet in diameter was identified and excavated to its base at approximately 7 feet bgs. The other structure was approximately 6 feet in diameter and was excavated to its base at approximately 6 feet bgs.

As stated in the *Remedial Work Plan* (November 2001, NRT), the MGP facility included a 200,000 gallon tar well that consisted of two chambers separated by a one-foot thick concrete wall. This tar well was visually inspected for free phase coal tar and coal tar was found. The contaminated material was excavated to the base of the tar well at approximately 20 feet bgs. Additional shallow soil from the northern and western portions of the site was excavated and aggregated with the tar well material to homogenize moisture and BTU value prior to thermal treatment. The area and approximate depth of the additional shallow soil excavation is shown on Sheet C040 in Appendix D1.

A majority of former MGP conveyance piping and storm sewers were excavated according to plan, as shown on Sheet C040 in Appendix D1. Pipe runs not encountered during the work are also indicated on Sheet C040 in Appendix D1. Where inaccessible, pipes were grouted to prevent preferential migration of groundwater. Conveyance piping, manholes and significantly contaminated surrounding soil were removed and segregated for treatment or disposal. MGP affected soil was thermally treated. Pipes were decontaminated prior to disposal at Valley Trail landfill.

Additional excavation along the north side of the TDU pad was conducted due to the presence of blue-stained soil, as shown on Sheet C040 in Appendix D1. A large concrete footing measuring approximately

10 feet by 15 feet was encountered. Soil adjacent to the foundation was removed and treated, and the foundation was left in place.

Two previously unidentified underground storage tanks (USTs) were encountered southwest of the former 500,000 ft3 gas holder, as shown on Sheet C040 in Appendix D1. The USTs appeared to be abandoned in place with sand. The USTs were removed, crushed, and hauled to Valley Trail landfill for disposal. Soil surrounding the USTs contaminated with what appeared to be gasoline residuals was excavated and treated with MGP contaminated soil.

4.4.1.1 Utility Corridor Investigation (Off-Property)

Utilities, both active and inactive, within the Court Street right-of-way were evaluated as preferential migration pathways using video inspection and test pits. An inactive storm sewer was abandoned.

Video Inspection

A video inspection of the active 8-inch sanitary sewer within Court Street right-of-way was conducted by Northern Pipe Equipment Inc. The sanitary sewer inspection began at the manhole located at the end of Court Street (manhole #1) and proceeded to manhole #3. Approximately 550 feet of sewer was inspected for cracks, leaks, and presence of coal tar. Several leaks and cracks were noted between manholes #1 and #2. A crack was also noted 127 feet north of manhole #2. No coal tar was noted during the investigations. Locations of manholes, video inspection report and video on compact disk are presented in the *Remedial Action Documentation Report* (February 2003, NRT).

WPSC notified the City of the sanitary sewer condition and requested approval to abandon the sanitary lateral 44 feet south of manhole #3. As shown on Sheet C040 in Appendix D1, a new manhole was installed 44 feet from manhole #3 and the lateral south of the new manhole was plugged with grout. Manhole #2 and #1 were abandoned and backfilled with clay and plugged with concrete.

The active 22 x 36-inch storm sewer within Court Street right-of-way was also video-inspected by Northern Pipe Equipment Inc. Video inspection began at the manhole located at Ceape Avenue and Court Street intersection (manhole #1) and preceded south towards the river outfall. Approximately 590 feet of the storm sewer was inspected for cracks, leaks, and presence of coal tar. No cracks, leaks or coal tar was noted during inspection.

Test Pits

Three test pits were excavated along Court Street to assess the presence of coal tar residuals around existing underground utilities. Locations of test pits are shown on Sheet C040 in Appendix D1. These utilities included the following:

- Inactive 12-inch storm sewer;
- Active 22 x 36-inch storm sewer;
- Previously abandoned 12-inch gas main; and
- Active 8-inch sanitary sewer.

Test Pit #1 located within Court Street approximately 70 feet south of Ceape Avenue was excavated across the utilities. The excavation was 6 feet by 35 feet and approximately 5 feet deep. Fill material (clay) around the abandoned 12-inch gas mains exhibited a slight odor, but no coal tar was present. No coal tar was present within pipe bedding around the active 8-inch sanitary sewer or active 22 x 36-inch storm sewer. The 6-inch water main located west of the 22 x 36-inch storm sewer and below the sidewalk was not encountered in Test Pit #1. As no MGP-related contaminants were found, the test pit was not extended to the water main.

Test Pit #2 located within Court Street approximately 75 feet from shoreline. The excavation was 6 feet by 35 feet and approximately 5 feet deep. Pipe bedding around active 22 x 36-inch storm sewer, 8-inch sanitary sewer and 12-inch gas main did not contain coal tar. Bedding material surrounding the 12-inch gas main exhibited a slight odor. In order to prevent the migration of contaminated groundwater or potential vapors north of the site, Test Pits #1 and #2 were backfilled with imported clay.

The third test pit was advanced in the alignment of groundwater intercept trench DS-1 (within the containment system). Within Court Street, the excavation was 6 feet wide by 40 feet long and approximately 11 feet deep. Pipe bedding around the active 22 x 36-inch storm sewer, 8-inch sanitary sewer and 12-inch gas main did not appear to contain coal tar residuals. A wooden box was encountered between the 8 and 12-inch gas mains at approximately 6 feet deep. The wooden box contained coal tar residuals and was removed.

Abandoned Storm Sewer

The inactive 12-inch storm sewer along the east side of Court Street was removed (within the containment system), as shown on Sheet C040 in Appendix D1. Removal was undertaken due to the presence of coal tar observed inside two of the three manholes. The storm sewer and surrounding soils were excavated between the two northern manholes. The excavation was approximately 150 feet long by 10 feet wide. Surrounding soils north of the southern manhole extending south to the river were observed to contain MGP contaminated material. As a result, an additional area of approximately 180 feet by 14 feet of MGP contaminated soil around the inactive storm sewer was removed for thermal treatment. Excavation depth was approximately 3.5 to 4 feet.

4.4.2 Thermal Treatment

A total of approximately 23,500 tons of soil was treated during remedial activities. Treatment verification samples were collected. Treated soil was stockpiled in 500-ton intervals pending laboratory analytical results at a frequency of one composite sample per stockpile. Post-treatment soil analytical results, along with the treatment soil standards, are listed on Table 3 in Appendix D2. Eight post-treated stockpiles exceeded one or more of the WDNR approved treatment performance standards. These stockpiles were transported to the pre-treatment or to the excavation area for consolidation with excavated material. The materials were then retreated and sampled. All treated material met the treatment soil standards prior to reuse as backfill on-site.

Post-treatment cyanide concentrations were below USEPA SSL of 40 mg/kg for migration to groundwater. Lead concentrations ranged from 400 to 1,000 mg/kg, as shown on Table 3 in Appendix D2.

