F I N A L D R A F T R E P O R T

REMEDIAL INVESTIGATION REPORT

ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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Acronyms, Abbreviations, And Definitions

ADCP	Acoustic Doppler Current Profiler
ADD	Average Daily Dose
ALM	Adult Lead Model
AOC	Administrative Order on Consent
APT	Aquifer Performance Test
AT	Averaging Time
ATSDR	Agency for Toxic Substances and Disease Registry
AVS:SEM	Acid Volatile Sulfides
AWQC	Ambient Water Quality Criteria
BERA	Baseline Ecological Risk Assessment
BETX	Benzene, Ethylbenzene, Toluene, Xylene
bgs	below ground surface
BW	Body Weight
C	Concentration
CBSQG	Consensus Based Sediment Quality Guidelines
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response and Compensation Liability Act
CSTAG	Contaminated Sediment Advisory Group
COPC	Chemical of Potential Concern
cm/sec	Centimeter Per Second
CR	Cancer Risk
CSM	Conceptual Site Model
CSTAG	Contaminated Sediment Technical Advisory Group
CTE	Central Tendency Evaluation
d.b.a.	doing business as
DNAPL	Dense Non-Aqueous Phase Liquid
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DQO	Data Quality Objectives
DGPS	Digital Global Positioning System
ECCS	Environmental Chemistry Consulting Services, Inc.
ED	Exposure Duration
EF	Exposure Frequency
EM	Electromagnetic Induction
EPC	Exposure Point Concentration
ERA	Environmental Risk Assessment
ES	Enforcement Standard
ESL	Ecological Screening Levels
ESSL	Ecological Soil Screening Levels

f.k.a.	formerly know as
ft.	feet
FS	Feasibility Study
FSP	Field Sampling Plan
gpm	gallons per minute
GPS	Global Positioning System
HEAST	Health Effects Assessment Summary Tables
HHRA	Human Health Risk Assessment
HI	Hazard Index
HMW	Heavy Molecular Weight
HQ	Hazard Quotient
I	Intake
ID	Inside Diameter
IEUBK	Integrated Exposure Uptake Biokinetic Model
IR	Intake Rate
IRIS	Integrated Risk Information System
Koc	Octanol-organic carbon content partition coefficient
L	Liter
L/day	Liters Per Day
LMW	Low Molecular Weight
LNAPL	Light Non-Aqueous Phase Liquid
LSRI	Lake Superior Research Institute
m^3/day	cubic meters per day
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
MCL	Maximum Concentration Limit
MDL	Method Detection Limit
MGP	Manufactured Gas Plant
msl	mean sea level
NAPL	Non-Aqueous Phase Liquid
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NOAA	National Oceanographic and Atmospheric Administration
NOEC	No Observed Effects Concentration
NPL	National Priorities List
NRC	National Research Council
NSPW	Northern States Power Wisconsin

OC	Organic Carbon
OSI	Ocean Services, Incorporated
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbon
PDB	Passive Diffusion Bag
PEC	Probable Effects Concentration
PEF	Particulate Emission Factor
PID	Photoionization Device
ppmv	parts per million-volume
PPRTV	Provisional Peer-reviewed Toxicity Value
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PVC	Polyvinyl chloride
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-based Concentration
RBSC	Risk-based Screening Concentration
RCL	Residual Soil Concentration
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RME	Reasonable Maximum Exposure
ROCs	Receptors of Concern
RV	Recreational Vehicle
SAP	Sampling and Analysis Plan
SAV	Submerged Aquatic Vegetation
SE	Sea Engineering
SEDFLUME	Sediment Flume
SEH	Short Eliot Hendrickson
SEM	Scanning Electron Microscope
SF	Slope Factor
SITE	Superfund Innovative Technology Evaluation
SOP	Standard Operating Procedures
SOW	Scope of Work
SQL	Sample Quantitation Limit
SQT	Sediment Quality Triad
SSA	Sediment Stability Assessment
SVOCs	Semi-Volatile Organic Compounds

TEC	Threshold Effects Concentration
TIC	Tentatively Identified Compound
TOC	Total Organic Carbon
TPAH	Total PAHs
TRVs	Toxicity Reference Value
UCL	Upper Confidence Limit
URS	URS Corporation
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet Light
VF	Volatilization Factor
VI	Vapor Intrusion
VOC	Volatile Organic Compound
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources
WWTP	Wastewater Treatment Plant
µg/L	micrograms per liter
µg/dL	micrograms per deciliter
$\mu g/m^3$	micrograms per cubic meter
µM	micrometer

EXECUTIVE SUMMARY

Site History

The Ashland NSP Lakefront Superfund Site (the "Site") consists of land and sediment located along the shore of Lake Superior, in Ashland, Wisconsin. The Site contains: (i) property owned by Northern States Power Company, a Wisconsin corporation (d.b.a. Xcel Energy, a subsidiary of Xcel Energy Inc. ("NSPW")); (ii) a portion of Kreher Park[1], a City owned property fronting on the bay which includes the former City Wastewater Treatment Plant (WWTP) structure; (iii) an inlet area containing contaminated sediment directly offshore from the former WWTP, and (iv) Our Lady of the Lake Church/School, as well as private residences. The Site is bounded by US Highway 2 (Lake Shore Drive) to the south, Ellis Avenue and its extension to the City marina to the west, Prentice Avenue and its extension to a boat launch to the east, and a line between the north termini of the marina and the boat launch to the north.

The NSPW property, located on an upper bluff fronting on Kreher Park, is the site of a former manufactured gas plant (MGP) that operated between 1885 and 1947. The MGP began as a small producer of gas for street lighting and other residential and commercial uses, and expanded over the next several decades. The plant predominantly employed the carburetted water gas process to manufacture gas.[2] The plant ceased operation in 1947 when the facility was dedicated to propane distribution. Since that time, the property has been used as an electrical repair shop and equipment storage facility first for Lake Superior District Power, followed by its current successor, NSPW.

Kreher Park includes lands formed from the filling of the bay during the late 1800s and early 1900s when the area was the site of major lumbering operations. These operations began in 1884 with the Barber Mill, which shortly changed ownership to the Sutherland Mill and then the Pope Mill over the succeeding 17 years. In 1901, the John Schroeder Lumber Company acquired the property and continued to expand lumber operations and shipping facilities on the lakefront. Schroeder's operations may have included wood treatment. Schroeder ceased

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[1] Kreher Park consists of a swimming beach, a boat landing, an RV park and adjoining open space east of Prentice Avenue, east of the subject study area of the Site. For purposes of this RI report and to be consistent with past documents, the portion of the Site to the west of Prentice Avenue, east of Ellis Avenue and north of the NSPW property is referred to as the "Kreher Park Area" or simply Kreher Park.

[2] LSDP and its predecessor records indicate that the MGP produced water gas exclusively during its tenure. An exception is for the year 1917, when records indicate that less than 15% of the total gas production was recorded as "coal gas." Brown's Directories for the same period (1913 – 1916) records that the Ashland MGP "will construct coal gas plant of 14,000,000 cf (14,000 mcf) capacity per annum." There is no further mention of this facility in Brown's beginning in 1917.

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operation around 1931, but owned the property until 1939. Ashland County then took ownership through a bankruptcy action in 1941, and subsequently transferred the title to the City of Ashland in 1942.

The lakefront property was utilized for the uncontrolled disposal of MGP waste (primarily tar through the ravine). Solid wastes, primarily demolition debris, were disposed along the western side of the property in the 1940s. The City's waste water treatment plant (WWTP) was constructed in the early 1950s, expanded in the 1970s and continued to operate through the early 1990s. Since the City's ownership, numerous construction activities that resulted in substantial filling operations continued. These included the aforementioned waste disposal operation, construction in the early 1950s (and expansion in the early 1970s) of the WWTP, and construction of the City's marina in the mid 1980s. Marina construction included construction of boat slips and the extension of Ellis Avenue, which forms the western boundary of the Site.

In 1989 during exploratory drilling in preparation for another planned WWTP expansion, the City encountered coal tar contamination in the area south of the plant. The City notified the Wisconsin Department of Natural Resources (WDNR). The plant was ultimately relocated southeast of the City. Since the early 1990s, the WWTP has remained dormant. Since that time, the Kreher Park area has been used only for minor recreational purposes (a one-time miniature golf facility) and dry-dock marina boat storage.

The discovery of contaminants at Kreher Park initiated several investigations that culminated in the identification by the WDNR of the former MGP, and the naming of NSPW a potentially responsible party (PRP) for the MGP wastes/contamination at the site. The City of Ashland and an operating railroad were also named as PRPs for solid wastes disposed on their properties, in the mid to late 1990s. The WDNR and NSPW subsequently performed a series of independent investigations to assess the extent of contamination at Kreher Park and the NSPW property, respectively. In 1998 a local environmental group petitioned the United States Environmental Protection Agency (USEPA) to evaluate the Site for scoring on the national priorities list (NPL) for Superfund. The site was nominated in 2000, and formally added to the NPL in 2002. NSPW subsequently signed an administrative order on consent (AOC) with USEPA in 2003 to conduct a remedial investigation/feasibility study (RI/FS) at the Site. The purpose of this program is to fill data gaps identified from earlier investigations, and develop remedial alternatives for the Site. This document presents the results of the first part of the RI/FS process, the Remedial Investigation Report.

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Site Setting

Site geologic conditions have been determined from previous investigations along with supplemental investigations completed during the RI performed during 2005. Historic investigations included the visual classification of subsurface soil units from numerous soil borings, monitoring well boreholes and exploration test pits. Supplemental investigations completed for the RI included the installation of additional monitoring wells, the collection of surface and subsurface soil samples from borings and test pits, and a downhole geophysical survey. Geologic units investigated at the Site include the Miller Creek Formation and underlying Copper Falls Formation. Fill soil units were also encountered at the upper bluff and at Kreher Park. At the upper bluff area, fill soil was encountered in a former ravine that dissected the Miller Creek Formation in the vicinity of the former MGP facility. Kreher Park consists of fill material used to fill the former lakebed.

Hydrogeologic units correspond to geologic units identified during previous phases of investigation. The uppermost water bearing unit at the upper bluff area includes the Miller Creek Formation. Groundwater is also encountered in the fill material used to backfill the former ravine that dissected the Miller Creek Formation in the vicinity of the former MGP facility. The uppermost water bearing unit at Kreher Park consists of fill material used to fill the former lakebed; this fill material overlies the Miller Creek Formation. The fine-grained low permeability Miller Creek Formation creates an aquitard overlying the Copper Falls aquifer, behaving as a confining unit.[3]

Previous investigations have identified groundwater contamination in the ravine fill, the Kreher Park fill and the underlying Copper Falls aquifer. Groundwater contamination in the underlying Copper Falls aquifer is the result of former MGP operations. Contaminants, including free product, migrated to the underlying Copper Falls aquifer in the vicinity of the former MGP facility where the Miller Creek Formation lacks plasticity and where vertical hydraulic gradients indicate downward flow in the Copper Falls aquifer. These migration pathways may have been exacerbated by construction operations during the early life of the MGP. Strong upward gradients have likely limited the vertical migration of contaminants at down gradient locations north of this area. The transition from downward to upward gradients within the Copper Falls aquifer occurs at the alley immediately south of the NSPW service center. Site investigation

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[3] This document utilizes the term "aquifer" when referring to the hydrogeologic conditions in the Copper Falls Formation; similarly, it uses the term "aquitard" when referring to hydrogeologic conditions in the Miller Creek Formation.

results indicate that contaminants in the Copper Falls aquifer have migrated laterally along the interface between the Copper Falls aquifer and overlying Miller Creek aquitard.

The contaminants at the Site are typical manufactured gas plant wastes. These include volatile organic compounds (VOCs) and a subgroup of the larger list of semivolatile organic compounds (SVOCs) referred to as polycyclic aromatic hydrocarbons (PAHs). The most abundant compounds from each of these groups include benzene (VOCs) and naphthalene (PAHs). Soils and groundwater at the Site are contaminated with these compounds, as are the offshore sediments in the affected inlet. Additionally, tar is present as a non-aqueous phase liquid (NAPL or free product) in the upper reaches of the ravine on the NSPW property, at isolated areas at Kreher Park, including the former "seep" area and north of the former WWTP, in an area parallel to the shoreline extending across the historic lakebed northwest of the former WWTP, and in the upper elevations of the deep Copper Falls aquifer.[5] The free-product in the deep aquifer has resulted in a dissolved phase contaminant plume that extends north from the area of the free-product in the direction of groundwater flow, toward the bay. However, the thick clay aquitard (the Miller Creek Formation) provides a hydraulic barrier that separates the deep aquifer from the shallow groundwater beneath Kreher Park and the bay waters in the area of the affected inlet. This separation is demonstrated by the strong artesian pressures measured at Kreher Park wells that are screened in the Copper Falls aquifer.

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NSPW implemented interim removal actions in 2000 and 2002 to mitigate exposure risks to contaminants and to recover free-product from the deep aquifer. A low-flow pumping system currently extracts free-product from the deep aquifer, treating the entrained groundwater before discharging it to the City of Ashland's sanitary sewer. Additionally, NSPW installed an extraction well at the base of the former filled ravine that was the source of the seep discharge at Kreher Park. This extraction well was part of a larger interim action that included excavation of contaminated materials at the former seep area and placement of a low-permeability cap to eliminate the intermittent seep discharge and mitigate environmental exposure of the associated contaminants.

Extent of Contamination

The sources of contamination at the Site consist of discrete free-product zones within each of the four affected areas, which include the upper bluff filled ravine, Kreher Park fill, the affected

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Deleted: are also present, predominantly at Kreher Park in the form of sheens on the water table. Although sheens constitute a regulatory definition of free-product, the VOC levels in groundwater found in samples collected from areas where sheens are present are an order of magnitude below where DNAPLs are found.

[5] Free-product in this description is defined as dense non-aqueous phase liquid (DNAPL), and light non-aqueous phase liquid (LNAPLs).

sediments and the Copper Falls aquifer. These free-product zones are similar in character and contain a light-weight fraction containing VOCs and a heavy-weight fraction containing primarily PAHs. The principal compounds within each of these parameter groups are the VOC benzene and the PAH naphthalene.

The upper bluff/filled ravine has a free-product mass at the base of the ravine. Part of the NSPW building includes an older section incorporating the former manufactured gas plant. The free-product is found at the base of the ravine, which varies in depth from 15 to 20 feet. It has been measured historically from a few inches to nearly 10 feet in thickness.[7] A perched water table has formed within the filled ravine within four to six feet of the ground surface. This is part of the regional water table that extends across the area within the Miller Creek Formation, a low permeability silty-clay/clayey silt that forms the surficial geologic unit underlying the fills in the Ashland area. Soil and groundwater in the filled ravine are contaminated largely by contact/proximity with the free-product mass. The fill is variable consisting of typical MGP wastes including cinders, debris, and other locally derived detritus.

The bulk of the existing mass of free-product in the ravine is located in the area of the former gas holders. Where the former ravine deepens and widens to the north of St. Claire Street, free-product was found along the alignment of a former 12-inch clay tile. This tile extended from St. Claire Street to the mouth of the ravine, and appears to have been a conduit for free-product migration.[8]

A free-product mass is also present underlying the Miller Creek Formation in the same area of the NSPW service center. This material is found within the upper reaches of the Copper Falls aquifer, a sandy, coarse grained unit. Free-product extends from depths of approximately 30 to 70 feet. The greatest thickness of free product is present directly south of St. Claire Street within the main access drive of the NSPW service center. It thins in all directions from this area. Since 2000, NSPW has maintained a free-product recovery system consisting of three extraction wells which have removed over 8,000 gallons of free-product mixed with water from the aquifer.

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[7] Free product has also been found within the confines of former gas holders constructed on the flanks of the ravine south of St. Claire Street. The extent of this material within one former holder was further defined during the Superfund Innovative Technology Evaluation (SITE) demonstration project performed in 2006-2007.