Based on the arithmetic mean of all pre-treatment and post-treatment results, thermal treatment achieved 99.90 percent removal of BTEX and 99.99 percent removal of PAH in soil. This is based on results shown on Table 4 in Appendix D2, in which the approximate arithmetic mean of pre-treatment soil concentrations of total BTEX and PAHs were 114 mg/kg and 1,460 mg/kg, respectively, and the average post-treatment soil concentrations were 0.116 mg/kg and 0.173 mg/kg, respectively. Averaged over the total tonnage treated of approximately 23,500 tons, the mass of BTEX and PAHs removed by thermal treatment was approximately 5,300 pounds and 68,800 pounds, respectively. In addition, approximately 2,400 pounds of total cyanide was removed.

4.4.3 Air Monitoring

Air monitoring was performed as described in the documentation report (February 2003, NRT) through the duration of the excavation, grading and thermal treatment.

4.4.4 Material Management Summary and Conclusions

In summary, the final approximate quantities of material encountered and/or used at the site and final disposition are listed below.

Material	Disposition	Approx. Tons
Excavated Soil Thermally-treated	Used as subsurface backfill	23,500
Contaminated Debris	Sent to landfill	2,700
Other Material (demolition debris)	Sent to landfill	1,300

4.5 Containment System

The containment system installed consisted of the following components:

- Vertical barrier wall; and
- Groundwater extraction and treatment system.

4.5.1 Vertical Barrier Wall

As stated in the Remedial Work Plan (November 2001, NRT), a combination of the Waterloo® Sheet Pile System and a cement-bentonite slurry wall was recommended for the vertical barrier wall. Both systems were keyed into the clay till at the site.

4.5.1.1 Waterloo System

The Waterloo® system consists of steel sheet pile with an oversized, rolled interlock cavity to be cleaned and sealed using a cement-based grout. C3 Environmental Limited (C3) was contracted to provide construction quality assurance (CQA) during installation of the vertical barrier sheet piles, grouting within sheet pile interlocks, and slurry wall installation of sheet pile and installation of the slurry wall. A CQA report of the vertical barrier wall installation is provided in the documentation report (February 2003, NRT).

As noted in the report, the Waterloo® sheet pile wall was installed in accordance with the drawings and specifications with only minor variations relating to pile depths, gas main alignment deviation, and utility corridor alignment. As shown on Sheet C083 in Appendix D1, Section B near the location of boring T1081B, the key depth was field-adjusted to four feet below original design depth. Based on conditions noted during sheet pile driving, the lean clay was apparently deeper near T108B. During the installation, sheet piles that could not be advanced to the design key depth with the vibratory pile driver were driven with a larger vibratory pile driver. The gas main alignment deviation and utility corridor sheet pile alignments were field adjusted due to the actual location of the utilities.

4.5.1.2 Slurry Wall

A cement bentonite slurry wall was installed around the utilities within the utility corridor, as shown on Sheet C081 in Appendix D1. The slurry wall was designed to:

- Have a maximum permeability of 1x10-7 cm/sec;
- Key into lean clay with 1x10-7 cm/sec permeability at the approximate elevation of 730 feet NAVD; and
- Serve as a barrier for groundwater discharge to the river in locations adjacent to utilities.

The sheet pile wall was keyed into each end of the slurry wall, a minimum of one foot.

Prior to construction, a bench-scale test was conducted. The bench-scale test results are presented in the documentation report (February 2003, NRT). A slurry mixture of bentonite, portland cement, blast furnace slag, and potable water was selected. Field samples collected show a permeability result less than $1x10^{-8}$ cm/sec.

Huntington Chase Geoservice provided CQA during installation of the slurry wall. The slurry wall CQA documentation is presented in the documentation report (February 2003, NRT). Constructed slurry wall location and dimensions are shown on Sheets C081 and C084 in Appendix D1, respectively.

4.5.1.3 Utility Penetrations

Two storm sewer outfalls were extended through the new sheet pile dock wall. A 22 x 36-inch outfall was located south of Court Street and a 12-inch outfall was located within the utility corridor in the eastern portion of the former MGP property. The 22 x 36-inch storm sewer was extended and sealed through the vertical barrier dock wall with a 42-inch steel pipe welded to the sheet pile wall. The connection between the former outfall and extension pipe was made using a steel band around a rubber gasket encased in concrete. The 42-inch pipe was welded to three sheet piles to ensure that the pipe was completely sealed within the sheet pile. Affected sheet pile interlocks were welded continuously using a 1-inch flatbar across each joint instead of sealing with grout.

The 12-inch PVC storm sewer was extended through the portion of the dock wall within the utility corridor. The storm sewer extends through the slurry wall, which provides the primary vertical barrier for the utility corridor. For secondary containment at the vertical barrier dock wall, a 12-inch steel pipe extension was welded to the dock wall and connected to the 12-inch PVC sewer with a rubber fitting and hose clamps. The dock wall interlocks within the utility corridor were grouted and concrete was poured at the base between the old and new dockwalls as an additional barrier.

4.5.1.4 Anchor System

In addition to the sheet piles, Lunda Construction installed a continuous shallow concrete anchor system for structural support of the dock wall. The anchor system, as shown on Sheet S010 and S011 in Appendix D1, consisted of 32 concrete anchor panels and tie rods placed every 16 feet along the length of the dock wall. The concrete panels were pre-cast off-site, delivered to the site and installed according to plan. Additional bracing and penetration sealing was added as shown on the plans.

Each anchor panel was placed approximately 16 feet inland from the sheet pile dock wall. The rods penetrated the sheet pile dock wall below the 100 year flood elevation and above the typical river elevation. To prevent river water from infiltrating the tie rod penetrations, a steel sleeve was welded to the sheet pile and epoxy resin and clamped rubber sleeve were used to seal the cavity.

Field-directed structural support included an angle brace placed approximately 10 feet from the southwest corner of the dock wall, as shown on Sheet S010 in Appendix D1. The brace consisted of 1-inch diameter tie rod, two anchor plates, and a PVC pipe to sheath the rod from weathering. The PVC cavity was sealed with grout. The sheet pile penetration cavities were sealed with Resi-Weld Gel Paste. An additional angle brace was directed to be placed near in the east wing wall and encased concrete to provide additional support.

4.5.2 Groundwater Extraction and Treatment System

Key components and operational aspects of the groundwater extraction and treatment system are summarized below:

- Four interceptor trenches (DS-1 through DS-4) installed at the locations indicated on Sheet C060 in Appendix D1. Each trench has an 11.5 foot sump that is placed at least a foot into the lower clay layer at approximately 736 to 739 feet NGVD. Each trench has a 6-inch diameter clean out at the opposite end of the trench from the sump. Alignment of trench DS-4 was adjusted based on the field-determined location of the former steam plant foundation.

- Each sump contains a pneumatic pump designed to operate at approximately 7 gallons per minute (gpm). A 4-inch conduit from each sump to MH-1 contain hoses for operation of the pump including an air supply hose, water discharge hose and air bubbler hose. A gate valve was placed in the conduit near the sump for the possibility of gravity feed discharge to the sanitary sewer if acceptable in the future.