[8] Groundwater samples from wells screened in the ravine north of St. Claire showed an increasing improvement in groundwater quality with distance from the MGP. However, at the seep, located approximately 100 feet northwest of the former mouth of the ravine at the bluff face, free-product was periodically observed as sheens on intermittent surface water discharges. During 2001, the source of the seep was investigated. A buried 12-inch clay tile outfall was identified. This tile was traced through a series of excavations along the base of the ravine to St. Claire Street, the tile was identified as a conduit for the source of this free product

Contaminated groundwater containing the principal VOC and PAH compounds is found in proximity to these free-product zones. However, contaminant migration via groundwater is likely limited. Prior to installation of the 12-inch clay tile the tar from the MGP was likely disposed in the ravine. Following installation of the clay tile much of the tar generated at the MGP was discharged through the tile. Within the filled ravine, contaminant migration in the downgradient direction toward Kreher Park occurred through both the fill as well as the tile that extended along the base of the ravine to its mouth at the historic lakeshore. This discharge was eliminated in 2002 with the installation of an interception well at the mouth of the former ravine The effluent is conveyed to the existing tar removal system for treatment prior to discharge to the sanitary sewer. Within the upper portions of the Copper Falls aquifer, the contaminant mass and dissolved phase plumes are potentially restricted from movement by the natural hydrogeologic conditions. North of the alley behind the service center, the Miller Creek Formation increases in plasticity creating an aquitard to the Copper Falls aquifer. Vertical gradients at nested wells screened in the Copper Falls aquifer indicate strong upward flow. These gradients increase in magnitude with both depth and distance toward Chequamegon Bay. Wells screened in the aquifer north of the bluff face forming the boundary between Kreher Park and the NSPW property are flowing (artesian) wells. Additionally, the aquitard thickens toward the shoreline. This creates a potential stagnation zone and likely restricts further horizontal flow from this area toward the north. In the deeper portions of the Copper Falls aquifer groundwater likely flows beneath Chequamegon Bay. As monitoring wells have not been installed at these depths at the shoreline, it is unknown whether contaminants are migrating with the deep Copper Falls groundwater beneath Chequamegon Bay.

Free-product (DNAPL) is present at the seep area north of the mouth of the filled ravine, and in the immediate area near TW-11 north of the former WWTP at Kreher Park. This material is limited in extent, but is found at the base of the fill/wood waste layer (historic lakebed) which comprises the majority of the filled material at the Park. Contaminated soil and groundwater conditions are widespread across the entire Kreher Park area. Free-product (LNAPL) is located throughout much of Kreher Park. Contaminated fill and groundwater (i.e., the water table) are found at the interface of a relatively clean surficial soil unit two to four feet thick underlain by contaminated wood waste and debris.

Free-product is also present in sediments in the offshore zone along the Kreher Park shoreline, mainly at the sand/wood waste interface (historic lakebed). The greatest mass of material extends between the marina and an area north of the former WWTP from 100 to 300 feet from the shore. Free-product is found at depths up to four feet below the sediment/water interface in this zone.

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A wood waste layer varying from sawdust sized particles to timber is present across the entire affected bay inlet at depths from a few inches to more than six feet covering the majority of the contamination at the historic lakebed. Approximately 95 percent of the impacted sediments underlie this wood waste layer. The greatest wood waste thickness is found at the area east of the WWTP, where the former Schroeder Lumber sawmill operated. Approximately 25,000 cubic yards of wood waste is present in this layer. The bulk of the contaminant mass is found immediately below the wood waste layer at the sediment surface (historic lakebed). However, some contaminants have been measured in samples collected from within the wood waste layer. Contaminated sediments are found across the entire inlet area, but contaminant concentrations decline significantly beyond a line between the north ends of the marina and the boat launch.

Contaminant Sources and Transport Mechanisms

The source of the contamination at the Site was caused by releases from the historic MGP operations with potential addition of contamination from the multiple industrial activities that began in the 1880's and continued until the mid 20th century. Although contaminant sources were no longer active after that time, continued filling activities may have further dispersed these contaminants.

The main source of contamination across the site is from the historic MGP operations.[9] Contamination likely resulted from discharge of waste tars/oils generated from the carbureted water gas manufacturing process. The material accumulated at the base of the ravine fill in the immediate area of the MGP facilities south of St. Claire Street. The migration of this material to the Copper Falls aquifer also occurred where the overlying Miller Creek Formation is less plastic and hydrogeologic conditions allow downward flow conditions and through man made conduits like gas holders and other excavations. This area is south of the alley behind the present NSPW service center. Because the MGP ceased operations in 1947, no further free-product has been added to the environment since this time.

Prior to installation of the 12-inch clay tile the tar from the MGP was potentially disposed in the ravine and discharged to the former lake bed (Kreher Park). Following installation of the 12-

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[9] During its life, the MGP generated over 600,000 gallons of tars as co-product. This volume was calculated from plant capacity measurements and historic operating records. Other wastes generated by the MGP that are not part of this volume were also likely released to the environment. These include ash, coke, clinker, drip oil, liquid scrubbing waste (and other wastewaters) and waste purification sludge.

inch clay tile, the tar from the MGP was disposed through the 12-inch clay tile which discharged to the former lake bed (current bay) through the open sewer system described below.

The source of the free-product at the seep was the buried clay tile at the base of the former ravine. This tile was likely part of a conveyance system installed during the early operation of the MGP. A 1902 City of Ashland ordinance required the underground discharge of MGP wastes, and this pipe may have been installed as a result. However, the free-product mass found south of St. Claire Street indicates this material was released at least in part and not entirely captured by this pipe system. Following backfilling of the ravine,[11] releases of free-product likely continued which were either directly or indirectly captured by the tile. This material migrated to the downstream end of the tile, likely connected to a second tile system identified during the 2005 RI. This tile paralleled the bluff face and was traced to the location of an upstream inlet of a former open sewer identified at the west side of Kreher Park. Once the open sewer was abandoned, free-product then discharged through breeches in the pipe network, such as at the seep.

The source of free product to the sediments likely resulted from a combination of effects. Direct discharges to the lake prior to the filling of "Kreher Park" and later, discharges from the open sewer prior to its filling and abandonment constitute one source. Additionally, the distribution of free product in the sediments indicates other discharge points in addition to the open sewer. It is likely that these sources include other possible historic industrial activities and spills during raw material off-loading. It is also likely that the distribution of this material has been affected by construction and filling activities that continued following cessation of industrial lakefront operations.

The highest levels of VOC contaminants at the Kreher Park are found at areas corresponding to free product zones. These are comparable with levels near other free-product zones at the upper bluff/filled ravine and Copper Falls aquifers. The levels are consistent for both soil and groundwater. Because of the high mobility and high solubility of the VOCs, the high permeability/flat horizontal groundwater gradient has led to widespread VOC contamination in groundwater at Kreher Park. However, these levels are generally an order of magnitude lower than samples collected near the free-product (DNAPL) areas.

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Deleted: These came from upland locations (including the MGP) connected to the open sewer.

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[11] Records indicate the ravine was backfilled to the bluff face by 1909.

In contrast, the soil data from Kreher Park show the opposite relationship regarding PAHs, with an order of magnitude increase in PAH levels across the majority of the Park compared to the upper bluff/filled ravine. The PAHs are less mobile and less soluble compared to the VOCs, degrading more slowly. This chemical behavior combined with the physical characteristics in the fill material have created conditions for the PAHs to remain present and at similar levels in the fill since they were first released. The highest levels are most pronounced in the area of the former coal tar dump. The high levels of PAHs likely originated from the off-loading of fuel feedstocks and other raw materials to support the MGP and possibly other lakefront industrial activities.

Contaminants in the affected sediments likely migrated there via a number of routes over time. One likely route being direct discharge into the former ravine prior to installation of the 12-inch clay tile and another likely route may have been the open sewer when it was functional. Discharges from the clay tile pipe system included material from the MGP. Later activities that were a source of contaminants in sediments along the entire shore line included the coal tar dump and filling activities associated with the initial construction of the WWTP in 1952, subsequent filling activities when the WWTP was expanded in 1973, and when the marina was constructed in 1986.

Human Health Risk Assessment Results

The results of the human health risk assessment (HHRA) indicate that only three exposure pathways result in estimated risk levels exceed USEPA's target risk levels: residential exposure pathways (for soil depths between 0 and 3 feet or all soil depths to 10 feet bgs), construction worker exposure pathway (for soil depths between 0 and 10 feet) and worker exposures to indoor air. These include estimates for the reasonable maximum exposure conditions for potential cancer risks (greater than 10^{-4}), and non-cancer risks (greater than a hazard index of 1). These conclusions are based on exposures to soil in the filled ravine area (for residential receptors) and the Kreher Park area (for construction worker receptors), and to indoor air samples collected at NSPW Service Center. Carcinogenic risks based on average exposure conditions indicate that only the residential receptor exposure to soil (all soil depths to 10 feet bgs) are estimated to be at 1×10^{-4}, the upper-end of the target risk range. Noncarcinogenic risks for the residential receptor (for all soil depths to 10 feet bgs) and risks associated with the construction scenario are within acceptable levels. However, residential receptor exposure to subsurface soil is not expected, given the current and potential future land use of the Site. For this Site, residential risks associated with exposures to surface soil (0 to 1 foot bgs) are within the target risk ranges.

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Deleted: a source unrelated to the MGP. Based on historic information including eyewitness testimony and these data, this source may possibly have been from wood treatment residuals remaining following Schroeder Lumber's tenure on the lakeshore. Another potential source is

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Although the results of the HHRA indicate risks for the construction workers under the reasonable maximum exposure conditions exceed USEPA's target risk levels, the assumptions used to estimate risks to this receptor were conservative and assumed the worst case. Given both the current and future land use of the Site, it is unlikely that construction workers would be exposed to subsurface soil in Kreher Park at depths beyond 4 feet bgs (a typical depth for the installation of underground utility corridors), as most activities associated with the implementation of the future land use would be associated with re-grading, landscaping, and road or parking lot construction. Therefore, risks to this receptor population are most likely overstated.

A hazard index of 3 was calculated for the worker exposure to indoor air pathway under the reasonable maximum exposure conditions. This risk level is likely to be an over-estimate because:

- It was estimated using the maximum detected concentrations as the concentrations at points of exposure.

- It was calculated based on the exposure parameters for the industrial /commercial workers (i.e., .an individual works at the Site for 8 hours per day, 5 days per week, 50 weeks per year for a total of 25 years). The NSPW Service Center is used as a warehouse; there is an office space inside the building, but used only on a part-time basis.

Risks to recreational users (surface soil), subsistence fishers (finfish), waders and swimmers (sediments), industrial workers (surface soil), and maintenance workers (surface soil) are all within USEPA's target risk range of 10^{-4} to 10^{-6} for lifetime cancer risk and a target hazard index of less than or equal to 1 for non-cancer risk.

Baseline Ecological Risk Assessment Results

The baseline ecological risk assessment (BERA) studied nine groups of ecological receptors. The results identified no unacceptable risks to six of these endpoints (omnivorous birds, insectivorous birds, piscivorous birds, omnivorous mammals, insectivorous mammals, and piscivorous mammals). Two of the other endpoints also yielded data that showed no unacceptable risks (fish community and omnivorous aquatic birds); however, the data also showed that contaminants in sediment are sporadically released to the aquatic environment where these receptors are potentially exposed. The final receptor group which was studied included benthic invertebrates. The results of the risk characterization indicated that there are

potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site.

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Summary

The datasets developed since 1995 for the Site are extensive for all media of concern. These datasets are comprehensive and are complete for characterization of the nature and extent of contamination. However, further study during the feasibility study process is recommended in the BERA to address concerns related to potential ongoing impacts to benthic macroinvertebrates, omnivorous aquatic birds and fish. The existing data are sufficient to assess and design the final remedial actions that will be proposed for the subject areas of concern.

1.0 INTRODUCTION

NSPW signed a formal Administrative Order on Consent (AOC) (CERCLA Docket No. V-W-04-C-764) with the USEPA on November 16, 2003 to perform a RI/FS at the Ashland/NSP Lakefront Site. The AOC included a scope of work (SOW) that defined the requirements to conduct a supplemental RI/FS at the Site. The SOW stated that the program was considered a supplemental RI/FS because significant information had previously been developed through prior investigations. The SOW further referenced that the RI/FS was intended to address the USEPA's 2002 Contaminated Sediment Advisory Group (CSTAG) recommendations for the Site, to identify data gaps, and to utilize previous data to the greatest extent practicable. The SOW also stated that risk assessments would be performed in accordance with the most recent USEPA guidance. Risk assessment reports (HHRA and BERA) have previously been submitted.

This Remedial Investigation (RI) Report has been prepared to describe activities completed for the Site in accordance with the approved February 2005 RI Work Plan. The Work Plan was prepared in accordance with the AOC. Since the Site has been the subject of similar groundwater, soil, sediment and air investigation work conducted under State of Wisconsin regulations, the Work Plan addressed data gaps and assessment work required under CERCLA as amended by SARA and the National Oil and Hazardous Substance Pollution Contingency Plan (NCP). This RI Report includes a detailed account of field activities performed during the supplemental RI investigations. In accordance with the SOW, this report utilizes the supplemental RI data and all historic data and information developed for the Site in the assessment of the nature and extent of contamination at the Site.

1.1 Purpose of Report

The purpose of this RI Report is to describe recently completed RI activities and to present results of RI activities along with historic data obtained during previous investigations. Data obtained during the RI along with historic data was used to identify the nature and extent of contamination, evaluate contaminant fate and transport, develop a conceptual site model and evaluate impacts to human health and the environment. Information presented in the RI was also used to evaluate potential remedial responses in the Remedial Action Objectives (RAO) Technical Memorandum included in Appendix A of this report. In addition to this initial memorandum, the following technical memoranda precede the Feasibility Study (FS) and are part of the RI/FS process:

- Alternatives Screening Technical Memorandum
- Candidate Technologies and Testing Needs Technical Memorandum

- Comparative Analysis of Alternatives Memorandum

After submittal of the initial draft RI Report and draft RAO Technical Memorandum, USEPA submitted comments to both drafts. Following discussions with NSPW, the Agency accepted and approved the Candidate Technologies and Testing Needs Technical Memorandum. The associated Treatability Study Work Plan was subsequently prepared and submitted, immediately followed by the Alternatives Screening Technical Memorandum. The sequence for the submittal of these documents was revised to maintain an accelerated schedule for completion of the Feasibility Study.

This revised RI report was submitted following submittal of the later two documents. This revised report will be followed by submittal for review and approval of the Comparative Analysis of Alternatives Memorandum evaluating and analyzing remedial alternatives retained from the Alternatives Screening document. It is anticipated that following USEPA's review of this final technical memo, the draft FS Report will be submitted. Based on the revised schedule, the treatability studies should be completed and the Treatability Study Evaluation Report prepared concurrent with the draft FS. The Agency will then review both documents to allow incorporation of the treatability studies in the Final FS.

1.2 Site Background

1.2.1 Site Description

The Site consists of property owned by NSPW, a portion of Kreher Park, and sediments in an offshore area adjacent to Kreher Park. The Site is located in S 33, T 48 N, R 4W in Ashland County, Wisconsin, shown on Figure 1-1. Existing Site features showing the boundary of the site are shown on Figure 1-2. Figure 1-3 shows the location of the former MGP facility. The location of existing wells is shown on Figure 2-1, and historical soil boring locations are shown on Figure 2-2. Sample locations at the upper bluff area are shown on Figure 2-3, and sample locations at Kreher Park are shown on Figure 2-3.

The NSPW facility is located at the south boundary of the Site at 301 Lake Shore Drive East in Ashland, Wisconsin. The facility is approximately 1,000 feet southeast of the shore of Chequamegon Bay of Lake Superior. The NSPW property is occupied by a small office building and parking lot fronting on Lake Shore Drive, and a larger vehicle maintenance building and parking lot area located south of St. Claire Street between Prentice Avenue and 3rd Avenue East. There is also a gravel-covered parking and storage yard area north of St. Claire Street between

3rd Avenue East and Prentice Avenue. A large microwave tower is located on the north end of the storage yard. The office building and vehicle maintenance building are separated by an alley. The area occupied by the buildings and parking lots is relatively flat, at an elevation of approximately 640 feet above mean sea level (msl). The total area occupies approximately 2.5 acres. Surface water drainage from the NSPW property is to the north. Residences bound the site east of the office building and the gravel-covered parking area. Our Lady of the Lake Church and School is located immediately west of 3rd Avenue East. Private homes are located immediately east of Prentice Avenue. To the northwest, the site slopes abruptly to the Canadian National (f.k.a. Wisconsin Central Limited) Railroad property at a bluff that marks the former Lake Superior shoreline and then to the City of Ashland's Kreher Park, beyond which is Chequamegon Bay.

The impacted area of Kreher Park consists of a flat man-made terrace (lake bed fill) adjacent to the current Chequamegon Bay shoreline. The surface elevation of the park varies approximately 10 feet, from 601 feet MSL, to about 610 feet MSL at the base of the bluff overlooking the park. The bluff rises to an elevation of about 640 feet MSL, which corresponds to the approximate elevation of the NSPW property. The lake elevation fluctuates about two feet, from 601 to 603 feet MSL. At the present time, the park area is predominantly grass covered. A gravel overflow parking area for the marina occupies the west end of the property, while a miniature golf facility formerly occupied the east end of the site. The former City of Ashland WWTP and associated structures front the bay inlet on the north side of the property. The impacted area of Kreher Park occupies approximately 13 acres and is bounded by Prentice Avenue and a jetty extension of Prentice Avenue to the east, the Canadian National Railroad to the south, Ellis Avenue and the marina extension of Ellis Avenue to the west, and Chequamegon Bay to the north.

The offshore area with impacted sediments is located in an inlet created by the Prentice Avenue jetty and marina extensions previously described. Contaminated sediments are primarily located in the inlet bounded by the northern edge of the line between the Prentice Avenue jetty and the marina extension. Contaminated sediment levels may decline beyond this boundary. The affected sediments consist of lake bottom sand and silts, and are overlain by a layer of wood chips, likely originating from former lumbering operations. The wood chip layer varies in thickness from 0 to seven feet, with an average thickness of nine inches. Approximately 25,000 cubic yards of wood material comprise this layer. Based on current data, the entire area of impacted sediments encompasses approximately ten acres. Section 4.4 includes a detailed description of the nature and extent of sediment contamination.

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1.2.2 Site History

Historically, Chequamegon Bay has been utilized as a vital transportation route for the shipment of various materials to and from Ashland including iron ore, lumber, pulp and coal. During the late 19th and early 20th centuries, Ashland was one of the busiest ports on the Great Lakes. In recent times, the shipping volume through the bay has declined because of the deterioration in the mining and lumber industries in the region.

The MGP

At the upper bluff, a former MGP was located at the NSPW property. The former MGP building has been incorporated into the main service facility, a block long "U" shaped building fronting on St. Claire Street. The former MGP building comprises the eastern one-third of the service facility. The former MGP operated as a manufacturer of water gas and carburetted water gas between 1885 and 1947.

The MGP's ownership during its life included the following: Ashland Light, Power and Street Railway Company (1887 – 1922); Lake Superior District Power Company (1922 – 1986) and NSPW (1986 - Present). The MGP operated as a water gas facility during its entire life. Early water gas operations included Lowe and Moses processes. There is some conflicting information regarding coal gas and water gas production during the 1917 ledger entries in the Ashland Light, Power and Street Railway Company records. The State of Wisconsin Railroad Commission reporting documents for this MGP also indicate that coal gas was produced in the 1918 report. However, all other company records indicate water gas production only.[12] Between 1923 and 1947, only the carbureted water gas process was used at the facility.

With the exception of partial production records, there are virtually no operations details available for the Ashland MGP. However, all the water gas processes used at MGP's involved heating coke or coal in a closed vessel or retort into which steam was injected, producing a flammable mixture of methane and carbon monoxide. Petroleum products were then sprayed into the mixture, creating another reaction in which petroleum (fuel oil) was "cracked" to form methane. This methane increased the heating and lighting value of the gas.

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[12] Brown's directories indicate "oil" between 1912 and 1916 and "oil and coal" between 1917 and 1920 as the gas production process. This conflicts with the company ledger information which, with the exception of a small amount of coal gas production during 1917, indicates water gas production only. A detailed history of the gas production process of the MGP, along with the production and disposition of tar from the plant, is included in Appendix D of the D&M March 1999 Ashland Lakefront Site Feasibility Report.

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A dense liquid (tar) would condense from the gas at various stages during its production, purification and distribution. Tars were separated from the water phase by simple gravity separation, typically in pits described as tar wells (a tar well was removed from the former Ashland MGP during the 1980's). This tar was sold, reused as fuel or discarded as waste. Despite efforts at reuse, recovery of tar was incomplete. Separators could not fully separate the tar from the water, especially when the two liquids existed as an emulsion. These emulsions were likely discharged to the environment. Tars also typically leaked and overflowed from storage and processing facilities.

After 1947, the carbureted water gas process was retired in favor of liquid petroleum (propane). During the entire time gas was manufactured, tars were produced as a normal co-product. Based on extensive gas production records and the aforementioned records on tar, including Brown's Directories of Gas Statistics and Wisconsin Railroad Commission operating reports, it is estimated that over 600,000 gallons of tar were produced during the MGP's life. Other wastes generated by the MGP that are not part of this volume were also likely released to the environment. These include ash, coke, clinker, drip oil, liquid scrubbing waste (and other wastewaters) and waste purification sludge. Limited records also indicate that the tar product was sold and also used on site for energy recovery after 1939.[13]

During the early tenure of the MGP, a currently filled ravine was open and trended north across the site from Lake Shore Drive to the bluff overlooking the bay. The head of this ravine began at Lake Shore Drive near its intersection with 3rd Avenue West, and trended north and west across the NSPW site where it opened to the former bay shoreline at the bluff face. The maximum depth of the ravine at its mouth was about 30 feet. Historic Sanborn maps indicate the ravine was filled from south to north, and by 1909 the entire ravine was filled nearly to the surrounding grade. Many of the MGP apparatus were constructed in or adjacent to the ravine.

The Ashland Lakefront

The Kreher Park area is reclaimed land of which the south boundary defined the original lake shoreline. Beginning in the mid to late 1800's, this area was filled with a variety of materials

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[13] In the State of Wisconsin during the life of the MGP, the Wisconsin Railroad Commission regulated MGP operations. An annual report of gas production records was required. Although the records are incomplete, from the year 1909 through 1922 either no record or "NONE" was recorded under tar collection. In 1938 "NONE" was recorded. The first record of tar being collected and sold is in 1939 (the Brown's Directory also notes only three years of tar production records, in 1939, 1941 and 1944).

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including slab wood, concrete, demolition debris, municipal and industrial wastes and earthen fill that created the land now occupied by the park. The filled area was used for lumbering and sawmill activities by a number of lumber companies that included the following:

- The Barber Mill (1884 – 1887),
- the W.R. Sutherland Mill (1887 – 1897),
- Pope Lumber (1897 -1901), and
- John Schroeder Lumber (1901 – 1939).

The lumbering and sawmill activities occurred during the deforestation of the northern portion of Wisconsin around the turn of the century. Timber was also cut in the Apostle Islands and the Arrowhead region of Minnesota, and logs were floated across Lake Superior and Chequamegon Bay into the Ashland area. The John Schroeder Lumber Company was the longest tenured of the mills at the Site with extensive operations across present-day Kreher Park.

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The John Schroeder Lumber Company ceased mill operations in the early 1930's and was dissolved in the late 1930's. Ashland County took possession of the property in 1941. In 1942, Ashland County transferred title of the land to the City of Ashland. Anecdotal information and eyewitness testimony indicates that the area was vegetated at this time, and there may have been a ponded area of a black tarry substance during at least a portion of this time interval. A 1953 record drawing prepared by Greeley and Hanson Engineering (the design engineer for the City of Ashland's original WWTP) indicates a "Tar Dump" was present at this time. Information also indicates that the property was used as a "dump" for solid waste, fly ash, and dredge spoils by property owners, residents, and the United States Army Corps of Engineers.

In 1951, the City of Ashland constructed the (now former) WWTP at the Site. It expanded the plant in the early 1970s, and continued to operate it until 1992. During the mid-1980s, the marina extension of Ellis Avenue was completed to permit establishment of a marina with full service boat slips, fuel and dock facilities and a ship store. [14]

In 1989, during exploratory work to expand the WWTP into the Kreher Park area, contaminated soil and groundwater were encountered by the City of Ashland. The City notified the WDNR, and subsequently closed the WWTP, and built a new WWTP facility a few miles away to the

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[14] Prior to the construction of the marina, the area was a rail boat dock used for offloading freight. This was used for this purpose beginning with the sawmill operations through the marina construction. The boat landing jetty extension of Prentice Avenue has also been used for this purpose for several decades; it was originally the log boom associated with the former Schroeder sawmill formerly located on the site of the WWTP.

southeast.

The Investigation

In 1994, WDNR initiated an investigation and evaluation of the area to characterize the extent of contamination on the property. As a result of this initial work, NSPW was named as a PRP for MGP waste contamination at the Site in 1995.[15] NSPW then began a series of investigations of its property[16]. These investigations identified subsurface contamination resulting from the historic MGP operations. Contamination exists as dissolved phase tar constituents in groundwater and as "pools" of dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) or free product as referred to in this document. Tar/free product has been encountered at the base of the ravine and in the underlying Copper Falls Aquifer. In the ravine, free product varying from one to two feet in thickness is present at the base of the ravine from south of the service facility north to the area of St. Claire Street. In the upper Copper Falls Aquifer, free product has been encountered from south of the service facility north to the gravel-covered parking and storage yard area located north of St. Claire Street. It has also been measured in piezometers installed on the Our Lady of the Lake church property west of Third Avenue East. NSPW installed an interim action free product recovery system on its property to remove free product from the Copper Falls Aquifer during the summer/fall of 2000; the system became fully operational in January 2001. More than 8,000 gallons of free product/water emulsification (approximately 10% oil/tar and 90% water)[17] have been removed, and more than 1,300,000 gallons of contaminated groundwater have been treated between January 2001 and May 2006.

The WDNR independently initiated investigations of the Kreher Park area in 1995, concurrent with NSPW's studies. These included several mobilizations to investigate subsurface conditions at the Park as well as the affected sediments. A distinct free-product pool varying in thickness up to five feet was identified in the area around the "seep"[18] located at Kreher Park just north of the mouth of the former ravine. A 12-inch clay tile pipe that discharged to the "seep" area (located north of the mouth of the buried ravine at the railroad) was encountered at the base of the backfilled ravine during investigations NSPW completed between September and November 2001. The clay tile pipe was traced up the ravine to the area of the MGP as part of these

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[15] In addition to NSPW, WDNR issued similar letters in 1997 to the City of Ashland and Wisconsin Central Limited Railroad (a.k.a. Canadian National Railway) for solid wastes disposed on their properties.

[16] The February 2005 Final Work Plan contains a detailed account of the investigation history.

[17] Test results on this same material also show a characteristic hazardous waste with a flash point < 100°F

[18] The seep area had been the location of intermittent groundwater discharge containing free-product and occasional odor of tar; this discharge was eliminated when NSPW performed the seep removal interim action in 2002.

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investigations. The buried clay tile likely behaved as a conduit for the migration of free product as well as contaminated groundwater from the MGP to the seep area (both dissolved phase and free-product were found in the pipe during the excavations). However, a significant portion of the clay tile was destroyed during the 2001 investigation activities.

This tile may have been part of a sewer system installed in response to a 1902 city ordinance specifying that MGP wastes were to be conducted underground. Although there is no documentation indicating the tile was installed by the owners of the MGP in response to the ordinance, it appears to be contemporaneous to a time prior to the final backfilling of the ravine.

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NSPW performed a second interim action during May 2002 to cap the seep area. Capping the seep was necessary to address a direct contact threat with tar/free product contaminants. Activities completed included the excavation of contaminated soil in the seep area, the placement of a low permeability cap over the seep area, and the installation of a groundwater extraction well installed at the base of the buried ravine. Contaminated groundwater collected near the mouth of the ravine via a fourth extraction well is conveyed to the on-site treatment system described above. (Figure 2-1 shows the location of the extraction wells, EW-1 through EW-4, and the treatment building located on the NSPW property.)

Following the commencement of RI/FS activities for the Superfund investigation in 2005, NSPW was approved to perform a Superfund Innovation Technology Evaluation (SITE) demonstration project through USEPA's technology assessment branch. The demonstration included an evaluation of in-situ chemical oxidation (ISCO) on the free-product mass at the former MGP site. This demonstration was designed to determine if the ISCO process will cause property changes on the free-product mass to improve recovery. The results of this study will be included as part of the Feasibility Study (FS) analyses of remedial options.

1.3 Report Organization

This report includes a detailed site description and site history, a description of completed RI activities, an evaluation of the nature and extent of contamination, an evaluation of contaminant fate and transport, development of a conceptual site model, and evaluation of impacts to human health and the environment. Information presented in the RI was also used to evaluate potential remedial responses in the Remedial Action Objectives Technical Memorandum included in Appendix A of this report. This report is organized as follows:

Section 1.0 Introduction

Introduction

This section describes the purpose of report and Site background, including Site description and Site history.

Section 2.0 Study Area Investigation and Technical Approach
This section includes detailed description of field methods and laboratory methods for the activities completed during the RI.

Section 3.0 Site Physical Characteristics
This section describes the physical characteristics of the Site including regional and Site geologic and hydrogeologic conditions, surface water hydrology, sediment stability, ecology, and demographics and land use.

Section 4.0 Nature and Extent of Contamination
This section describes Site contaminant source areas and nature and extent of contamination in Site soils, groundwater, surface water and sediment, and soil vapor.

Section 5.0 Contaminant Fate and Transport
This section describes contaminant characteristics and persistence at the Site, potential routes of migration and contaminant transport processes, and contaminant distribution and trends.

Section 6.0 Conceptual Model
This section provides a comprehensive interpretation of contaminant sources and present conditions and supports exposure assessments in the HHRA and BERA.

Section 7.0 Human Health Risk Assessment
This section includes a brief description of the human health risk assessment including hazard identification, dose-response assessment, exposure assessment, and risk evaluation.

Section 8.0 Baseline Ecological Risk Assessment
This section includes a brief description of the baseline ecological risk assessment including problem formulation, analysis, and risk characterization.

Section 9.0 Summary and Conclusions
This section includes a summary of Site conditions including the nature and extent of contamination, contaminant fate and transport, and a risk assessment. This section also describes data limitations, recommendations for future work, and recommended remedial action objectives.

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2.0 STUDY AREA INVESTIGATION AND TECHNICAL APPROACH

Data gathered to address the data needs during the recently completed RI and historic investigation results were used to characterize the nature and extent of contamination at the Site and to evaluate impacts to human health and the environment. Field investigations consisted of the collection of samples from impacted media (i.e., surface soil, subsurface soil, soil gas, sediment, surface water, and groundwater) from discrete site areas to define physical and biological characteristics of the Site as a whole. Environmental media evaluated include the following:

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- Soils at the Upper Bluff/Filled Ravine on the NSPW property near the former MGP facility;
- Soil vapor in the vicinity of the NSPW property;
- Fill soil at Kreher Park;
- Groundwater contamination (aqueous phase and non-aqueous phase) in the ravine fill, Kreher Park fill, and underlying Miller Creek and Copper Falls Formations, and
- Sediment contamination and impacts to surface water and aquatic organisms in the Chequamegon Bay inlet adjacent to Kreher Park.

Activities described in the Work Plan and completed during the RI field investigation include the following:

- Installation of additional monitoring wells MW-2C, MW-15A, MW-15B, and MW-21 in December 2003 to further characterize the vertical extent of groundwater contamination at the Upper Bluff/Filled Ravine;

- Installation of additional wells MW-7R, MW-7B, MW-23A, MW-23B, P-24, MW-24, MW-24A, P-25, MW-25, MW-25A, P-26, MW-26, and MW-26A at Kreher Park in May 2004. These wells were installed to evaluate the relationship between surface water and groundwater in the filled lakebed along the shoreline, and to further characterize the lateral extent of groundwater contamination in the underlying Copper Falls aquifer;

- Collection of four rounds of groundwater samples from all wells in the monitoring well network at the Site in June 2004, September 2004, December 2004, and March 2005 to characterize groundwater quality and flow conditions;

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- Collection of subsurface soil samples from borings advanced in the vicinity of the former MGP in April 2005 to further characterize the lateral and vertical extent of contamination in the backfilled ravine south of St. Claire Street;

- Collection of subsurface soil samples from borings advanced at Kreher Park in the vicinity of the former "seep" area and monitoring well TW-11 in April 2005 to characterize free-product observed at these locations;

- Collection of additional surface soil samples at the upper bluff to evaluate the direct contact exposure pathway in the vicinity of the former MGP in June 2005;

- Collection of additional surface soil samples at Kreher Park to evaluate the direct contact exposure pathway in the area in June 2005;

- Completion of an exploration test pit investigation at Kreher Park in June 2005 to characterize the uncontrolled solid waste disposal area, former coal tar "dump" area, the former "seep" area and other potential source and free-product conveyance areas at Kreher Park;

- Completion of a supplemental exploration test pit investigation at Kreher Park in November 2005 to identify the lateral extent of a clay pipe encountered between the former seep area and the former open sewer area;

- Completion of a borehole geophysical survey to verify subsurface geologic units, and a visual (downhole camera) inspection of two artesian wells open to the Copper Falls Aquifer at Kreher Park in November 2005;

- Completion of an air emission investigation at the upper bluff between March and July 2005 to evaluate the potential inhalation pathway for exposure to potential soil vapors at this area of the Site where nearby residents may be potentially affected;

- Performance of a wildlife habitat and wetland survey in June 2005 to characterize the terrestrial habitat of the Site;

- Completion of a Sediment Quality Triad (SQT) investigation between May and September 2005 to evaluate bulk sediment chemistry, sediment toxicity and benthic

macroinvertebrate community characteristics of Site sediments. This included performance of sediment toxicity tests of benthic invertebrates and fish larvae under both natural and ultraviolet light;

- Collection of surface water samples during low and high energy events in June and November 2005 to evaluate levels of contaminants in surface water in the Chequamegon Bay inlet area adjacent to Kreher Park;

- Collection of fish tissue in April 2004, April 2005, and June 2005 to support the BERA and HHRA ;

- Completion of a sediment stability analyses that included quantitative (modeling) and an empirical evaluation of sediment stability in aquatic portions of the Site;;

- Performance of sediment toxicity tests, fish larva bioassays, and ultraviolet light (UV) studies to evaluate impact on selected species;

- Conducting a BERA to describe the likelihood, nature and severity of adverse effects to ecological receptors resulting from their exposure to contaminants at the Site under current conditions, and

- Completing a HHRA to provide a risk-based interpretation of the data collected during the RI and to provide conservative estimates of potential human health risks posed by chemicals that are present at or migrating from the Site.