- All four 4-inch conduits were connected to manhole MH-1. A 10-inch conduit was connected from the junction box to the treatment building to contain hoses from each of the sumps.

- Aboveground treatment equipment, piping and controls were placed inside a treatment building located north of the City pump station. The building has two separate rooms including an equipment room and control room. The explosion proof equipment room includes four dewatering sump monitoring stations, multi-phase separator settling/transfer tank, two bag filter units and a compressor. The control room contains a control panel, power center and an air desiccator. A process and instrumentation diagram for the treatment system is on Sheet M010 in Appendix D1.

- An air stripper was installed in September 2003 to reduce the organic contaminant concentrations in the effluent to meet the City of Oshkosh discharge limit. The air stripper was installed after the bag filters, as shown on Sheet M010 in Appendix A1. A summary of treatment system results following installation of the air stripper, and record drawings of the air stripper was included in the Air Stripper Operation Report (January 2004, NRT).

4.6 Earthen Cap

During excavation activities, the earthen cap subgrade was continuously under construction. After thermally treated soil was confirmed, through laboratory analysis, to meet the treatment performance standards, treated soil was placed and compacted in areas of excavation. The majority of the treated soil was placed along the north, west and south side of the TDU pad. Thermally treated material was not placed within 100 feet of the river or on City property, including the Court Street right-of-way.

After post-treated soil was placed and the TDU pad was removed, approximately 600 cubic yards of additional soil was required to construct a minimum 2.5 percent slope for positive surface water drainage. Imported clay was used to complete the subgrade construction to required grades.

The property and portion of Court Street right-of-way were capped, as shown on Plate 1 in Appendix A1. The earthen cap consisted of three different layers providing an earthen cap of at least 1.5 feet in thickness. Fine-grained fill material at least 6-inches thick, consisting predominantly of clay, was placed and compacted above the subgrade. Drainage tile including 4-inch corrugated HDPE pipe and cleanouts was placed along the dock wall and east wing wall above the fine-grained fill layer to provide positive subsurface drainage above the fine-grained fill layer. Granular fill approximately 6-inches thick was placed atop of the fine-grained fill material to allow lateral drainage of infiltrated water except the access drive around the pump station and substation consisted of gravel (1-foot thick). Lastly, a 6-inch layer of topsoil was placed above the granular fill to complete the earthen cap construction.

4.7 Soil Quality Remaining

Prior to placement of the earthen cap, discrete shallow soil samples were collected at the earthen cap extent at approximately 100 linear foot intervals, as shown on Plate 1 in Appendix A1. Table 6 in Appendix D2 is a summary of the soil quality at the earthen cap extent including BTEX, PAHs, total lead and total cyanide. Remaining soil quality at the earthen cap extent, areas unexcavated including off-property for total benzene, BTEX, naphthalene and PAHs are presented on Plate 1 in Appendix A1.

4.8 Modifications to the Monitoring Well Network

During remedial construction activities, monitoring wells RW-1 (former pump test well), GW-5, OW-3, MW-101, MW-105, MW-106, MW-107, MW-108, MW-109, P-102, and P-107 were abandoned because they were either damaged during construction or were scheduled for abandonment.

Former industrial wells PW-A and PW-C were inspected for free-phase coal tar prior to abandonment. Coal tar was not found in either of the wells. Previous work had been done to remove the former pump and hydraulic oil from PW-A, as reported to the WDNR in the *Remedial Design Report* (April 2000, NRT). Both wells were abandoned in accordance with NR 812.26 and the steel casings were cut below the earthen cap subgrade.

During site restoration activities, monitoring wells OW-3R, MW-101R, MW-108R, P-102R, and P-107R were installed to replace the respective monitoring wells that were damaged from construction activities. All monitoring well abandonment forms and construction forms were included in the documentation report (February 2003, NRT).

4.9 Park Construction

In December 2003, the City of Oshkosh purchased the property from WPSC. The City's consultant STS Consultants, Ltd. submitted a park development plan (July 2004, STS) to WDNR to summarize the proposed site modifications associated with redevelopment of the property as an expansion of Riverside Park and request for approval. The following design features were proposed in the park development plan:

- Remove the existing earthen cap and temporarily stockpile the material for reuse on the property. The former MGP property was to be regarded and the earthen cap to be replaced; however, the new environmental cap would consist of concrete or asphalt pavement, and greenspace areas would be constructed using the stockpiled earthen cap materials to create a cap consistent with existing conditions;
- Construction of an asphalt parking lot and several walkways;
- Construction of several buildings including a performance pavilion (amphitheatre), concession, and restrooms. The performance pavilion to be supported on a pile foundation;

- Riverfront improvements including pedestrian walkway, decorative fencing, and an overlook pavilion;

- Modifications to the dewatering sumps and monitoring wells to match final grades;

- Construction of low permeability trench plugs within utility trenches at the locations where trenches enter and exit the property boundaries to limit the potential for contaminants to migrate within the trench backfill beyond the areas containing contaminated soils. A plug to be installed at the new storm sewer penetration through the west wing of the vertical sheet pile barrier wall; and

- Landscaping with plantings of shade trees, flowering trees and shrubs. A geocomposite liner (GCL) to be utilized as a hydraulic barrier over the property fill material beneath landscaped areas.

Construction of Riverside Park expansion was initiated during the fall of 2004 and was substantially completed in June 2005. In June 2006, STS Consultants, Ltd, the City of Oshkosh consultant, submitted the *Riverside Park Construction Documentation Report* (June 2006, STS). A copy of the June 2006 documentation report is presented as Appendix D4. Based on the June 2006 documentation report and NRT's knowledge, the following items differed from the development plan (July 2004, STS):

- Monitoring well and GW-2 and P-2 were damaged during utility construction in 2005. These wells were subsequently replaced (GW-2R and P-2R). Copies of the boring log, well construction report and abandonment forms are provide in the June 2006 documentation report (June 2006, STS), Appendix D4;

- Trench plugs installed within utility trenches exiting the site were constructed of lean concrete on top of bentonite instead of silty clay proposed in the July 2004 development plan. Based on field notes from the City's contractor, a 72" wide by 50" deep notch was made in the vertical barrier west-wing wall and a bentonite trench plug was constructed at the storm sewer penetration;

- Approximately 5,600 tons of contaminated soil was generated during the park construction activities. Based on the landfill disposal tickets in the June 2006 documentation report (June 2006, STS), about 5,300 tons of contaminated soil was transported and disposed at a licensed landfill and remaining 300 tons of soil was reused on-site as fill below the reconstructed cap;

- GCL was utilized instead of 6-inches of compacted clay where soil cap thickness (1.5 feet) could not be obtained due to site consideration. Areas where GCL was placed are shown on the park documentation drawings in Appendix D4; and

- Non woven geotextile was installed in the tree planting areas as a warning layer above the GCL on the east and south side slopes of the pavilion seating area.

Based on the purchase agreement between the City of Oshkosh and WPSC, it is the City's responsibility to maintain the cap and dock wall at the site consistent with the remedial design approved by the WDNR and documented in the *Remedial Action Documentation Report* (February 2003, NRT). An operation and cap maintenance plan was included in the June 2006 documentation report (June 2006, STS). The cap and the dock wall are inspected by the City of Oshkosh on an annual basis during the months of May through August to assess the integrity and effectiveness. In addition to the City's inspections, WPSC continues to conduct annual inspections of the cap (asphalt, concrete and greenspace), vertical barrier wall and components, and the gradient control system components including surface covers for the monitoring wells, dewatering sumps and cleanouts, the treatment system building, and piping and equipment.

4.10 Access Agreements

As part of the sale of the property in December 2003, WPSC and the City of Oshkosh entered into a mutually acceptable access agreement that provides continual site access for WPSC personnel and authorized agents to continue remedy monitoring required by State and Federal agencies, and maintenance of the remedy components. In addition, declaration of a sediment easement was included in the sale of the property to use during future sediment RI/FS activities. However, the declaration was amended in 2006 to revise the original sediment area along the river and to add an area west of Court Street for potential sediment staging area (Appendix D5).

5 POST-REMEDIAL UPLAND INVESTIGATIONS

5.1 Overview

The post-remediation upland investigations focused on:

- Evaluation of groundwater flow and quality within shallow bedrock in the northern portion of the site;
- Assessment of bedrock groundwater quality at depth;
- Assessment of regional influences on shallow bedrock flow, including surface water elevation patterns for Lake Winnebago due its close proximity and influence on local hydrogeology, private and public water well usage and influence on groundwater flow, and site-specific geology, groundwater flow and quality, and related surface water/sediment interactions; and
- Evaluation of groundwater flow and quality within shallow bedrock south of the river.

5.2 Investigation Chronology

Bedrock groundwater investigations completed through 2007 are separated into those performed pre- and post-remediation. Pre-remedial investigations (completed through 2001) focused on determining the magnitude and extent of groundwater contamination beneath the site, as summarized in Section 2. Post-remediation investigations focused on:

- Evaluation of groundwater flow and quality within shallow bedrock in the northern portion of the site;
- Assessment of bedrock groundwater quality at depth;
- Assessment of regional influences on shallow site bedrock flow, including surface water elevation patterns for Lake Winnebago due its close proximity and influence on local hydrogeology, private and public water well usage and influence on groundwater flow, and site-specific geology, groundwater flow and quality, and related surface water/sediment interactions; and

- Evaluation of off-site groundwater flow and quality within shallow bedrock south of the river.

- In February 2001, as requested by WDNR (December 2000, WDNR), monitoring well MW-109 and piezometer P-107 were installed to define the extent of the affected groundwater to the east.

- In October 2001, utilizing February 2001 groundwater data, monitoring well MW-110 and piezometer P-108 were installed in the Broad Street right-of-way to evaluate the extent of the plume east of the MW-109/P-107 well nest.

- In 2004, three bedrock piezometers (P-109, P-110 and P-111) were installed to assess bedrock groundwater flow and quality to the north and south of the former MGP property. Soil samples were not collected from the boreholes. Groundwater samples were collected quarterly for VOC, PAH and weak acid dissociable cyanide (WAD) for the first two sampling rounds, and BTEX, trimethylbenzenes, and PAH thereafter.

Piezometer locations are shown on Figures 3 and analytical data are provided in Tables 2 and 3. Site investigation activities occurred as summarized below.

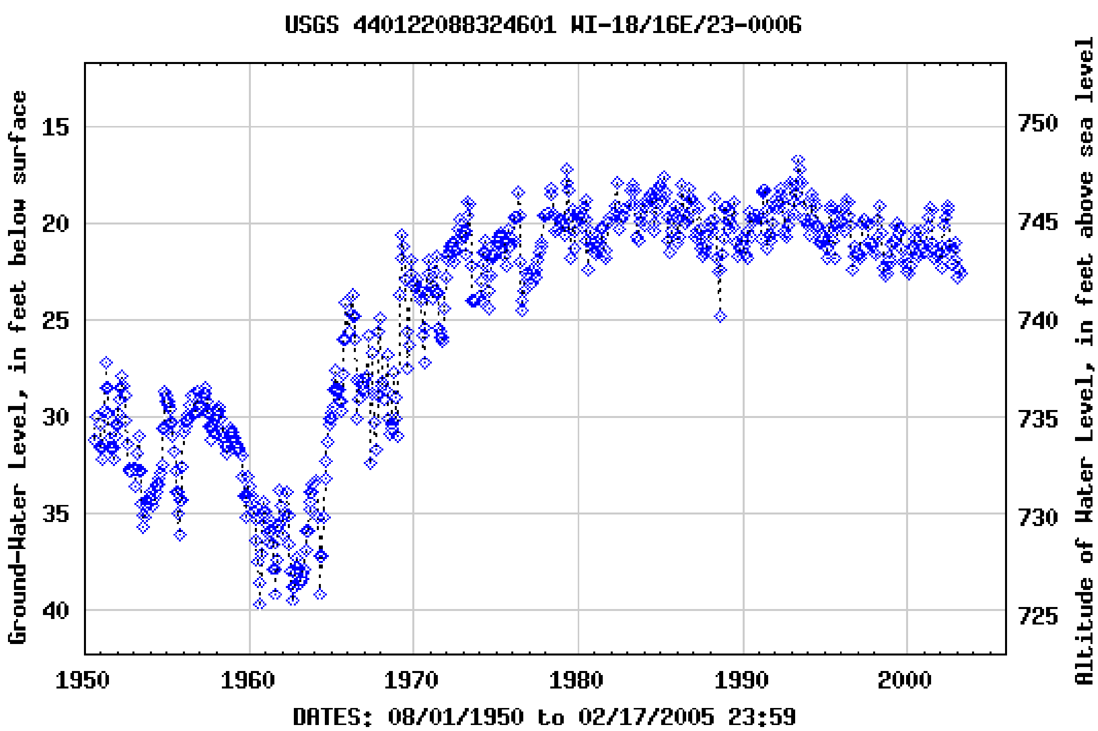
5.3 Potable Wells

To evaluate historic and current groundwater use in the area, well construction, and location information for commercial, private, and public wells located within one mile of the former MGP facility were obtained from the City of Oshkosh Public Health Department, Ms. Kathy Sylvester (WDNR), and from the WDNR Water Well Data Files. Well data are summarized on Figure 8 (Appendix E1) and specific well records are included as Appendix H in the NRT August 31, 2005 report *Operation, Maintenance and Monitoring Semi-Annual Report and Supplemental Bedrock Assessment*. Between 1954 and 1960, three high capacity wells, permitted by the City of Oshkosh, were constructed; one well located 7,500 feet northwest of the former MGP property was permitted to pump 288,000 gallons per day (gpd) and two located 4,000 feet south of the former MGP property were permitted to pump 77,000 gpd. City of Oshkosh records do not provide data on whether these wells are active. A permitted well is located approximately ¾ of a mile northwest of the former MGP property. This well (identified as BH518 by the WDNR) is permitted as a high capacity well (greater than 70 gpm) on WDNR's website; however, it has an approved capacity of only 50 gpm and typically pumps 1,000 gpd from the dolomite bedrock, based on WDNR website data.