Field methods used to gather additional data during the RI and analytical methods are described in detail in Section 2.1 and 2.2 of this report.

2.1 Field Methods and Completed Activities

The sampling locations, frequencies, analytical parameters and sample rationale for samples collected during the RI field investigation were described in detail in the final Work Plan. Methods and procedures used to complete the planned activities were described in detail in the FSP and QAPP. The FSP includes SOPs describing field methods in detail.

- Geological investigations that included the installation of additional monitoring wells, the collection of surface and subsurface soil samples, an exploration test pit investigation, and a borehole geophysical survey,

- Hydrogeologic investigations that included the collection of four rounds of groundwater samples to evaluate groundwater quality and fluid level measurements to evaluate groundwater flow conditions;

- Soil vapor and indoor air quality investigations in the vicinity of the former MGP facility at the upper bluff area;

- Sediment and surface water investigations of the Chequamegon Bay inlet area adjacent to Kreher Park and reference stations in Chequamegon Bay, and

- An ecological investigation that included wetland and wildlife habitat surveys, a Sediment Quality Triad, and the collection of tissue samples from fish caught in aquatic portions of the Site.

A description of completed activities follows.

2.1.1 Geological Investigations

Site geologic conditions were interpreted from previous investigation and supplemental investigations completed during the RI. Geologic units investigated at the Site include the Miller Creek Formation and underlying Copper Falls Formation. Fill soil units are also encountered at the upper bluff and at Kreher Park. At the upper bluff area, fill soil was encountered in a former ravine that dissected the Miller Creek Formation in the vicinity of the former MGP facility. Kreher Park consists of fill material used to fill the former lakebed. Regional and Site geologic conditions are described in detail in Section 3.1.

Investigation activities included the visual classification of subsurface soil units from numerous soil borings, monitoring well boreholes, and exploration test pits. Supplemental investigations completed for the RI included the installation of additional monitoring wells, the collection of surface soil samples, subsurface soil samples, and a borehole Geophysical survey as described below.

2.1.1.1 Monitoring Well Installation

Monitoring wells were installed at the upper bluff and at Kreher Park during previous phases of investigation. For the RI, additional water table observation wells (MW-7R, MW-24, MW-25, and MW-26) and shallow piezometers (P-24, P-25, and P-26) were installed at Kreher Park. Piezometers were also installed to further characterize the lateral and vertical extent of groundwater contamination and hydrogeologic conditions in the underlying Copper Falls aquifer. Wells MW-2C, MW-15A, MW-15B, and MW-21B were installed at the upper bluff in December 2003. Wells MW-7R, MW-7B. MW-23A, MW-23B, MW-24A, MW-25A, and MW-26A were installed at Kreher Park in May 2004. These wells were installed per USEPA's conditional approval prior to final approval of the Work Plan. All site monitoring well locations are shown on Figure 2-1.

As shown on Figure 2-1, well MW-2C was installed adjacent to wells MW-2R, MW-2AR, and MW-2BR in the NSPW storage yard on the north side of St. Claire Street. Wells MW-15A and MW-15B were installed in the alley south of the NSPW service center building near well MW-15. Well MW-21B was installed adjacent to MW-21A in a lawn area on the north side of the Our Lady of the Lake Church property. Well MW-7R was installed at the seep area to replace well MW-7, which was destroyed during the seep remediation remedial response completed in May 2002. Wells MW-24, P-24, MW-25, P-25, MW-26, and P-26 were installed along the shoreline to evaluate groundwater contamination and the hydraulic connection between groundwater in the fill soil and surface water. Wells MW-23A and MW-23B were installed at Kreher Park north of wells MW-21A and MW-21B. Well MW-24A, MW-25A, and MW-26A were installed along the shoreline at Kreher Park adjacent to wells P-24/MW-24, P-25/MW-25, and P-26/MW-26, respectively.

Water table observation well MW-7B, MW-24, MW-25, and MW-26 were constructed with 2-inch diameter schedule 40 polyvinyl chloride (PVC) well casings and well screens. Well screens 10-feet in length were placed in the Kreher Park fill soil unit. Wells P-24, P-25, and P-26 were installed in the Kreher Park fill as shallow piezometers in the fill soil. These wells were also installed with 2-inch diameter schedule 40 PVC well casings, but with well screens 1-foot in length. Piezometers MW-15A, MW-23A, MW-24A, MW-25A, and MW-26A were installed in the upper Copper Falls aquifer below the Miller Creek-Copper Falls contact. Wells MW-7B, MW-15B, MW-21B, and MW-23B were installed as deeper piezometers between 20 and 25 feet below the Miller Creek-Copper Falls contact adjacent to previously installed piezometers. Each piezometer was constructed with 2-inch diameter schedule 40 PVC well casing and screens 5-feet in length. Sand packs were placed around each well screen, and the annular space above the

sand pack was backfilled with bentonite slurry tremied (filled by pumping from the bottom up) in place. Wells MW-7B, MW-23A, and MW-23B were installed with above-grade protective well casing, and the remaining wells were installed with flush mount protective well casings cemented in place. Due to strong upward gradients resulting in flowing artesian conditions at wells MW-7B, MW-23A, MW-23B, MW-24A, MW-25A, and MW-26A, down-hole water tight caps were installed in these wells.

Well MW-2C was installed at the bottom of the Copper Falls aquifer. Because this well was advanced through a NAPL zone in the upper Copper Falls aquifer, it was constructed in a borehole with an outer secondary well casing. A 10-inch diameter borehole was advanced through the NAPL zone by mud rotary to 60 feet. A 6-inch diameter black iron outer casing was placed below the NAPL zone at a depth of sixty feet. The annular space was sealed with bentonite slurry and allowed to set for four days. A 6-inch diameter borehole was advanced below this pipe by mud rotary drilling methods. This piezometer was constructed with 2-inch diameter schedule 80 PVC well casing and a well screen 5-feet in length. The approved Work Plan specified that a bedrock piezometer be installed with a five-foot screen at a depth of 10 feet below the bedrock surface. During drilling, WDNR requested a deviation from the plan for the screen location, preferring the screen be placed above the bedrock surface. The State of Wisconsin expressed concern that any potential dense non-aqueous phase liquid may not be captured if the screen was installed below the bedrock surface. Consequently, the well was installed only to five feet into the underlying sandstone bedrock.

Soil samples were collected from each monitoring well boring and visually classified in accordance with the Unified Soil Classification System. Well MW-2C was installed in a borehole advanced by mud rotary using a truck mounted drill rig. The remaining wells were installed in boreholes advanced with 4¼ -inch ID hollow stem augers using a truck mounted drill rig. Drilling services were provided by Boart Longyear of Schofield, Wisconsin. Monitoring wells were developed after well installation. All drilling, well installation, and well development were completed in accordance SOP 140 of the FSP and with Wisconsin Administrative Code NR 140 requirements. Soil boring logs, well construction, and well development forms are included in Appendix B1.

2.1.1.2 Surface Soil Sample Collection

Ten surface soil samples (SS-1 through SS-10) were previously collected from Kreher Park by SEH in November 1997 (SEH 1997). For the RI, additional surface soil samples were collected at the upper bluff area in the vicinity of the former MGP and at Kreher Park to determine if there

are any contaminants on the surface, potentially serving as a direct contact threat to human health and the environment. At each sample location, soil was collected from a depth between 0 and 12-inches utilizing hand tools. Surface soil samples were collected from 24 locations at Kreher Park and from 12 locations at the upper bluff area. All surface soil samples were collected in laboratory provided containers in accordance with SOP 140 included in the FSP, held on ice, and shipped to the laboratory along with a completed chain-of-custody form in accordance with SOP 210. All surface soil samples collected from Kreher Park and in the vicinity of the MGP site were collected in June 2005 concurrent with exploration test pit activities. Background surface soil samples were collected concurrent with background subsurface soil sample collection in April 2005.

Previous investigations in the vicinity of the former MGP have shown that subsurface soil contamination at the upper bluff is generally limited to the backfilled ravine; most of this area is covered by facility buildings, gravel, asphalt pavement, or City streets. Samples SS-14 through SS-21 were collected from unpaved areas in the vicinity of the former MGP facility and filled ravine area. RI soil sample locations at the upper bluff area are shown on Figures 2-3 and 2-4. The SS-14 sample is located on the east side of the former ravine east of the former MGP facility building. Sample SS-15 is located northwest of the former MGP facility on the east side of the backfilled ravine. The SS-16, SS-17, and SS-18 samples are located within the footprint of the backfilled ravine northwest of the former MGP facility. Samples SS-19, SS-20, and SS-21 are located west of the former MGP facility on the west side of the backfilled ravine. Samples SS-22 and SS-23 (Figure 2-4) are located in the residential area west of the backfilled ravine and the former MGP facility between Second and Ellis Avenues. Sample SS-24 is located in the residential area south of the backfilled ravine and former MGP facility, and sample SS-25 is located east of the backfilled ravine and the former MGP facility along Prentice Avenue (Figure 2-3).

Previous investigations have also shown that groundwater flow in the filled ravine and Miller Creek Formation is to the north. Consequently, these background soil sample locations are near the southern boundary of the Site hydraulically up gradient from the former MGP facility and backfilled ravine. These background surface soil sample locations were selected based on guidance presented in USEPA documents Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation, (EPA/540/1-89/002 December 1989) and Role of Background in the CERCLA Cleanup Program (OSWER 9285.6-07P, April 26, 2002). The purpose of collecting background samples is to compare site-related contamination from naturally occurring or other non-site related levels of chemicals. Although previous subsurface investigations have shown contamination at the upper bluff is limited to the former MGP facility and the backfilled ravine,

these background locations may have chemicals present from other anthropogenic sources. Accordingly, background samples were collected from locations not influenced by Site activities. In their guidance documents, USEPA recognizes that chemicals may be present in background samples and identifies two types of sources for these chemicals. Naturally occurring levels of chemicals are ambient concentrations of chemicals present in the environment that have not been influenced by humans. Anthropogenic levels of chemicals are concentrations of chemicals that are present in the environment due to human-made, non-site sources.

At Kreher Park, additional surface soil samples were collected from eight exploration test pit locations in the former solid waste disposal area (TP-100, TP-101, TP-102, TP-104, TP-105, TP-106, T-107, and TP-108), two test pits advanced in the vicinity of the former open sewer (TP-103 and TP-107), and eight test pits (TP-112 through TP-119) in the vicinity of the former coal tar dump area. Samples were also collected from three test pit locations (TP-110, TP-111, and TP-121) and from three surface soil sample locations (SS-11, SS-12, and SS-13) outside the former solid waste disposal and former coal tar dump areas. Test pits TP-110, TP-111, and TP-121 are located on the north side of Marina Drive near the vacant waste water treatment plant building in the vicinity of a backfilled former drainage swale. Sample SS-11 was collected on the north side of the former City wastewater treatment plant. Sample SS-12 was collected between the former solid waste disposal and the former coal tar dump areas, and sample SS-13 was collected east of the former coal tar dump area. RI surface soil sample locations at Kreher Park are shown on Figure 2-4.

2.1.1.3 Subsurface Soil Sample Collection

Previous site investigations completed at the Site included the collection of soil samples from soil borings and monitoring well borings. Additional subsurface soil samples were collected from Geoprobe (direct push) borings advanced during the RI to further characterize source areas identified during previous investigations. RI Geoprobe investigations included the collection of subsurface soil samples from 39 borings (GP-100 through GP-138) advanced in the vicinity of the former MGP at the upper bluff, 8 borings (GP-139 through GP-146) were advanced at Kreher Park near monitoring well TW-11, and 12 borings (GP-147 through GP-158) advanced near the former seep area at Kreher Park. These Geoprobe investigations were completed in April 2005. Geoprobe boring locations at the upper bluff area are shown on Figure 2-3, and Geoprobe boring locations at Kreher Park are shown on Figure 2-4.

Borings GP-100, GP-101, GP-102, and GP103 were advanced beneath the concrete floor of the NSPW Service Center building. As shown in Figure 2-4, this building is located south of the

MW-8/8A well location near the southwest corner of St. Claire Street and Prentice Avenue. A concrete coring machine was used to cut a four-inch diameter hole in the concrete floor prior to advancing the Geoprobe boring. Concrete between 8.5 to 12 inches thick was encountered in this part of the building. Subsurface obstructions prevented borings GP-100 and GP-101 borings from being advanced below three feet. At boring GP-103, a second 12-inch-thick concrete slab was encountered beneath the floor. A hydraulic jackhammer with an extension was used to access soil beneath this second concrete slab. Concrete cores were also cut in the floor of the center of the U-shaped NSPW service center at 14 additional locations (GP-118, GP-119, GP-121, GP-122, GP-124, GP-125, GP-126, GP-127, GP-129, GP-130, GP-132, GP-133, GP-135, and GP-136). The concrete floor is approximately seven inches thick in this part the building. Soil borings GP-104 through GP-117 were advanced in the asphalt paved area on the north side of U-shaped NSPW service center building. Six additional borings (GP-120, GP-123, GP-128, GP-131, GP-134, and GP-137) were advanced in the alley on the south side of the building. Additionally, background samples were collected near private homes at the upper bluff area to evaluate background conditions. Background subsurface soil samples were collected from the following three locations.

- GP-159 collected from yard of residence at 118 Prentice Avenue located at the southeast corner of the intersection of Prentice Avenue and St. Claire Street;
- GP-160 collected from yard of a residence along Second Avenue at 121 East Lake Shore Drive; and,
- GP-161 collected from yard of residence at 110 North Ellis Avenue.

As shown on Figure 2-4, at Kreher Park, RI soil borings GP-139 through GP-146 were advanced near monitoring well TW-11 to identify the lateral extent of NAPL in this area. Soil borings were initially advanced north (GP-139), west (GP-140), south (GP-141), and east (GP-142) of well TW-11. These borings were terminated when native soils were encountered beneath the fill soil and wood waste generally between 12 and 15 feet bgs NAPL was encountered in borings GP-139, GP-141, and GP-142 in the underlying wood waste layer and underlying beach sand layer. NAPL, wood waste, or beach sand was not encountered at GP-140. Additional borings (GP-143, GP-144, GP-145, and GP-146) were advanced at distant locations to identify the lateral extent of NAPL GP-143 was advanced south of GP-141, but could not be advanced below eight feet. GP-144 was advanced south of GP-143, and NAPL was encountered at this location near the shoreline. GP-145 was advanced east of GP-142, and NAPL or wood waste was not encountered at this location. GP-146 was advanced northwest of GP-139, and NAPL was encountered at this location. Concrete structures to the north and the shoreline to the south

prevented additional borings near TW-11. This prevented the identification of the lateral extent of NAPL encountered in the underlying wood waste and beach sand layers near TW-11.

A total of 12 soil borings (GP-147 through GP-158) were also advanced in a grid pattern at the former seep area at Kreher Park (see Figure 2-4) to identify the lateral extent of NAPL within the fill in this area. These borings were terminated when native soils were encountered beneath the fill, generally between 12 and 15 feet bgs. Clean fill was encountered between four and six feet bgs. This clean fill material was placed as a cap over the former seep area in 2002 following the excavation of contaminated surface soil. NAPL was encountered in the underlying wood waste and beach sand layers. NAPL or wood waste was not encountered at GP-149 and GP-157 locations. Wood waste was not encountered at GP-154, but NAPL was encountered in the fill soil below the seep area cap. NAPL was encountered in the wood waste at the remaining locations, and in test pits excavated north and west of the former seep area as described below in Section 2.1.1.4. The lateral extent of NAPL was not identified in the former seep area because the rail way to the south and a wooded area to the east prevented access for additional borings.

Soil samples were collected using a 2-inch diameter Geoprobe macro sampler lined with disposable polyethylene sampling tubes. The four-foot long macro sampler was used to collect soil samples continuously. Soil samples were field screened for organic vapors with a hand-held photoionization detector (PID) at two-foot intervals. Field screening results and field observations were used to selected soil samples for laboratory analysis. The Work Plan specified the collection of three soil samples per boring for laboratory analysis. However, fewer than three samples were collected at several locations due to poor sample recovery or drilling refusal. Selected subsurface soil samples were collected in laboratory provided containers in accordance with SOP 140 included in the FSP, held on ice, and shipped to the laboratory along with a completed chain-of-custody form in accordance with SOP 210.