5.4 Regional Cone of Depression

A cone of depression within the bedrock aquifer is depicted by Olcott (1966 and 1968). The cone of depression envelopes the entire City of Oshkosh with the outer edge of the cone at an elevation of approximately 740 feet. Regional piezometric surface elevations without influence from pumping indicate an equilibrated system in the Oshkosh area would likely be at an elevation of 760 to 780 feet (Olcott, 1968). Long-term monitoring by USGS indicates that groundwater elevations in the bedrock, illustrated below, have at least partially rebounded since the period of peak pumpage (1950s through early 1960s). The current levels are at least 15 to 35 feet below expected regional piezometric elevations under natural conditions (without influence from pumping).

The hydrograph below shows historic groundwater elevations for a USGS observation well in the sandstone aquifer (elevations after 2003 were not available).



Graph showing historic groundwater elevation in a USGS observation well located 4,600 feet northwest of the Oshkosh MGP and screened in the sandstone aquifer at a depth of 200 feet (See Appendix G for reference datum)

5.5 Investigation Results

5.5.1 Refinements to Site Geological Interpretations

Several refinements to the interpretation of site geology resulted from findings of the sediment and post-remedial upland investigations. Specifically:

- At least 10 feet of lean clay separate shallow fill and the bedrock unit beneath the southwest portion of the former MGP property (Appendix E2, Plate 1 - Geologic Cross Section B-B'). BTEX and PAH concentrations in groundwater samples collected from bedrock piezometers P-103 and P-105 (Tables 3 and 4) are relatively low in this area (discussed below). These conditions suggest little or no vertical migration to bedrock through the lean clay confining layer in the southwest portion of the former MGP property.

- A high point in the dolomite bedrock surface, greater than 720 feet in elevation, occurs beneath the southwest corner of the former MGP property (Appendix E1, Figure 7 and Appendix E2, Plates 1 and 2). Bedrock elevation decreases to the north, east, and south. The lowest bedrock surface elevation encountered prior to 2004 was approximately 702 feet in elevation.

- Bedrock elevations beneath the Fox River range from less than 702 to 723 feet, with the highest elevations adjacent to the aforementioned bedrock high (SB-113), and the lowest (707 feet) with field observed presence of tar in the vicinity of P-107. Of note, bedrock elevations beneath the Fox River are interpreted from refusal of hollow-stem augers (HSA) and not on collection of core samples. These elevations may represent a weathered bedrock surface with competent bedrock present 5 to 10 feet deeper, as interpreted by regional geology references (Olcott 1966 and 1968).

- The north bank of the Fox River extended 20 to 300 feet farther north than the current shoreline from 1890 to at least 1911, during MGP operations (Appendix A1, Sheet C020). Depths of these excavated and filled channels are unknown. Based on soil borings advanced as part of the sediment investigation, hard to very hard clay is present at elevations of 715 to 735 feet indicating the historic depth of the channel ranged from approximately 25 to 35 feet bgs, except in the area of the bedrock high.

- Discontinuous coarse-grained material immediately overlying bedrock (Appendix E1, Figure 5), is hydraulically connected with bedrock, and considered part of the bedrock unit for the site. The majority of the coarse-grained material is present beneath the current riverbed and in areas that were within the river in the late 1800s and early 1900s.

- Piezometer P-111 was positioned to evaluate the base or north wall of the bedrock valley, confirmed to be present beneath the north portion of the former MGP property during the sampling of PZ-109; bedrock is present at an elevation of 684 feet at P-111, defining the north slope of the bedrock valley (Appendix E2; Plate 1). Based on regional bedrock maps, the bedrock tributary valley slopes toward the west. In addition, 19 feet of gravel is present above the bedrock interface at P-111 (Appendix E2, Plate 1).

5.5.2 Groundwater Flow

5.5.2.1 Shallow

Post-remedial shallow groundwater flow is related to performance of the groundwater remediation system, it is described in Section 6.

5.5.2.2 Bedrock

Potentiometric surface elevations from 2003 through 2007 indicate that the river is a line source for groundwater recharge to the dolomite beneath the Site. Potentiometric surface data south of the river were not available to NRT, other than in regional groundwater flow maps (Olcott 1966 and 1968). These maps depict a cone of depression north of the river, with a small portion of the cone extending south of the river. Historic groundwater elevation data indicate a cone of depression was present within the shallow bedrock of the Oshkosh area resulting from industrial pumpage of the Galena-Platteville dolomite and the underlying sandstone aquifer. As noted earlier, water levels in the Oshkosh area have begun to recover since the referenced regional map was produced in the mid 1960s.

Potentiometric surface elevation changes observed in the bedrock piezometers are attributed to changes in regional groundwater withdrawals and river elevation, rather than effects of groundwater extraction in the shallow unit. This observation is based on the continuity of the lean clay and gravelly lean clay confining units, which separates the shallow fill from the shallow bedrock unit and the similar correlation of bedrock groundwater elevations to surface water elevations (for piezometers along the river both close to and distant from the groundwater extraction zone).

5.5.3 Groundwater Quality

5.5.3.1 Shallow

Post-remedial shallow groundwater quality is described in Section 6.

5.5.3.2 Bedrock

Concentrations of MGP-related constituents are predominately decreasing (see table below) in all piezometers where exceedances historically occurred (Figure 4 and Tables 2 and 3). The extent of groundwater concentrations exceeding groundwater quality standards has been defined with the exception of the southeast portion of the former MGP property and adjacent to the 1903 Fox River shoreline (P-107R), where concentrations of Bap, BbF, chrysene, naphthalene, and benzene continue to fluctuate above NR140 ESs; although total PAH and BTEX concentrations have declined.