Subsurface drilling equipment was decontaminated between soil borings in accordance with SOP 190. Soil samples were transferred from the polyethylene tubes and placed in sample containers with stainless steel spatulas. Equipment used to remove soil from the sample tube, including spatulas, shovels used to dig soil for surface soil samples, and stainless steel bowls used for soil sample composites, were decontaminated in accordance with SOP 190. Subsurface soil units were visually classified in accordance with the Unified Soil Classification System, and recorded on field logs. Drilling services were provided by Coleman Engineering of Iron Mountain, Michigan. All drilling and borehole abandonment was completed in accordance SOP 140 of the FSP and with Wisconsin Administrative Code NR 140 requirements. Soil boring logs are included in Appendix B2, and borehole abandonment forms are included in Appendix B6.

In addition to the collection of soil samples, NAPL were visually observed in all three areas of investigation. Observations made during these Geoprobe investigations were used to identify the lateral extent of NAPL in these source areas as described in Section 4.1 and shown on Figures 4-1 and 4-2.

2.1.1.4 Exploration Test Pit Investigation

Twenty exploration test pits (TP-100 through TP-120) were excavated at Kreher Park between June 6 and 16, 2005 to further characterize the limits of fill for the solid waste disposal area, and the former coal tar dump area shown on the 1951 Greeley & Hanson record drawings (see Figure 1-2). Additional test pits (TP-121 through TP-132) were later excavated to identify the lateral extent of clay pipes encountered at two test pits (TP-108 and TP-118). This subsequent work was done between November 1 and 3, 2005 in accordance with a Work Plan addendum that was submitted to USEPA on September 28, 2005. All test pit excavations were completed in accordance with SOP 130. Photographs showing excavation activities and conditions encountered at each test pit are included in Appendix C. RI test pit locations are shown on Figures 2-4 and 5-1.

Fill material was encountered at each test pit location. Fill material consisted predominantly of silty clay soil mixed with rocks, bricks, concrete, wood, and miscellaneous debris, which includes steel cables, cast iron pipes, and scrap steel. At most locations, a layer of wood waste was encountered beneath the fill soil. This underlying wood waste layer consists of wood chips and larger planks, and is typically several feet thick. A black organic soil layer, possibly soil mixed with sawdust, was encountered above the wood waste layer at several locations. Groundwater was encountered at all test pit locations. Typically, groundwater seeped into the excavation after penetrating the underlying wood waste layer. The rate of seepage prevented further excavation at each test pit location. A description of the fill soil and underlying wood waste layer was recorded on field test pit logs included in Appendix B3. Table 2-1 includes a summary of observations made at each test pit location.

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Obvious signs of contamination, which included petroleum-like odors and NAPL, were encountered at several locations. Samples of NAPL-stained soil and water were collected for forensic analysis to further characterize the composition of the NAPL. Grab samples were collected in laboratory provided containers in accordance with SOP 140 of the FSP, placed on ice, and submitted to Woods Hole Group Environmental Laboratories for forensic analyses in accordance with SOP 210.

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All excavated material was returned to the test pits. Site restoration included placement of clean topsoil, seed, and mulch placed over the backfilled test pits. A detailed description of the conditions encountered at the former solid waste disposal area, the former coal tar dump, and results of the clay pipe supplemental investigation are described below.

Solid Waste Disposal Area

Exploration test pits were excavated at ten locations (TP-100 through TP-109) in the vicinity of the former solid waste disposal area. Two test pits were excavated on each side of the former solid waste disposal area (eight total), and two test pits were also excavated within the solid waste disposal area and in the vicinity of a former open sewer. RI test pit locations are shown on Figure 2-4 and 5-1. The location of the former solid waste disposal area is shown on Figures 1-2 and 5-1. Rather than excavate one large test pit, a series of two to four small excavations were completed at the TP-102, TP-103, TP-104, and TP-105 locations to further characterize the nature and extent of the fill material at these locations. Significant observations made during the excavation activities at the Solid Waste Disposal Area are as follows:

- Fill soils with rocks, bricks, and debris overlying a wood waste layer was encountered in the solid waste disposal area;
- The lateral extent of filling in the solid waste disposal area could not be distinguished to the north, east, and west. The absence of rock, bricks, and debris at TP-108 and TP-109, excavated in an area adjacent to the railway that lies several feet below the remainder of Kreher Park, approximates the southern extent of filling in this area;
- No obvious signs of contamination, such as soil staining or odors, were encountered in fill soils;
- Obvious signs of contamination (NAPL staining and strong odor) within the wood waste layer was observed at several locations; however, significant contamination was observed at TP-103 and TP-107. These test pits were excavated in the vicinity of the former open sewer shown in historical documents. No indication of the former open sewer was found;
- The wood waste layer was not encountered at TP-101 and TP-108, but was encountered in the remaining test pits excavated within the solid waste disposal area. Seepage prevented a deeper excavation at TP-101, and excavation at TP-108 was terminated when a clay pipe was encountered;
- The clay pipe encountered at TP-108 was encountered between 3.5 and 4-feet bgs. This east-west trending clay pipe is approximately 10-inches in diameter. A three-foot section of pipe was removed intact, wrapped in plastic, and stored on the NSPW property, and
- No obvious signs of contamination was observed outside the clay pipe, but the pipe was found to be full of soil; the lower half of sediment in the pipe was stained with NAPL with strong odors.

Former Coal Tar Dump Area

Eight exploration test pits (TP-112 through TP-119) were excavated in the former coal tar dump area shown in historic records. Figures 2-4 and 5-1 show RI test pit locations, and Figure 1-2 and 5-1 show the location of the former coal tar dump. Rather than excavate a large test pit, a series of small excavations were completed at the TP-112, TP-113, TP-114, TP-116, and TP-118 locations to identify the lateral extent of the former coal tar dump area. Only single test pit excavations were completed at the TP-115, TP-117 and TP-119 locations. Significant observations made during the excavation activities at the Former Coal Tar Dump are as follows:

- Several feet of clean fill soil ranging in thickness from two to five feet were encountered overlying a wood waste layer at all locations;
- The fill soil unit in this area consists predominantly of silty clay soil mixed with demolition debris (wood, bricks, rocks, concrete, and asphalt), and the underlying wood waste layer consists of wood chips and horizontal planks. A black organic soil layer, possibly soil mixed with sawdust, was encountered above the wood waste layer at the TP-114, TP-117, and TP-119 locations. This soil layer was generally observed between 1 and 5 feet below ground surface;
- A distinct layer of weathered tar was observed in some of the test pits;
- Obvious signs of contamination (NAPL staining and odor) were encountered within the underlying wood waste layer throughout this area;
- Obvious signs of contamination were also encountered in the fill soil above the wood waste layer within the footprint of the former coal tar dump area;
- Test pits excavated around the perimeter of the former coal tar dump encountered contamination within the fill soil (overlying the wood waste layer), but this contamination disappeared with distance. This finding was used to approximate the lateral extent of the former coal tar dump to the north (TP-112), east (TP-114 and TP-119), and west (TP-113 and TP-116);
- A northwest-southeast trending clay pipe was encountered within 3 feet of the ground surface at TP-118 located on the south side of the former coal tar dump area. The clay pipe was empty; no odors or NAPL staining was observed inside or outside the pipe. This pipe is aligned with the clay pipe encountered in the backfilled ravine at the upper bluff area. A second test pit was excavated north and south of the initial TP-118 test pit but the clay pipe was not encountered at that location, and

- A buried metal pipe was encountered on the east end of test pit TP-117.[19] Abandoned water and sewer mains are located in this area, extending from Third Avenue to the south to the former wastewater treatment plant to the north.

Test pits were also excavated on the north side of Marina Drive. Test pits TP-110 and TP-111 were excavated northwest and north of the former coal tar dump area in the vicinity of a former culvert/ditch shown on the 1951 Greeley & Hanson record drawings. Test pit TP-120 was excavated northeast of the former coal tar dump area also in the vicinity of a former culvert/ditch. Clean fill soil overlying wood waste was encountered at all three locations. Obvious signs of contamination were also encountered within the underlying wood waste layer at the TP-110 and TP-111 locations, but not at the TP-120 location. Additionally, a corrugated steel culvert was encountered at the TP-110 location. The culvert was filled with fill soil, but no obvious signs of contamination were observed in the fill soil above the wood waste layer.

Supplemental Clay Pipe Investigation

A supplemental clay pipe investigation was completed in November 2005 to identify the lateral extent of clay pipes encountered at TP-108 and TP-118 in June 2005. Because the lateral extent of each pipe could not be determined at that time, a Work Plan addendum for a supplemental site investigation was subsequently submitted to USEPA in September 2005. Following Work Plan approval, test pits TP-121 through TP-132 were excavated along clay pipe alignment between November 1 and 3, 2005. Test pit locations are shown on Figure 2-4, and the clay pipe alignment identified during the supplemental investigation is shown on Figure 5-1.

The elevation of the top of the clay pipe encountered in each test pit was surveyed relative to site datum. The elevation of well TW-06 was used for the reference elevation for the clay pipe encountered at (from east to west) TP-127, TP-125, TP-108A, TP-121A, TP-121, and TP-124A. The elevation of well TW-09 was used for the reference elevation for the pipe encountered at (from east to west) TP-130, TP-129, TP-128, the lateral pipe encountered at TP-128, and the elevation of the pipe encountered at the TP-118A test pits.

[19] This pipe is a 6 to 8-inch diameter metal pipe aligned north-south toward the former wastewater treatment plant. It was not broken. This pipe is likely the abandoned water main servicing the former wastewater treatment plant, which was identified by the City utility location crew prior to excavation.

Top Of Clay Pipe Elevations		
Location	**From TW-06 Reference Elevation (610.27)**	**From TW-09 Reference Elevation (610.02)**
TP-130		605.25
TP-129		604.27
TP-128		613.48
TP-128 lateral		604.71
TP-127	603.69	
TP-125	603.27	
TP-108A	602.01	
TP-121A	602.93	
TP-121	602.87	
TP-124A	602.92	
TP-118A (south)		605.92
TP-118A (north)		605.92

Survey results indicate that the clay pipe encountered between the former seep area and the former open sewer area slopes to the west. The elevations of the pipe encountered at the TP-118A indicate that that clay pipe slopes away from the former seep area toward the former tar dump. However, the elevation of the pipe encountered at TP-118 is higher than the clay pipe encountered at TP-130 indicating that two pipes were likely not connected.

Test Pit TP-108 Vicinity

Test pit TP-108A was excavated east of and adjacent to former test pit TP-108, and the clay pipe was uncovered. Test pits TP-121, TP-121A, TP-122, TP-123A, TP-124B, TP-124A and TP-124B were excavated west of TP-108A between TP-108 and the former open sewer drainage (Figure 2-4). Significant observations made during the excavation activities in the vicinity of TP-108 are as follows:

- The clay pipe was encountered in test pits TP-125 through TP-130 excavated east of TP-108A between the former seep area and TP-108A;
- Only broken pieces of clay pipe were observed at the TP-126 location, but the clay pipe was uncovered intact at the remaining locations;
- The inside of the clay pipe contained NAPL-stained soil;
- The clay pipe trends east-west parallel to the bluff and railroad tracks;
- The western-most extent of the clay pipe was encountered at TP-124A, located east of TP-108; this location is in the vicinity of the former open sewer;

- At TP-124A, delineation of the clay pipe to the west and north was prevented due to the presence of boats in the marina parking lot (north) and the presence of buried utilities (west);
- The elevation of this pipe decreased from east to west indicating flow was to the west in the pipe; and
- A north-south trending lateral pipe was encountered at TP-128, located between the former seep and TP-108. The lateral pipe was connected to the east-west trending pipe (90 degree connection). The north-south trending pipe was full of soil but no staining of this soil was observed.

Samples were collected from the main pipe at the TP-128 location and submitted for forensic analyses. Samples were also collected from the western-most extent of the clay pipe (TP-124A) and the eastern most extent of the clay pipe (TP-130) for forensic analyses.

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Test Pit TP-118 Vicinity

TP-118A was excavated adjacent to TP-118, and the clay pipe was uncovered. Test pits TP-131 and TP-132 were excavated south of TP-118A (Figure 2-4). These tests pits were located in an area where abandoned water and sewer mains are located [20]. Significant observations made during the excavation activities in the vicinity of TP-118 are as follows:

- The clay pipe was not encountered, but broken pieces of clay pipe were observed in the fill soil, and
- This clay pipe terminates between TP-118 and TP-117 near the south end of the former coal tar dump area.

Forensic samples were not collected from this clay pipe because there were no obvious signs of contamination in or on the outside of the pipe and the pipe was empty.

[20] As described above, the abandoned pipes extend from Third Avenue to the south to the former wastewater treatment plant to the north. A buried metal pipe was encountered on the east end of test pit TP-117. No residual of the clay pipe was found at this location. This metal pipe is likely an abandoned water main that serviced the former treatment plant.

2.1.1.5 Geophysical Downhole Survey

Logging activities consisted of downhole video surveillance and electromagnetic induction (EM) measurements on artesian wells AW-1 and AW-2, and EM and gamma measurements on monitoring wells MW-2C, MW-2BR and MW-2ANET. Prior to logging the artesian wells, the depths were determined to be 82.25 feet below the top of casing (TOC) for AW-1 (near Prentice Avenue) and 161.45 feet below the TOC for AW-2 (the marina). The video camera could not be advanced below 40 ft in AW-1 and 37 ft in AW-2 because of a decrease in the well diameter at these depths. Subsequent EM logging of these wells confirmed that the well casing material consists of steel pipe for the entire length of each well. The natural gamma log identified thick portions of the Miller Creek aquitard in both artesian wells. Geophysical results confirm that the Miller Creek thickens between the bluff face a observed s with other logs for wells installed in Kreher Park.

EM logging at MW-2C was completed below the outer steel casing, but natural gamma logs were completed on adjacent wells MW-2BR and MW-2C. In general, lithologic conditions identified within the upper 70 feet at MW-2BR on the original drilling log agree with the natural gamma log for MW-2C. Because MW-2BR and MW-2C are adjacent, the signatures should be essentially the same. However, the natural gamma log for MW-2BR differs from the original drilling log because the bentonite seal for that well has affected the natural gamma log signature. The natural gamma log for MW-2C also identified several fine-grained units below 155 feet that were not previously identified on the soil boring log. At all locations where iron pipe did not interfere (artesian wells and MW-2BR), the EM logs identified high conductivity in the upper zones (fill and Miller Creek units). The geophysical interpretation of these conditions is either indicative of contamination, or natural clay conductivities. Well locations are shown on Figure 2-1. The Geophysical Survey report is included in Appendix D1.

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2.1.2 Hydrogeologic Investigations

Previous investigations have identified groundwater contamination in the ravine fill, the Kreher Park fill, and the underlying Copper Falls aquifer. Contaminants, including free product, migrated to the underlying Copper Falls aquifer in the vicinity of the former MGP facility. Site investigation results indicate that contaminants in the Copper Falls aquifer have migrated laterally along the interface between the Copper Falls aquifer and overlying Miller Creek Formation. Regional and Site geologic and hydrogeologic conditions are described in detail in Sections 3.1 and 3.2. A detailed description of the nature and extent of groundwater contamination is included in Section 4.3.

2.1.2.1 Groundwater Monitoring

As an interim response, a low flow free-product recovery system was installed for the Copper Falls aquifer in 2001. Prior to execution of the AOC (November 2003), quarterly monitoring reports were submitted to the Wisconsin Department of Natural Resources (WDNR). Each of these previous reports included the results of analyses of the previous quarter's groundwater monitoring samples collected from select wells screened in the aquifer, and air and water quality sample data for the free product removal system between September 2001 and June 2003. These reports were prepared and submitted in accordance with an approved work plan for the interim system developed according to ch. NR 700, Wisconsin Administrative Code. Groundwater samples were also collected in September 2003 prior to executing the AOC. Rather than include sample results in a quarterly report, these sample results were presented in Progress Report No 1 (December 2003) in accordance with the AOC.

Eleven quarterly groundwater sampling events were conducted prior to execution of the AOC. These data were provided to the WDNR in progress reports between September 2001 and June 2003. Additional groundwater sampling events were conducted subsequent to execution of the AOC as part of the RI. In September 2003 the USEPA conditionally approved the installation of additional wells at the upper bluff and the collection of groundwater samples from all Site monitoring wells. Groundwater samples collected in December 2003 and March 2004 included the collection of samples from wells MW-15A, MW-15B, MW-21B, and MW-2C, which were installed at the upper bluff in December 2003. Wells MW-7B, MW-23A, MW-23B, MW-24, MW-24A, MW-25, MW-25A, MW-26, and MW-26A were subsequently installed in May 2004 following conditional approval of the February 2004 Revision 01 Draft Work Plan in April 2004 for well installation and groundwater sample collection. Monitoring well locations are shown on Figure 2-1, and monitoring well construction details are included on Table 2-2.

Groundwater samples were collected from all site wells in June 2004, September 2004, December 2004, and March 2005. These groundwater sampling activities satisfied the monitoring requirements for the RI as specified in the approved February 2005 Revision 02 Final Work Plan. June 2004 samples were collected between June 14 and 23, and September 2004 samples were collected between September 20 and 27. December 2005 samples were collected between December 6 and December 13, and March 2005 samples were collected between March 14 and 21. The monitoring network consists of 70 monitoring wells including water table observation wells screened within the Miller Creek Formation, the ravine fill, and the Kreher Park fill and piezometers screened within the underlying Copper Falls aquifer.

All monitoring wells were purged prior to sample collection. A dedicated bailer was used to purge shallow water table wells, and dedicated submersible electric pumps were used to purge deeper piezometers. For artesian wells, the water tight cap was removed and a PVC cap attached to tubing was placed over the well casing and the well was allowed to flow. Purge water from all site wells was collected in a portable tank and later discharged to the interim on-site groundwater treatment system.

All site wells were purged until the well was purged dry, four well casing volumes were removed, or field stabilization test results indicated that an adequate volume of water was removed. Stabilization tests were completed on all piezometers purged with submersible pumps and on the artisan flowing wells by measured pH, dissolved oxygen, specific conductance, oxidation reduction potential, and temperature. A YSI 556 MPS probe was used to record field parameters in conjunction with a flow-through cell. Field parameters were recorded approximately every 0.5 well volumes or every 5 minutes until parameters reached stabilization. Stabilization was achieved, and purging was terminated, when field parameter measurements stabilized within 10-percent of the previous reading. For wells purged with a bailer, field parameters were recorded at the time of sample collection. A LaMotte 2020 turbidity meter was also used to record turbidity measurements. Field measurements were performed in accordance with SOP 110 of the SOP. Final purge volumes, the color, odor, and physical condition of each well, and field parameters were recorded on field sampling form in accordance with SOP 150 of the FSP. Field measurements between December 2003 and March 2005 are summarized in Table 2-3.

Groundwater samples were placed in laboratory-supplied containers and preserved in accordance with SOPs 150 and 160 of the FSP. For the collection of dissolved analytes, samples were filtered in the field before being submitted to the laboratory. Field filtering was conducted using a peristaltic pump and a 0.045 micron filter in-line filter; groundwater was pumped from a clean transfer bottle into the appropriate laboratory supplied container. Field filtering of groundwater samples was done in accordance with SOP 170 of the FSP. Following groundwater sample collection, all sample containers were packed into laboratory-provided coolers, placed on ice, and shipped via overnight courier to Northern Lake Service in Crandon, Wisconsin for analysis. Sample coolers were shipped in accordance with SOP 210 of the FSP.

In addition to the collection of groundwater samples, six polyethylene-based passive diffusion bag (PDB) samples were collected from six shallow temporary wells installed adjacent to the shoreline at Kreher Park to evaluate the interrelationship between groundwater and contaminants in the fill at the Park and the affected sediments. Wells PDB-01 through PDB-06 were installed

in two clusters (three wells per cluster) at Kreher Park on June 16, 2005. Wells PDB-01, PDB-02, and PDB-03 were installed perpendicular to the shoreline approximately 25 feet apart on the west side of the former wastewater treatment plant approximately 90 feet east of the MW-25 well nest. Wells PDB-04, PDB-05, and PDB-06 were installed approximately 25 feet apart near the entrance to the boat storage area approximately 80 feet east of the MW-24 well nest. PDB-01, PDB-02, PDB-03, and PDB-04 were installed four feet bgs, and PDB-05 and PDB-06 were installed five feet bgs. Each well was installed in a borehole advanced with 4¼-inch ID hollow stem augers, and constructed with 2-inch diameter schedule 40 PVC well casings and screens two-feet in length. A sand pack was placed around each well screen, the annular space was backfilled with granular bentonite, and each well was encased in a flush mount protective well casing. Temporary wells and PDBs were installed in accordance with procedures stated in SOP 300 of the FSP. Drilling services were provided by Coleman Engineering of Iron Mountain, Michigan. Soil boring logs and well construction forms are included in Appendix B1, and PDB well locations are shown on Figure 2-1.

Soil cuttings from PDB wells were placed in a 55-gallon drum, temporarily stored near the groundwater treatment system, and later transported off-site for disposal. Wells PDB-01, PDB-02, PDB-03, and PDB-04 were developed using dedicated bailers following completion of well construction. These wells contained approximately 18 inches of water while wells PDB-05 and PDB-06 were not developed because they were dry.

PDBs provided by Columbia Analytical Services in Rochester, New York (http://www.caslab.com/products.php) were installed after well development on July 16, 2005. One 24-inch long PDB containing analyte free water was suspended in the bottom of each temporary well using nylon rope. The PDBs were retrieved for analyses on July 19, 2005 after allowing 32 days of equilibration between groundwater and the water within the PDB. Upon removal from the well, the exterior of each PDB was rinsed with deionized water. A small hole was then cut at the top of the PDB, and the contents of each PDB was collected in 40 mL vials with zero head space and were preserved with HCl. PDB samples were collected in accordance with the approved Work Plan and SOP 300 of the FSP. Following sample collection, the sample containers were placed into a cooler, placed on ice, and shipped to Northern Lake Service in Crandon, Wisconsin for VOC analysis. The cooler was shipped in accordance with SOP 210 of the FSP.

2.1.2.2 Groundwater Elevations and NAPL Thickness Measurements

Static water levels were measured in all site wells in accordance with SOP 100 of the FSP prior to groundwater sample collection, and in June and November 2005 concurrent with exploration test pit activities. Water levels were measured in all wells within a 24-hour period prior to sample collection. However, during winter sampling events (December 2004 and March 2004), heavy snow and ice conditions, which obstructed access to most flush-mounted monitoring wells, prevented the measurement of static water levels in all site wells within a single 24-hour period. A Solinst electronic water level meter was used to measure the depth to water at each to the nearest 0.01 foot from the top of each well casing. Water levels at flowing artesian wells were measured by adding additional lengths of PVC casing to the well casing. After allowing the hydraulic head to equilibrate, the water column height above the surveyed well casing was measured to the nearest 0.01 foot. Following water level measurements, the water level meter was decontaminated between wells in accordance with SOP 190 of the FSP.

Groundwater elevation data was used to evaluate groundwater flow conditions as described in Section 3.2. As described in Section 2.1.1 above, wells P-24, P-25, and P-26 were installed as shallow piezometers in the Kreher Park fill soil to evaluate the hydraulic connection between groundwater in the fill soil and surface water and no samples were collected from these wells. The relationship between groundwater in the fill soil at Kreher Park and surface water in the adjacent Chequamegon Bay inlet area as described in Section 3.2. Depth to water measurements and groundwater elevations measured between June 2003 and November 2005 are summarized in Table 2-4, and vertical hydraulic gradients are summarized in Table 2-5.

Consistent with previous events and the previous WDNR approved sampling program and the approved Work Plan, samples were not collected for water quality parameters if more than one foot of DNAPL was measured in the wells. Static water levels were measured in wells that have historically had NAPL or suspected to have NAPL present using a weighted “popper” attached to the end of a graduated tape. The popper was only used in wells with NAPL or suspected NAPL to prevent interference with, and contamination of the electronic water level indicator. The water level meter was decontaminated between wells in accordance with SOP 190 of the FSP. DNAPL thicknesses were measured by attaching a weight to a length of clean nylon rope and slowly lowering it through the DNAPL to the bottom the well. The rope was then withdrawn from the well and the DNAPL thickness was then determined by measuring the prominent stained section of rope. The stained section of rope was placed on plastic sheeting to prevent contact with the ground surface, and the thickness of DNAPL layer was recorded to the nearest 0.01 foot using a tape measure. DNAPL measurements were completed in accordance with SOP 270 of the FSP.

Following DNAPL measurement activities, the remaining DNAPL was removed from the well using a dedicated bailer or submersible pump and discharged to the interim on-site groundwater treatment system.

2.1.3 Soil Vapor and Air Quality Investigation

The inhalation pathway for potential exposure to hazardous vapors was evaluated by installing vapor probes in the unsaturated zone and collecting vapor samples in the vicinity of the former MGP. Thirteen vapor probes were installed at 10 exterior and one interior location on February 28, 2005 as follows:

- VP-1 was installed in the filled ravine east of the NSPW office building and south of the Service Center building near the southeast corner of the asphalt parking lot;
- VP-2S and VP-2D were installed in the filled ravine near monitoring wells MW-13C and MW-13D located south of St. Clair Street and north of the paved courtyard area;
- VP-3S, VP-3I, and VP-3D were installed in the filled ravine near monitoring well MW-2R in the NSPW storage yard north of St. Claire Street;
- VP-4, VP-5, and VP-6 were installed east of the filled ravine north of St. Claire Street;
- VP-7 and VP-8 were installed in the backfill of the storm sewer line located beneath the center of St. Claire Street;
- VP-9 was installed on the west side of 3rd Street west of the former gas holder located in the southwest corner of the existing facility building, and
- VP-10 (subslab vapor probe) was installed within the NSPW Service Center building, beneath the concrete floor and above the former gas holder located in that area.

RI vapor monitoring probe locations are shown on Figure 2-3.

Vapor probes were installed in two-inch diameter boreholes advanced by a truck mounted Geoprobe (direct push) drill rig. Each vapor probe was constructed with a six-inch long stainless steel mesh soil gas implant (screen) anchored in place by a disposable steel drive point. Implants were connected to ¼-inch nylon tubing, and a removable cap was placed on the surface end of each tube. A 12-inch filter pack consisting of fine sand was placed around the implant, and granular bentonite was placed in the annular space above the filter pack. Nested vapor probes (VP-2S and VP-2D and probes VP-3S, VP-3I, and VP-3D) were installed in a single borehole. Each nylon tube was labeled and encased in a flush mounted protective well casing cemented in place. Vapor probe construction details are summarized below.

Soil Vapor Probe Construction Details			
Soil Vapor Probe ID	**Total Depth of Probe**	**Top of Sand Filter Pack**	**Top of Bentonite Seal**
VP-1	2.0	1.0	0.5
VP-2S	2.0	1.0	0.5
VP-2D	4.0	3.0	2.0
VP-3S	2.0	1.0	0.5
VP-3I	7.0	6.0	2.0
VP-3D	14.0	13.0	7.0
VP-4	2.0	1.0	0.5
VP-5	2.0	1.0	0.5
VP-6	2.0	1.0	0.5
VP-7	2.0	1.0	0.5
VP-8	2.0	1.0	0.5
VP-9	2.0	1.0	0.5
VP-10	3.0	2.0	0.5

Note: All depths reported in feet below ground surface.

All probes were installed in accordance with SOP 360 of the FSP. Boring logs for vapor probe borings are included in Appendix B4.

Two rounds of soil vapor samples were collected following probe installation in accordance with SOP 200 of the FSP. A winter round of samples was collected in March 2005 when the ground was frozen, and a summer round was collected in July 2005 after ground thaw. Winter samples were collected on March 14 and 15, 2005, and summer samples were collected July 19 and 20, 2005. During both rounds, samples were collected from exterior probes VP-1, VP-2S, VP-2D, VP-3S, VP-3I, VP-3D, VP-5, VP-6, VP-7, VP-8, VP-9, and interior probe VP-10 installed beneath the slab floor of the NSPW service center. Samples could not be collected from vapor probe VP-4 during either round because the probe was damaged.

Prior to sample collection, vapor probes VP-1 through VP-10 were purged of standing vapors. A peristaltic pump was used to purge probes in March and a Casella Apex air sampling pump was used in July. After purging a minimum of one gas probe volume, a 6 Liter Summa canister under negative pressure was connected to the vapor probe using ¼-inch Teflon tubing with an in-line particulate filter. The Summa canister valve was opened and the negative pressure in the Summa canister was used to extract soil vapor from the probe. After the pressure in the Summa canister equilibrated, typically within 10 to 30 seconds, the valve was closed. Labeled canisters were then shipped to Severn Trent Laboratories in Knoxville, Tennessee for VOC analysis by USEPA Method TO-15 in accordance with SOP 210 of the FSP.

Indoor and background ambient air samples were also collected concurrent with vapor probe sample collection in accordance with SOP 200 of the FSP. The indoor air sample was collected inside the NSPW Service Center building near vapor probe VP-10 over a 24-hour period. Summa canisters under negative pressure equipped with in-line particulate filters and a laboratory-calibrated 24-hour regulator were used to collect these samples. Background ambient air samples were collected over a one-hour period using a one-hour regulator and particulate in-line filter at locations upwind of the Site as determined by local weather conditions at the time of sample conditions. During the March 2005 sampling event, the wind direction was northeasterly and the background air sample was collected in the NSPW storage yard northeast of St. Claire Street and Prentice Avenue. However, during this winter sampling event, a sampling error occurred with the collection of the ambient indoor air sample. Rather than collect a 24-hour indoor ambient air sample at VP-10, a 24-hour sample was collected directly from the probe. On April 18 and 19, 2005 vapor probe VP-10, was re-sampled and the 24-hour indoor, and the one-hour background samples were recollected. At that time, the wind was southwesterly and the one-hour background air sample was collected in the parking lot for the Our Lady of the Lake School. In July, the one-hour background air sample was again collected in the parking lot of Our Lady of the Lake School as winds were out of the southwest. Labeled canisters from the April and July 2005 sampling events were also shipped to Severn Trent Laboratories in Knoxville, Tennessee for VOC analysis by USEPA Method TO-15 in accordance with SOP 210 of the FSP.

2.1.4 Sediment and Surface Water Investigations

Contaminated sediments in the aquatic portions of the Site were further characterized during the RI. As part of this RI, a number of investigations were completed to supplement historic data. Soil boring logs from previous off shore investigation are included Appendix B5. Investigation results were used to support environmental impact studies and ecological and human health risk assessments for the Site. These investigations included the following:

- Sediment investigation that included samples collected as part of the supplemental sediment sampling and sediment quality triad investigations;
- Sediment toxicity testing;
- Benthic macroinvertebrate community studies;
- Sediment stability assessment (URS 2006b);
- Surface water collection;
- Collection of fish tissue, and
- Characterization of wetlands and terrestrial habitats.

Results of these investigations are presented in reports appended to the Baseline Ecological Risk Assessment Report (BERA), or in reports submitted separately to USEPA as follows:

- Sediment Stability Assessment report (previously submitted to USEPA);
- Sediment Quality Triad Investigation Report (included as Appendix B of the BERA);
- Sediment Investigation Report (included as Attachment 1 to Appendix B of the BERA);
- Overview of Bioassays Report (included as Attachment 2 to Appendix B of the BERA);
- Benthic Community Investigation Report (included as Attachment 2 to Appendix B of the BERA);
- Fish Tissue Investigation Report (included as Appendix C of the BERA);
- Surface Water Investigation Report (included as Appendix D of the BERA), and
- Characterization of Wetlands and Terrestrial Habitats Report (included as Appendix E of the BERA).

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The collection of sediment and surface water samples are described below in Sections 2.1.4.1 and 2.1.4.2. The collection of fish tissue samples and characterization of wetland and terrestrial habitats is described in Section 2.1.5.

2.1.4.1 Sediment Investigation

Sediment samples were collected during three mobilizations between May and September 2005. A reconnaissance survey to identify reference stations was conducted in May 2005, and subsequent samples were collected in June and September. These investigations were conducted in accordance with the approved RI Work Plan. Details are provided in Appendix B (Attachment 1) to the BERA.

2.1.4.2 Surface Water Sample Collection

Surface water samples were collected during both low- and high-energy events to evaluate surface water impacts from contaminated soil in the Chequamegon Bay inlet area adjacent to Kreher Park. The low energy samples were collected under conditions of low winds, small waves and/or wind chop. The high-energy samples were collected during a period where wave conditions exceeded 30 centimeters during the 24-hour period prior to sampling. This investigation was conducted in accordance with the approved RI Work Plan. Details are provided in Appendix D to the BERA.

2.1.5 Ecological Investigations

2.1.5.1 Sediment Quality Triad

In addition to collecting sediment samples for bulk sediment chemistry, samples were collected for use in sediment toxicity testing and for benthic invertebrate community analyses. Additionally, fish tissue samples were collected and Site wetland and terrestrial habitat were characterized. Results of these investigations are presented in reports appended to the BERA, or in reports submitted separately to USEPA (see Section 2.1.4 for a complete list). This investigation was conducted in accordance with the approved RI Work Plan. Details are provided in Appendix B to the BERA.

2.1.5.2 Fish Tissue

Smelt sampling was performed in April 2004 in accordance with the approved April 2004 Work Plan addendum. It was again performed in April 2005. Smelt specimens were collected, at the height of the seasonal run in the Ashland area. The collection of fish tissue samples was also conducted for the HHRA and the BERA in accordance with the approved RI Work Plan. Other target species were collected during the week of June 17 through June 20. These species consisted of:

- Walleye (HHRA);
- Smallmouth bass (BERA);
- Brown bullhead (BERA), and
- Shorthead redhorse (HHRA).

2.1.5.3 Characterization of Wetland and Terrestrial Habitats

The upland habitat was evaluated on June 15, 2005 by a URS environmental scientist. The survey was conducted in accordance with the approved RI Work Plan. Details are provided in Appendix C to the BERA.