Well	Trend	Sample Year(s)	BaP, BbF, Chrysene	Naph-thalene	PAH, Total	Benzene	Ethyl-benzene	BTEX, Total
Shallow Bedrock Unit Piezometer (Bottom of Screen at 720 feet)								
P-103	Declining Highest in 01-04	93 – 05	PAL / ES	nd /--/PAL	0.9 - 44	PAL/ES	--	4.5 – 158
		06 – 07	nd	-- / PAL	38 – 53	ES	--	15 - 27
Bedrock Unit Piezometers (Screen Elevations 696 - 711 feet)								
P-106	Fluctuating Highest in 07	96 – 06	PAL/ES	--	nd - 16	--/PAL	--	nd – 24
		07	ES	--	16	PAL	--	3
P-104	Declining - Highest in 01 / 02	96 – 03	--/PAL/ES	nd/--	nd - 5.4	--/ES	--	nd – 190
		04 – 07	nd/PAL	nd/--	0.1 - 1.0	--	--	nd - 0.5
P-105	Declining	96 – 03	ES	--	1.1 - 19.2	ES	--	nd – 32
		04 – 07	PAL / ES	--	0.4 - 5.4	--	--	nd - 0.4
P-107 / P-107R	Fluctuating / Declining Highest in 03	92 – 04	-- / ES	-- / ES	290 - 4,880	ES	PAL/ES	213-4,561
		05 – 06	--	--	137 - 499	ES	PAL	161-401
		07	ES	ES	1,375	ES	PAL	478
P-108	Declining	98 – 02	--	PAL	9.9 - 152	ES	--	8 - 166
		03 – 07	--	--	4 - 33	--/PAL / ES	--	1.1 - 24
Deeper Bedrock Unit Piezometers (Top of Screen Below 685 feet)								
P-109	Declining, low concentrations	04 – 07	nd / PAL (05)	--	0.1 - 1.1	nd / PAL (04)	--	nd - 2.8
P-110	Declining, low concentrations	04 – 07	PAL	--	0.03 - 1.1	nd / PAL (04)	--	nd 3.5 (04)
P-111	No PAL / ES Exceedances	04 – 07	--	--	0.1 - 3.9	--	--	nd 0.7 (04)

Note: All concentrations in µg/L
--: Constituent concentrations below NR 140 PAL and ES
nd: not detected above minimum detection limit

5.5.4 Bedrock/Sediment Interface Assessment

One or more potential migration pathways may have contributed to the presence of coal tar at the bedrock interface (Appendix E1, Figure 9). A complete discussion of sediment conditions is provided in the *Revised Sediment Investigation Report*, dated August 22, 2005. An overview and assessment of the potential pathways is provided below:

- Migration of historic surface/shallow subsurface discharges from the former MGP property to the shallow and exposed bedrock areas near the river: Residual MGP tar and groundwater are now contained in the shallow unit within the existing containment system.

- Residual migration along the gravel/weathered bedrock interface: The ongoing groundwater monitoring program indicates that the highest concentrations of BTEX and PAH are at the bedrock interface near the river. As depicted on Figure 9 in Appendix E1, movement of trace tar and dissolved phase constituents by either gravity or hydraulic flow through the weathered bedrock is possible where the confining clay is thin or absent. This last pathway is discussed further below, as it relates to the bedrock/sediment interface.

The highest concentrations of BTEX and PAH compounds in bedrock have been observed beneath the southeast portion of the Site at piezometer P-107/P-107R where the lean clay is thickest along the north river bank (approximately 32 feet) and the bedrock surface is lowest (Appendix E2, Plate 2-Geologic Cross Section D-D'). Trace tar was observed in the deep sand and gravel immediately overlying bedrock at P-107. It is unlikely that tar migrated downward through the 32 feet of lean clay separating the shallow and bedrock units in this area. However, the confining layer is thin or absent beneath the river (Appendix E2, Plate 1). These observations, particularly the absence of a significant confining layer in the river channel, lead to the conclusion that the river channel is a likely historic migration pathway to bedrock, both for tar and for BTEX and PAH compounds. Furthermore, low concentrations of BTEX and PAH compounds in the inland monitoring wells (P-106 and P-104) suggest that migration in the dolomite is very slow, either because the compounds are degrading and/or because the formation has low hydraulic conductivity.

Since tar and groundwater in the shallow unit are now contained, there is little potential for the addition of new source material to the bedrock. This suggests that concentrations will not increase above current levels, and may begin to decrease. However, the rate of decrease may be slow due to the characteristically low hydraulic conductivity of the dolomite bedrock (Olcott, 1966).

5.6 Summary of Findings

A discussion of post-remedial groundwater flow and quality in the shallow zone is presented in Section 6. The following findings focus on bedrock conditions, based on geologic and groundwater quality data collected through 2007:

- Groundwater flow in the bedrock north of the river is away from the river toward a cone of depression;

- Groundwater flow in the shallow unlithified unit is separated from flow in the dolomite by a continuous layer of lean clay and gravelly lean clay, and there continues to be no evidence of significant hydraulic connection between these units in the upland portion of the site;

- MGP residual related constituent concentrations that exceeded Wisconsin groundwater standards have generally decreased in the bedrock piezometers with the exceptions of P-107R. Concentrations in this piezometer continue to fluctuate, with the highest concentrations recorded to-date observed from 2003;

- The extent of MGP residual related constituent concentrations in shallow bedrock has been defined downgradient (north) of P-103; and

- The extent of MGP residual related constituent concentrations in bedrock has not been defined downgradient of P-107R.

Primary potential migration pathways for movement of tar or dissolved phase MGP residuals to the river have been addressed. A secondary pathway via the connection between bedrock and the river bed tar may exist where the lean clay confining layer is thin or absent. Because inputs to river sediments have been addressed, concentrations of dissolved BTEX and PAH compounds in the bedrock are not expected to increase, and may decrease over time, although that decrease may occur over a long period since migration rates in the bedrock appear to be slow.

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6 POST-REMEDIAL PERFORMANCE MONITORING RESULTS

6.1 Overview

Startup of the gradient control system was conducted on October 24, 2002. NRT has documented the system's performance from October 24, 2002 to December 31, 2006 in the "Operation, Maintenance, and Monitoring Reports", dated September 19, 2003, February 9, 2004, August 30, 2004, August 31, 2005, June 8, 2006, and February 7, 2007. The following performance monitoring activities are conducted at the site:

- Groundwater monitoring is conducted annually via bailer sampling method. The groundwater-monitoring network currently consists of a total of 27 wells, as indicated on Table 6. Groundwater samples are analyzed from 10 monitoring wells and 9 piezometers for BTEX, TMB, and PAH. Four of the piezometers (P-2R, P-4, P-102R and P-101) are pending agency approval for abandonment, as discussed below, and water levels only are collected from four monitoring wells (MW-108R, GW-2R, MW-101R and OW-4);

- Quarterly water levels are collected from all monitoring wells, piezometers, dewatering sumps, and the river staff gauge;

- Field measured parameters (temperature, field conductivity, pH, dissolved oxygen (DO), and oxidation/reduction potential (ORP)) are collected annually from the 10 monitoring wells and 9 piezometers;

- Operation and maintenance of the biosparge system is conducted at least monthly by WPSC field employee and quarterly by NRT/WPSC personnel. Effluent sample is collected quarterly and a composite influent sample from all dewatering sumps is collected semi-annually from the treatment system; and

- An annual site inspection is completed to assess the condition of the remedy components.

The system's performance from January 1 to December 31, 2007 is detailed below.