2.1.6 Site Mapping

The Site was surveyed by Coleman Engineering of Iron Mountain, Michigan in May and June 2005. This survey included roads, buildings, and topographic elevations. Additionally, this survey also included all permanent monitoring locations (i.e., monitoring wells, extraction well passive diffusion bag wells, and vapor probe locations), and the approximate locations of buried

utilities. In addition to vertical control, the elevation of the top of each PVC well casing for existing and new wells was surveyed as the reference elevation from which groundwater elevations are derived. Coleman provided both paper and electronic survey maps from which site maps utilized in this report were created. June 2005 test pit locations were surveyed by Coleman prior to completing this investigation. Geoprobe boring locations, surface sample locations, and November 2005 test pit locations were determined relative to site datum from field measurements. The lateral extent of the wetland area at Kreher Park and several surface soil sample locations were located by a portable GPS. Reference station locations in Chequamegon Bay were recorded using portable GPS.

In addition to the survey of upland portions of the Site, side-scan sonar, subbottom profile and hydrographic surveys were performed to document bathymetric conditions and geomorphology of the sediment surface in aquatic portions of the Site (See Appendix B, Attachment 1 for a description of he latter surveys).

2.2 Analytical Sample Summary

The RI included the collection of additional soil, groundwater, and air samples from the Site. Soil samples included surface samples and subsurface soils collected from Geoprobe borings. Groundwater samples included samples collected from all site monitoring wells and two artesian wells located in Kreher Park. Air samples included soil gas samples collected from monitoring probes, indoor ambient air samples collected from inside the NSPW service center building, and outdoor background ambient air samples. An analytical sample summary for these soil, groundwater, and air samples is presented below in Sections 2.2.1 through 2.2.3, respectively. RI samples locations at the upper bluff are shown on Figure 2-3, and sample location at Kreher Park are shown on Figure 2-4. (Historical soil boring locations in the upper bluff area and in Kreher Park are shown on Figure 2-2.)

Sediment and surface water investigations were also completed during the RI. These investigations include the collection of sediment and surface water samples, and ecological testing of benthic organisms and fish tissue samples. An analytical sample summary for sediment and surface water samples is presented below in Section 2.2.4, and an analytical sample summary for ecological samples is presented in Section 2.2.5. RI sediment samples locations in the Chequamegon Bay inlet area are shown on Figure 2-5, and RI sediment reference sample locations in Chequamegon Bay are shown on Figure 2-6.

The data were checked against the data quality objectives (DQOs) identified in the approved Quality Assurance Project Plan (QAPP) (URS, 2005). Details of the procedures for assessing the precision, accuracy, representativeness, completeness and comparability of field data and analytical laboratory data are described in the QAPP. Qualifications to the data usability are discussed in the quality assurance section of any reports presenting the data. Data generated under this program were considered technically sound and of sufficient quality and quantity to support the needs of the data users. Laboratory reports are included in Appendix E, and the results of the quality assurance/quality control evaluation are provided in Appendix F. Appendix G includes all data validation reports.

2.2.1 Soil Samples

As described in Section 2.1.1.2 above, the RI included the collection of surface soil samples from Kreher Park and the Upper bluff.

A total of 24 surface soil samples were collected from locations SS-11, SS-12, SS-13 and exploration test pit locations TP-100 through TP-121 in Kreher Park. An additional 8 surface soil were collected at locations SS-14 through SS-21 samples were collected from unpaved areas in the vicinity of the former MGP, and 4 surface soil samples were collected from borings SS-22, SS-23, SS-24, and SS-25 as background sample at the upper bluff. All samples were collected in laboratory provided containers, submitted to Northern Lake Service, Inc, in Crandon, Wisconsin, and analyzed for VOCs, SVOCs, and inorganic compounds included in Table 2-6[21] Laboratory reports are included in Appendix E1.

As described in Section 2.1.1.3 above, the RI included the collection of subsurface soil samples from Geoprobe borings advanced at the upper bluff in the vicinity of the former MGP, and at Kreher Park in the vicinity of the former seep area and near TW-11. A total of 94 subsurface soil samples were collected from 38 soil borings advanced at locations GP-100 through GP-137 in the vicinity of the former MGP in the upper bluff area. Borings GP-138 and GP-159 through GP-161 were advanced at background locations, and 11 subsurface soil samples were collected at these locations. In the TW-11 area, 15 soil samples were collected from eight borings (GP-139 through GP-146), and 19 samples were collected from 12 borings (GP-147 through GP-158). All samples were collected in laboratory provided containers, submitted to Northern Lake

[21] Table 2-6 is a list of compounds that was determined by Battelle under contract with SEH as site specific contaminants. This list was derived by Battelle following data review and validation on historic site analytical results.

Service, Inc, in Crandon, Wisconsin, and analyzed for VOCs, SVOCs, and inorganic compounds included in Table 2-6. Laboratory results are summarized in Appendix E1.

As described in Section 2.1.1.4, samples were also collected from exploration test pits for forensic analyses when NAPL was encountered.. These samples were analyzed for a selected list of forensic parameters by the Woods Hole Group.

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2.2.2 Groundwater Samples

As described in Section 2.1.2, there are 70 monitoring wells in the Site monitoring network. Three of these wells (P-24, P-25, and P-26) were used only for water level measurements. Samples were not collected from wells containing more than one-foot of DNAPL, but samples were collected from the remaining wells. Samples collected in December 2003 and March 2004 included wells MW-2C, MW-15A, MW-15B, and MW-21B installed in December 2003. Samples collected in June 2004, September 2004, December 2004, and March 2005 included samples collected from wells MW-7R, MW-7B, MW-23A, MW-23B, MW-24, MW-24A, MW-25, MW-25A, MW-26, and MW-26A installed in May 2004. Monitoring well locations are shown on Figure 2-1. All samples were collected in laboratory provided containers, submitted to Northern Lake Service, Inc, in Crandon, Wisconsin, and analyzed for VOCs, SVOCs, and inorganic compounds included in Table 2-6. Laboratory results are summarized in Appendix E2.

2.2.3 Soil Vapor and Ambient Air Samples

As described in Section 2.1.3 above, soil vapor samples were collected from monitoring probes in March and July 2005, and indoor ambient and outdoor ambient background samples were collected in April and July 2005. Vapor probe locations are shown on Figure 2-3. All soil vapor, indoor air, and background air samples were collected in Summa canisters provided by the laboratory, and submitted to Severn Trent Laboratories in Knoxville, Tennessee, and analyzed for VOCs by EPA Method TO15A. The VOCs included in this analysis are listed in Table 2-7[22] Laboratory results are summarized in Appendix E3.

[22] The TO-15 parameter list is larger than the VOCs list included in Table 2-7 soil/groundwater/sediments list derived by Battelle (see Footnote #19).

2.2.4 Sediment and Surface Water Samples

As described in Section 2.1.4, sediment and surface water samples were collected from aquatic portions of the site from reference stations in the surrounding Chequamegon Bay. Surface water and sediment sample locations are shown on Figures 2-5, 2-6, and 2-7. Sediment samples were collected in accordance with SOP 250, and surface water samples were collected in accordance with SOP 310 in the FSP. Following sample retrieval, sediment and surface water samples were collected in laboratory provided containers, submitted to Northern Lake Service, Inc, in Crandon, Wisconsin, and analyzed for VOCs, SVOCs, TOC and inorganic compounds included in Table 2-6. Samples were placed into a cooler on ice, and shipped to Northern Lake Service in Crandon, Wisconsin in accordance with SOP 210 of the FSP. Laboratory results are summarized in Appendix E4.

During a reconnaissance study of site sediments, sediment samples were also submitted to an on-site mobile laboratory, and results were obtained within 12 hours to screen potential samples locations. Mobile laboratory services were provided by Environmental Chemistry Consulting Services, Inc. (ECCS) of Madison, Wisconsin. Sediment samples selected for grain size (ASTM D422) and TOC were analyzed by Severn Trent Laboratories in Burlington, Vermont.

2.2.5 Ecological Testing

As described in Section 2.1.5 above, bioassay and benthic community studies were completed on samples collected from Chequamegon Bay. Sediment samples were collected from a total of six reference stations and eight Site stations. Bioassays included the following:

- 28-day exposure of *Hyalella azteca*;
- 21-day exposure of *Hyalella azteca* to reference sediment only;
- 28-day exposure of *Hyalella azteca* to new reference sediment and previous non-reference sediment;
- ten-day exposure of *Hyalella azteca* to a sediment dilution series under laboratory and ultraviolet light conditions with some treatments containing detritus;
- one seven-day fathead minnow exposure;
- one seven-day fathead minnow exposure under ultraviolet light,
- early life stage *Chironomus dilutus* exposure, and
- *Lumbriculus variegatus* bioaccumulation study.

The endpoints of survival and growth were determined for most studies except for the bioaccumulation study and PAH equilibrium study. Only survival was used as an endpoint for the 21-day exposure of *Hyalella azteca* to the newly collected reference sediment.

Bioassay samples were collected in laboratory provided containers, placed into a cooler on ice, and shipped to the appropriate laboratory for analysis. Benthic community samples remained preserved in ethanol until delivery to the laboratory. Samples for sediment bioassays were relinquished to a representative of the LSRI Superior, Wisconsin. Coolers were shipped in accordance with SOP 210 of the FSP at the completion of each sampling day. Benthic community samples were returned to the URS Milwaukee office, packaged for hazardous material shipment, and shipped to Aquatic Resources Center in Nashville, Tennessee who did the sample identification. All samples were received in satisfactory condition by each respective laboratory.

As described in section 2.1.5 fish tissue samples were also collected. Fish tissue samples were analyzed for lipids using a laboratory specific gravimetric method and PAHs analyzed by EPA Method 8270C SIM by Severn Trent Laboratories in Burlington, Vermont. Laboratory results are summarized in Appendix E5.

3.0 SITE PHYSICAL CHARACTERISTICS

Site physical characteristics were determined from previous investigations and supplemental investigations completed during the RI. These investigations focused on characterizing the nature and extent of contamination in the vicinity of source areas. A detailed description of regional and site geologic and hydrogeologic conditions, surface water and sediment characteristics of the Chequamegon Bay inlet area is included in this section. Site ecological conditions and meteorological conditions, demographics, and land use in the vicinity of the site are also described in detail below.

3.1 Regional and Site Geology

Regional geology in the Ashland area consists of unconsolidated glacial deposits overlying Precambrian aged sedimentary bedrock. Unconsolidated deposits consist of the Miller Creek Formation, which overlies the Copper Falls Formation. Precambrian-aged sandstone of the Oronto Group, is the uppermost bedrock unit in the Ashland area. Thickness of the sandstone unit has not been determined. The Oronto sandstone is most likely underlain by Precambrian basalt. Geologic cross-sections showing Site geologic units are shown on Figures 3-1 through 3-7.

Surficial soils in the Ashland area are underlain by red clay and silt deposits of the Miller Creek Formation, the predominant surficial lithologic unit in the Ashland area. The Miller Creek Formation is a fine-grained clayey silt to silty clay. It consists of lacustrine deposits and glacial till deposited during the last major advance of glacial ice. The thickness of the Miller Creek Formation in the Ashland area ranges from approximately 15 to 50 feet based on local well logs. The Miller Creek Formation encountered at the Site consists of clays, silts and sands and ranges in thickness from 5.5 to 40 feet. The thinnest portion of the Miller Creek Formation at the Site is found at the base of the bluff where the former lake shoreline was located.[23] This thin zone likely resulted from wave erosion of the Miller Creek Formation, forming the "bench" shaped bluff and former lake shoreline. Data from soil borings and downhole geophysics confirm that the Miller Creek Formation thickens to the north of the bluff.

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Sand and gravel layers interbedded with silty clay lenses have been encountered near the contact of the Miller Creek Formation and the underlying Copper Falls Formation. The Copper Falls Formation consists of interbedded glacial clays, sands, and gravels. To the south, beneath the

[23] The boring log at the MW-7A well indicates clay from 12 to 17.5 feet. For this report, it is assumed this location is the thinnest portion of the Miller Creek Formation.

NSPW facility, the Copper Falls consists of silty sands with discontinuous lenses of silty clay and silt. To the north, beneath Kreher Park, the Copper Falls Formation consists of clean sands with occasional gravel intervals, interpreted to be outwash sediments. The Copper Falls occurs between 25 and 55 feet bgs in the Ashland area and is more than 100 feet thick. It is 155 feet thick at the MW-2C locations, the only boring in which Precambrian sandstone bedrock was encountered.

In addition to unconsolidated glacial deposits, fill soil units are present beneath the upper bluff area and Kreher Park. Fill soil encountered in the upper bluff area was placed in a former ravine that dissected the Miller Creek Formation in the vicinity of the former MGP facility. Historic documents indicate that the ravine was filled by 1909. Kreher Park consists of fill material used to fill the former lakebed. Historic documents indicate that the former lakebed was filled beginning in the late 1800s, and continued to be altered by filling activities until the 1950s.

The ravine fill unit consists of silty clay fill material mixed with solid and liquid MGP wastes, ash, cinders, slag, and fragments of concrete and brick, glass bottles, scrap steel, and wire. There are also minor amounts of wood waste, although this material does not appear to originate from the former MGP. As shown on Figures 1-2 and 1-3, the backfilled ravine is located on the NSPW property and extends from the bluff slope south beneath the NSPW storage yard, St. Claire Street, and the NSPW service center. The former ravine is deepest at the current bluff face where the ravine formerly opened to the former lake shoreline. The fill thickness along the center line of the former ravine ranges from 28 feet near the bluff face to 15 feet beneath the NSPW service center facility. The ravine fill thickness diminishes at the east and west flanks, and at the southernmost extent of the former ravine south of the NSPW service building. Based on historic Sanborn maps and confirmed by exploration borings, the width of the ravine narrows from approximately 90 feet at St. Claire Street to about 30 feet at the east-west portion of the service center building. Clay soils of the underlying Miller Creek Formation were encountered at the base of the former ravine. The thickness of these soils has been measured at as little as 5.5 feet of clay and sand lenses at one soil boring location (at the mouth of ravine where it opened to the former lake shoreline).

Fill material at Kreher Park consists predominantly of silty clay soil mixed with rocks, bricks, concrete, wood, and miscellaneous debris. A buried clay berm is also located along the shoreline on the northeast side of the Site near the former WWTP. This fill unit ranges in thickness from 3 to 7 feet. A wood waste layer consisting of wood planks was encountered beneath the fill soil. Native soil underlying the fill unit includes a beach sand layer (predating filling of the lakebed) that ranges in thickness from 0 to 5.5 feet at Kreher Park. The Miller Creek Formation was

encountered below the fill and beach sand and ranges in thickness from 7 feet at the MW-7 well nest to 40 feet at the MW-26 well nest.

Offshore geology of the Chequamegon Bay inlet area consists of a discontinuous layer of submerged wood chips and debris of varying size on the lake bottom underlain by variably fine to medium grained sediments. The sediments are underlain by silts and clays of the Miller Creek Formation. The Copper Falls Formation was not encountered during investigation of the offshore sediments. Consequently, the thickness of the Miller Creek Formation below the bay is unknown.

3.2 Regional and Site Hydrogeology

3.2.1 Regional Hydrogeology

Regional hydrogeologic units correspond to regional geologic units. The three aquifers that occur in the Lake Superior Basin in the vicinity of Ashland include the following:

- The Pleistocene sand and gravel aquifer (Copper Falls Formation);
- The Precambrian sandstone aquifer (Oronto Formation); and
- The Precambrian basalt aquifer.

The deep Precambrian aquifers produces moderate to low yields of groundwater. Yields in the basalt are typically controlled by fracture densities within the aquifer. The basalt aquifer is commonly used as a water supply source south of Ashland where the aquifer occurs closer to the surface. Site investigation results indicate that soil and groundwater contamination is limited to the unconsolidated glacial deposits and fill soil units. Consequently, neither bedrock aquifer was characterized during the RI.

The Copper Falls aquifer occurs between 25 to 55 feet below ground surface in the Ashland area. Based on deep piezometer boring information, the Copper Falls aquifer is over 150 feet think. Sandy till units within the aquifer yield low volumes of water (5 to 10 gpm), while sand and gravel lenses can yield up to 100 gpm. The Copper Falls aquifer is confined by the overlying Miller Creek Formation near the Chequamegon Bay shoreline where the Miller Creek Formation has a higher plasticity and clay content. The low permeability Miller Creek Formation functions as an aquitard for the underlying Copper Falls aquifer in this area.

Wells screened in the Copper Falls aquifer frequently exhibit artesian conditions in the Ashland area, particularly close to the Chequamegon Bay shoreline. Static heads of more than 12 feet above the surface of Lake Superior have been reported at some locations along the Ashland shoreline.