6.2 Containment Performance

The objective of the containment system is to prevent outward migration of MGP affected groundwater. This is achieved by pumping groundwater within the barrier and maintaining an inward hydraulic gradient. To demonstrate gradient control, two performance measures have been identified:

- Primary Measure: Evaluation of groundwater elevation data; and
- Secondary Measure: Evaluation of contaminant (primarily benzene and naphthalene) concentration trends in the shallow groundwater monitoring wells exterior to the containment barrier.

Depth to groundwater was measured in each well prior to collection of groundwater analytical samples during the September 2007 monitoring event. Field notes from the monitoring event, as well as March, June, September and December system maintenance visits are included as Appendix F1. Shallow groundwater elevation data are summarized in Table 1 and water table elevation contours based on November 2007 data are presented on Figure 3. The groundwater flow map indicates a cone of depression centered around the dewatering sumps located in the center of the site, indicative of inward hydraulic gradients and plume containment within the vertical barrier wall.

Additionally, concentrations of benzene and naphthalene are decreasing or stable in shallow monitoring wells exterior to the containment zone (GW-4, GW-1, and MW-110; Figure 3 and Tables 2 and 3). Laboratory analytical reports are included as Appendix F2.

Benzene, toluene, ethylbenzene and xylene (BTEX) concentrations continue to be below their respective NR140 Preventive Action Limits (PALs) at all exterior monitoring wells except for benzene at GW-1, which remain below NR140 Enforcement Standard (ES). PAH concentrations in the exterior monitoring wells are below NR 140 ESs except for benzo(a)pyrene [BaP], benzo(b)fluoranthene [BbF] and chrysene at MW-110, and chrysene at GW-1. At GW-4, BaP, BbF, and chrysene were detected at concentrations above their respective PALs. Future monitoring of GW-4 will continue for evaluation of contaminant concentrations downgradient of GW-1.

6.3 Gradient Control System Performance

6.3.1 Operation and Maintenance

NRT and WPSC receive a weekly fax from the treatment system notifying that the system is working and indicating whether an alarm is activated. Should an alarm arise, an additional fax is sent to NRT and WPSC notifying which alarm is activated. Alarm conditions may include, but are not limited to, differential pressure between bag filters greater than 10 psi, high pressure of the compressor, low pressure of the compressor, high compressor temperature above the factory pre-set limit, and high building sump water level. During this reporting period, the alarms were for bag filter replacement and equipment room low temperature. The thermostat in the equipment room was not operating properly and subsequently has been replaced.

Operation and maintenance of the treatment system is completed at least monthly by a WPSC dedicated field employee and quarterly by NRT/WPSC personnel (quarterly field notes included in Appendix F1). Operation and maintenance includes:

- Monitoring influent and effluent contaminant concentrations;
- Monitoring for any dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) in respective accumulation tanks;
- Monitoring for any sediment accumulation in the transfer tank and the multi-phase separator;
- Monitoring compressor, bag filter and air stripper pressure readings;
- Inspection and cleaning of air stripper diffusers;
- Bag filter changes;
- Compressor oil and air filter changes; and
- Monitoring all dewatering pump pressure readings and flow rates.

The groundwater extraction and treatment system operated 90 percent of the time between January 1 and December 31, 2007. Dewatering sump groundwater elevations and system operational data is summarized in Table 4. To maintain the gradient control at a reduced discharge rate, DS-2 was not operated during this reporting period and has been inactive since April 28, 2005. DS-1, DS-3 and DS-4 did not operate between sometime after September 11 and October 4, 2007, due to leaks in the air and water lines, and location of the pumps which were too close to the bottom of the sump as noted during a monthly site visit. The lines were subsequently repaired as noted in Table 4. During a site visit on October 12, 2007, DS-1 and DS-4 were not operating properly, due to leaks in the air lines. The lines and pump locations were subsequently restored and were returned to operation on October 12th. Meanwhile, pump DS-3 continued to operate and maintain gradient control during this time period (October 4 through October 12, 2007).

On November 20th during a monthly site visit, DS-1 pump was not operating. The pump was removed from the sump and DS-2 pump was placed in the DS-1 sump temporarily until the DS-1 pump could be inspected and repaired. WPSC personnel inspected DS-1 pump in December 2007. The pump appeared to be in working condition; it is assumed that the issue may have been the result of a faulty hose connection.

No free product accumulated in the DNAPL or LNAPL collection tanks during the reporting period. Based on the effluent flow meter, about 1,970,000 gallons of contaminated groundwater were extracted and treated prior to sanitary sewer discharge. As discussed in the 2005 annual report (June 2006, NRT), contaminant mass removal was not calculated during this period since the primary objective of the system is gradient control.

In June and September 2007, a composite sample was collected from each dewatering sump except DS-2 since the pump has been turned off since April 28, 2005. Effluent samples were collected once per quarter (March, June, September, and December 2007). All effluent sample results for this reporting period are below the City of Oshkosh discharge limits (Table 5). Influent and effluent samples will continue to be collected in 2008. Treatment system analytical laboratory reports are provided in Appendix F2.

6.3.2 Shallow Groundwater Quality

Monitoring wells within the containment zone sampled during the annual September 2007 event include MW-102, MW-104, GW-3, OW-3R, GW-2R, MW-103, OW-1, and MW-109R.

Of note during the September 2007 event:

- BTEX and PAH concentrations at well MW-102 are decreasing.
- Naphthalene and benzene concentrations generally were within the order of magnitude previously reported at each well within the groundwater containment zone, with the exception of MW-109R in which naphthalene and benzene concentrations were an order of magnitude lower, and the lowest concentrations since 2001.
- Contaminant concentrations detected in wells near the edge of the containment zone (MW-103 and MW-104) and upgradient (OW-1) are below NR140 ESs for all PAH and BTEX compounds except at MW-104. Concentrations of BaP, BbF, and chrysene exceeded their respective ESs at MW-104; but remain within the range of those previously reported.

6.4 Other Remedy Components Performance

WPSC is responsible for long term performance monitoring of additional remedy components including surface covers for the monitoring wells, dewatering sumps and cleanouts, the treatment system building, and piping and equipment. These features were most recently inspected in June 2007. Based on the purchase agreement between the City of Oshkosh and WPSC, it is the City's responsibility to maintain the cap and dock wall at the site consistent with the remedial design approved by the WDNR and documented in the *Remedial Action Documentation Report* (February 2003, NRT).

On June 20, 2007, NRT inspected the cap (asphalt and earthen) and dock wall in addition to the inspection of the other remedy components (i.e. monitoring wells, and dewatering sumps and cleanouts) concurrent with an operation and maintenance visit. The cap and dock wall appear to be in good condition except for soil that is exposed around piezometers P-103 and P-105. A copy of the Earthen Cap Maintenance Inspection Log is included in Appendix F3.

Also during the 2006 inspection activities, the protective covers on monitoring wells MW-104R, MW-102 and P-104 could not be properly closed; therefore, during the June 2007 site visit, new flushmounts and surface seals at these monitoring well were installed. In addition, flushmount cover bolts and well caps were replaced on several monitoring wells.

6.5 Proposed Piezometer Abandonment

As stated in the bedrock report (August 31, 2005, NRT), abandonment of P-4 and P-101 is recommended. In addition, NRT recommend abandoning P-2R and P-102R in the 2005 OM&M report (June 2006, NRT). All four piezometers (Figure 3, Appendix F4) are screened within the intermediate silt/clay zone. Collection of groundwater samples and elevation data within this intermediate silt/clay is not necessary for the following reasons:

- There were no PAL exceedences in P-101 and P-4 since March 2002 and March 2003, respectively and groundwater is adequately characterized in these areas by other wells;
- P-102R does not appear to monitor vertical migration of the contaminants of concern, because the BTEX and naphthalene concentrations in shallow well OW-3R, which is nested with this well is lower. Rather, concentrations in P-102R likely reflect historical activities and the alignment of historic shorelines at the Site, as shown on Figure 2;
- Hydraulic conductivity of the clay is significantly lower than the overlying and underlying units. There is no appreciable vertical flow through this unit and it does not provide a hydraulic connection between the overlying and underlying units; and
- Vertical extent of the affected groundwater is defined using wells screened in the bedrock beneath the intermediate zone.

6.6 Future Groundwater Monitoring

Groundwater monitoring will continue on an annual basis to evaluate water quality at the Site and to monitor performance of the remedial actions performed. In 2008, groundwater samples will be collected from all wells that do not contain free product and analyzed for BTEX, TMB and PAH with the exception of MW-108R, GW-2R, MW-101R, and OW-4 (Table 6). MW-108R, GW-2R, MW-101R, and OW-4 are within the containment system and/or in close proximity to other monitoring wells, and therefore do not provide significantly unique data. Water levels will be measured at each well prior to sampling. Water levels will continue to be collected quarterly in the shallow wells within and exterior to the containment system including MW 101R, GW-2R, MW-108R, and OW-4 (Table 6). Piezometric surface elevations will be measured in all the piezometers on an annual basis (Table 6).

WPSC/NRT will continue to inspect the cover and vertical barrier system annually and subsequently provide observations of deficiencies in the cover and barrier system to the City of Oshkosh since they are responsible for maintenance of these systems.

The treatment system will continue to be monitored and maintained monthly by a WPSC representative. Groundwater effluent samples will be collected, in conformance with the discharge permit, on a quarterly basis and analyzed for BTEX, PAHs, and total cyanide. Total suspended solids will be analyzed on a semi-annual basis (Table 6). A composite influent sample from all operating extraction trenches will be collected on a semi-annual basis and analyzed for BTEX, PAHs and total cyanide (Table 6). A record of laboratory data will be maintained by WPSC and the effluent data will be made available to the City of Oshkosh as requested, per the discharge permit.

On-going annual reporting of the treatment system operations and groundwater quality will continue in accordance with the draft Master Schedule Submitted to the USEPA on May 19, 2006 or as revised in the Site-Specific Work Plan to be submitted.

7 IDENTIFIED PATHWAYS AND CONCLUSIONS

7.1 Exposure Pathway Analysis

As discussed previously in this Completion Report, remedial actions have been performed on the former MGP facility.

Exposure pathways addressed by the remediation work performed to date include:

- Soil direct contact and migration to groundwater pathways: Protection of human health from direct contact with contaminated soil and from soil contaminant migration to groundwater have been addressed as a result of contaminated soil excavation, thermal treatment, backfilling, placement of an earthen cap, and additional direct contact barriers installed to date (i.e., pavement, buildings); and

- Groundwater to surface water pathways: Protection of human health from ingestion of groundwater to surface water/seeps has been addressed as a result of installing the sheet pile barrier wall.

These and other media/pathways identified by the multi-site CSM are discussed below with respect to remaining soil and groundwater quality at the site.

7.1.1 Surface Soil

Surface soil conditions on-property and Court Street right-of-way are protective of direct contact given the extent of contaminated soils have been thermally-treated and placed at least one-foot below ground surface. Remaining contaminated soils are either below the earthen cap or pavement, as discussed in Section 5. These actions combined with long-term performance monitoring of the remedy components are protective of human health for direct contact concerns, but rely on risk management tools for long-term protection. Institutional controls to maintain the cap were contemplated as part of remedial actions, but have not been formalized. Potential ecological receptors will be evaluated as part of the Site-Specific Work Plan.

7.1.2 Subsurface Soil

Potential human health concerns with subsurface soil conditions include construction worker exposure. As noted above and detailed in Section 5, the former Oshkosh MGP property has undergone extensive subsurface soil remediation and installation of a vertical barrier wall to contain the MGP-affected soil. Risk management tools are also required to maintain the cap and provide notification for construction workers that may be in direct contact with subsurface soils or have potential inhalation exposures.

Potential ecological receptors will be evaluated as part of the Site-Specific Work Plan.

7.1.3 Groundwater

Soil excavation/treatment followed by installation of the sheet pile barrier wall (primary remedy), and installation of the gradient control system, address protection of groundwater quality. A network of water table monitoring wells is in place both inside and outside the containment system. Bedrock groundwater quality is generally characterized, except at P-107R. As described in Section 5.3, potable wells are permitted within approximately ¾ mile from the former MGP. On-going groundwater monitoring and system operation, maintenance and monitoring minimize the potential risks due to shallow groundwater under the present groundwater use conditions, along with the results of on-going groundwater monitoring, there does not appear to be a significant exposure pathway due to groundwater. However, risk management tools may be warranted for future use scenarios.

7.1.4 Sediments

MGP residuals in the channel have likely migrated via preferential pathways from the upland portion of the site. Primary migration pathways involving direct inputs to river sediments were addressed by upland remedial actions. Further evaluation of the occurrence of MGP residuals within gravel/bedrock and potential for dissolved phase migration both north and south of the river is in progress. Potential human health exposures would be limited to recreational use. Potential ecological exposures evaluated as part of the Site-Specific Work Plan.

7.2 Summary of Additional Data Needs

Areas and media that need further assessment and/or were not fully addressed by previous work with respect to public health, welfare or the environment are summarized as follows:

1. Soil Quality (Subsurface)

   a. Risk Management Tools. Risk management tools are required for the Site to protect potential damage to the remedy components and minimize potential exposure to human health receptors. Risk management tools may be considered along Court Street and within the former MGP property.

2. Groundwater Quality

   a. Continued Monitoring. Continued monitoring of the existing monitoring well network, barrier wall, and gradient control system is warranted in the near-term to confirm containment of MGP residuals and to evaluate whether continuing pre-treatment of the groundwater is necessary prior to sanitary sewer discharge.

   b. P-107R. Continued evaluation of groundwater quality in the vicinity of P-107R to confirm bedrock flow direction.

3. Sediment RI/FS. Evaluate further assessment needs, including risk assessment if deemed appropriate, using the multi-site RI/FS Planning Documents.

The above work elements will be incorporated into a Site-Specific Work Plan, to be submitted to USEPA in accordance with the established schedule.

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