3.2.2 Site Hydrogeology

Site Hydrogeologic Units

Unconsolidated glacial deposits and fill soil units encountered during site investigations correspond to Site hydrogeologic units. The uppermost water bearing unit at the upper bluff area is the Miller Creek Formation. In this unit the water table is encountered between one and six feet bgs, but it fluctuates several feet seasonally, typical of fine-grained soils. Because the ravine fill soil unit overlies the Miller Creek Formation at the upper bluff, the ravine fill soil unit is the uppermost water bearing unit. The ravine fill unit behaves as a perched aquifer within the surrounding Miller Creek Formation. The water table in the ravine fill is encountered between three and six feet bgs on the south side of St. Claire Street, and between 10 and 20 feet bgs on the north side of St. Claire Street. However, groundwater elevations in the ravine fill fluctuate seasonally in response to localized precipitation. The direction of groundwater flow in both the Miller Creek and saturated ravine fill soils is to the north toward the bluff face separating Kreher Park from the upper bluff (see Figures 3-8 and 3-9).

At Kreher Park, the uppermost water bearing unit is the fill material that forms the area of the former lakebed. These fill soils overlie a beach sand unit, which in turn overlies the Miller Creek Formation. The water table in this fill unit is encountered between four and seven feet below ground surface. Groundwater elevations in saturated Kreher Park fill units also fluctuate seasonally. The general direction of flow in the Kreher Park fill soil units is to the north toward Chequamegon Bay (see Figures 3-8 and 3-9).

The fine-grained Miller Creek Formation separates the overlying fill soil units encountered at Kreher Park and in the upper bluff from the underlying Copper Falls aquifer. It also behaves as a confining unit for the underlying Copper Falls aquifer along the lakeshore and bluff areas. An upward hydraulic gradient is present in the Copper Falls aquifer in the northern portion of the upper bluff, and diminishes eventually changing to a downward gradient to the south. The general direction of flow in the Copper Falls aquifer is to the north towards Chequamegon Bay (see Figures 3-10 through 3-13).

Permeability of Site Hydrogeologic Units

The permeability of Site hydrogeologic units was determined from laboratory permeability tests, in-situ hydraulic conductivity tests completed on site monitoring wells, and an aquifer performance test (APT) completed in extraction well EW-1 prior to installation of the interim response product recovery system (SEH 1995, Dames & Moore 1996, 1997, and 1998). Laboratory permeability tests were completed on undisturbed soil samples collected with thin walled tubes at the MW-4A, MW-4B, and MW-13A well locations. In-situ hydraulic conductivity tests included bail recovery tests and "slug" tests. Bail recovery tests were performed by lowering the water level in the well by bailing, and measuring water levels as the well recovered. Slug tests were performed on wells that recovered quickly. Slug tests were performed by removing a "slug" of water with a bailer and measuring water levels as the well recovered with a pressure transducer installed in the well with a data logger. The APT completed on EW-1 was performed in September 1997 and consisted of a 48-hour constant rate test followed by a recovery test. Permeability information obtained during previous investigations is summarized below.

NSPW Ashland Lakefront
Hydraulic Conductivity Measurement Results

Well Location	Hydrogeologic Unit	Sample Depth or Filter Pack Interval (ft.)	Hydraulic Conductivity - Slug Test/Bail Recovery Test (cm/sec)	Hydraulic Conductivity- Thin Wall Tube Samples (cm/sec)
MW-1	Ravine Fill	9 – 21.5	3.4×10^{-5}	
MW-2	Ravine Fill	8 – 21	5.36×10^{-4}	
MW-3	Ravine Fill	3 – 16	7.34×10^{-3}	
MW-4	Ravine Fill	4 – 15.5	6.83×10^{-5}	
MW-5	Ravine Fill	16 - 28.5	5.4×10^{-3}	
MW-6	Ravine Fill	2.5 – 18	6.7×10^{-5}	
TW-13	Ravine Fill	3 – 14	1.36×10^{-4}	
MW-4A	Miller Creek Formation	15.75		4.6×10^{-8}
MW-4B	Miller Creek Formation	21.5		4.5×10^{-8}
MW-8	Miller Creek Formation	5 – 16	2.5×10^{-6}	
MW-10	Miller Creek Formation	4 – 21	8.5×10^{-7}	
MW-13A	Miller Creek Formation	25		6.9×10^{-8}
MW-1(NET)	Kreher Park Fill	3 – 14	1.03×10^{-1}	
MW-2(NET)	Kreher Park Fill	2.5 – 13.5	2.27×10^{-2}	
MW-3(NET)	Kreher Park Fill	4 – 15	1.23×10^{-3}	
MW-7	Kreher Park Fill	4.5 – 15	1.6×10^{-4}	
TW-6	Kreher Park Fill	3 – 14	6.23×10^{-4}	
TW-9	Kreher Park Fill	3 – 14	9.08×10^{-2}	
TW-11	Kreher Park Fill	3 – 14	2.89×10^{-5}	
TW-12	Kreher Park Fill	3 – 14	9.34×10^{-2}	

NSPW Ashland Lakefront Hydraulic Conductivity Measurement Results				
Well Location	**Hydrogeologic Unit**	**Sample Depth or Filter Pack Interval (ft.)**	**Hydraulic Conductivity - Slug Test/Bail Recovery Test (cm/sec)**	**Hydraulic Conductivity- Thin Wall Tube Samples (cm/sec)**
MW-4A	Copper Falls Aquifer	19 - 27	7.4×10^{-5}	
MW-4B	Copper Falls Aquifer	48 - 55.5	7.2×10^{-4}	
MW-5A	Copper Falls Aquifer	30.5 – 34	1.1×10^{-4}	
MW-5B	Copper Falls Aquifer	42 – 49	1.5×10^{-3}	
MW-5C	Copper Falls Aquifer	69 – 76	6.6×10^{-4}	
MW-6A	Copper Falls Aquifer	40.8 - 47.5	6.7×10^{-4}	
MW-8A	Copper Falls Aquifer	43 – 50	1.4×10^{-6}	
MW-9A	Copper Falls Aquifer	128.5 - 136	1.2×10^{-2}	
MW-10A	Copper Falls aquifer	44 – 50	1.1×10^{-5}	
MW-13A	Copper Falls Aquifer	38 – 46	9.4×10^{-4}	
MW-13B	Copper Falls Aquifer	63 – 70	3.7×10^{-4}	
EW-1	Copper Falls Aquifer	32 - 56	3.64×10^{-5}	

Notes: 1- No slug test performed on MW-7A and MW-2A(NET); artesian flow.
2- MW-4A, MW-6, MW-7, MW-8, MW-8A, MW-9A, MW-10, and MW-10A were bail recovery tests; all other well hydraulic conductivity measurements were derived from slug tests.
3- Laboratory permeability tests performed on thin wall tube samples utilized back pressure constant head method.

Permeability test results of the Miller Creek Formation yielded hydraulic conductivity values ranging from 2.5×10^{-6} to 4.5×10^{-8} cm/sec. Fill soils located in the former ravine yielded hydraulic conductivity values ranging from 5.4×10^{-3} to 7.3×10^{-5} cm/sec, approximately 1,000 times higher than the surrounding Miller Creek Formation soils. Fill soils in Kreher Park yielded permeability test results between 1.3×10^{-1} to 2.9×10^{-5} cm/sec. The higher hydraulic conductivity values are typically found in locations with saturated wood waste fill; the permeability of the wood waste layer likely contributes to this wide permeability range for Kreher Park fill soils.

Permeability test results on the Copper Falls aquifer yielded hydraulic conductivity values ranging from 1.4×10^{-6} cm/sec at MW-8A to 1.2×10^{-2} cm/sec at MW-9A. Well MW-9A is screened in the clean glacial outwash sands encountered in the lower portions of the Copper Falls Formation. The permeability of these clean sands is nearly two orders of magnitude greater than the permeability of the silty sand layer encountered at shallow intervals in the Copper Falls Formation. The range of hydraulic conductivity values at wells MW-4B, MW-5A, MW-5B, MW-5C, MW-6A, MW-13A, and MW-13B screened in the silty sand unit is narrow. (1.1×10^{-4} cm/sec to 1.5×10^{-3} cm/sec). An average hydraulic conductivity calculated from these seven wells screened in the upper Copper Falls is 8×10^{-4} cm/sec. Wells MW-4A, MW-8A, and MW-10A were also screened in silty sand layers of the Copper Falls, but yielded lower hydraulic

conductivity values (7.4×10^{-5} cm/sec, 1.4×10^{-6} cm/sec and 1.1×10^{-5} cm/sec, respectively). These lower hydraulic conductivity values result from a higher percentage of fines within the silty sand layers.

Groundwater Flow Conditions of Site Hydrogeologic Units

Based on June and November 2005 groundwater elevations, the direction of groundwater flow at the upper bluff is to the north toward the bluff face separating the upper bluff area from Kreher Park (see Figures 3-8 and 3-9). The horizontal hydraulic gradient of the Miller Creek Formation at the upper bluff area is 0.1 ft/ft. A groundwater mound centered over the backfilled ravine is located beneath the NSPW service center on the south side of St. Claire Street. On the north side of St. Claire Street, the horizontal hydraulic gradient of the ravine fill soil is similar to the Miller Creek (approximately 0.1 ft/ft).

At the upper bluff, the depth to water (relative to ground surface) increases to the north, toward the bluff face separating the upland area from Kreher Park. This indicates that groundwater from the Miller Creek Formation discharges to Kreher Park. Seeps are common along the bluff face along the former Lake Superior shoreline. Groundwater elevations in the backfilled ravine also indicate groundwater discharges through the mouth of the former ravine into Kreher Park. An intermittent groundwater discharge to the surface used to be present at the base of the bluff at Kreher Park near the proximity of the mouth of the former ravine in the form of a seep. Surface water in the seep contained elevated concentrations of COPCs (including free-product). Because of its location near the mouth of the former ravine, it was initially believed to be a discharge for ravine groundwater intersecting a low permeability layer (i.e., the Miller Creek), causing it to discharge to the surface. However, water levels in standpipes installed immediately adjacent to the seep yielded much lower head levels. This seep was found to be caused by a buried 12-inch clay tile pipe that traversed the length of the ravine at its base, acting as a groundwater and contaminant conduit. The elevation of the seep was more than five feet above the water table levels measured in MW-7, formerly located immediately adjacent to the seep.[24] As described above, the buried pipe was located and the seep area capped as part of the 2002 interim action response.

Groundwater elevations measured in wells screened in the Kreher Park fill soils indicate that the horizontal hydraulic gradient in this fill unit is flat (< 0.0004 ft/ft to the north measured during

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[24] MW-7 was abandoned during the 2002 interim action; it was replaced by MW-7R in May 2004.

June 2004) consistent with similar filled lake bottom areas. Groundwater is encountered at elevations between 602 and 604 feet MSL (see Table 2-4). The direction of groundwater flow is generally toward the shoreline. However, groundwater elevations measured at MW-3NET are consistently lower than measured at other well locations at Kreher Park (see Table 2-4). Lower groundwater elevations have also been measured for wells TW-9 and TW-12. These results indicate that local groundwater flow in the fill soil in Kreher Park is influenced by the type of fill encountered. Hydraulic conductivities of these fill soils range from 0.1 to 10^{-5} cm/sec; the higher hydraulic conductivity values are typically found in locations with saturated wood waste fill.

Groundwater elevations measured in water table observation wells and shallow piezometers installed in the fill soil along the existing shoreline indicate that groundwater in the fill soil is hydraulically connected with surface water in the adjacent Chequamegon Bay. At the MW-24/P-24 location, upward vertical gradients were observed between June 2004 and November 2005 indicating this is a groundwater discharge area. At the MW-25/P-25 location, upward gradients were measured in September 2004, March 2005, and November 2005, but downward vertical gradients were measured in June 2004, December 2004, and June 2005 indicating both recharge and discharge conditions. At the MW-26/P-26 location, upward gradients were measured in September 2004, but downward vertical gradients were measured in June 2004 and between December 2004 and November 2005, indicating predominantly recharge conditions at this location. These variations in vertical gradients along the shoreline indicate that the groundwater-surface water interaction between the fill and the bay is influenced by perturbations (e.g., wave and storm events) in lake levels. Additionally, variations in permeability values measured in the fill account for a non-uniform water table surface (the surface is very flat, and flow direction has widely varied between measurements).

As described earlier, groundwater discharge from the Miller Creek Formation to surface water (the original Lake Superior shoreline) has been measured. However, the low permeability of the Miller Creek confirms that this constitutes a very low volume. The great majority of the contribution to surface water (and groundwater) at the Site is from surface runoff. Runoff will have a significant effect on lake levels, and therefore affect groundwater/surface water interaction.

These flow variations are also documented by the diffusion bag data. The west line of diffusion bags showed increasing VOC (primarily benzene) levels with decreasing distance toward the shoreline; the east line showed no variation in VOC levels (see Section 4.3.2). This indicates that surface water (or suspended sediment) may flow some relatively small distance beneath Kreher Park, depending on lake levels at any one time.

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As discussed the Miller Creek Formation behaves as a confining unit beneath Kreher Park separating the overlying ravine fill and Kreher Park fill soil units from the underlying Copper Falls aquifer. Artesian conditions are present at the Site in the Copper Falls aquifer. Hydraulic head levels approximately 12 feet above ground surface have been measured at piezometers installed along the shoreline. Artesian conditions have not been observed in the Copper Falls aquifer in the vicinity of the former ravine area or the upper bluff area. Upward hydraulic gradients are present in the Copper Falls aquifer in the northern portion of the upper bluff area, but diminish and eventually change to downward gradients to the south of the NSPW service center building. The Miller Creek Formation becomes less cohesive and thinner in the area at the head of the backfilled ravine. Consequently, the confining conditions dissipate, and downward gradients in the Copper Falls aquifer are measured.

As shown on Figures 3-10 and 3-11, the direction of flow in the upper Copper Falls aquifer beneath the Upper Bluff and southern portion of Kreher Park is to the north toward Chequamegon Bay. As shown on Figures 3-12 and 3-13, groundwater flow within the lower Copper Falls aquifer is also northerly toward Chequamegon Bay. However, Figures 3-10 and 3-11 identify an area of groundwater flow convergence beneath the middle of Kreher Park, near MW-02BNET. This flow pattern is indicative of a potential groundwater stagnation zone. Cross-sectional information shown on Figures 3-2, 3-3 and 3-4 confirm that the Miller Creek aquitard thickens (and deepens) to the north from this potential stagnation zone. These same figures also show flowlines converging at this point. Although discharge through the Miller Creek is likely, the low vertical permeability (see table on page 3-5) of this unit indicates the discharge through the aquitard is very low.

Figures 3-12 and 3-13 indicate that regional flow in the deep zones of the Copper Falls Aquifer continue northward. These northward trending flowlines are also shown on the cross-sections (Figures 3-2 through 3-4). Although the shallow zone is convergent at the potential stagnation zone, the regional flow shows a northerly trend.

3.3 Surface Water Hydrology

In the Ashland area, regional surface water drainage flows to the north through Fish Creek and several small unnamed creeks and swales into Chequamegon Bay. Surface water at the Site flows either to the City of Ashland storm sewer system, or discharges directly to Chequamegon Bay. Information provided by the City of Ashland's Department of Public Works indicates that the City had a combined storm and sanitary sewerage system until the early to mid 1980's. The

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Deleted: However, the near surface flow lines streamlines Water level data from piezometers screened below the Miller Creek clay at Kreher Park indicate , where groundwater could be leaking up through the Miller Creek Formation to the shallow groundwater system. Another potential option is that groundwater in the vicinity of these converging flow lines flows laterally, and parallel to the shoreline. This is an area with limited groundwater monitoring points in the Copper Falls aquifer; therefore, the exact flow conditions and directions cannot be quantified in this portion of the Copper Falls. However, the most likely scenario is that groundwater flows northeast or southwest in this area and ultimately discharges to Chequamegon Bay.

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storm sewer system was separated from the sanitary system at that time to reduce flow to the former WWTP. In the past, storm water discharged directly to Chequamegon Bay through three known outfalls within the Site. Those outfalls have been closed and storm water is now re-routed to a discharge point east of the site.[25]

An open sewer is depicted on historic Sanborn Fire Insurance maps dating from 1901 to 1951 on the western portion of Kreher Park. The head of the sewer is shown at a location about two-thirds of the distance from the shoreline to the bluff face with no identified upstream inlet. An east-west trending clay pipe leading to the former open sewer was identified during a supplemental test pit investigation completed in November 2005 (see Section 2.1.4). It is unknown if the open sewer was used for storm water or sanitary water discharge to Chequamegon Bay; however, contaminants consistent with MGP waste tars were encountered from the pipe terminus along the reach of the former open sewer to shoreline.

No contaminants were detected in twelve unfiltered surface water samples collected on January 14 and 15, 1998 by SEH. However, in one unfiltered water column sample collected during a period on May 14, 1998, when wave heights were estimated to be between 60 and 90 cm,[26] benzo(a)anthracene and benzo(a)pyrene exceeded secondary chronic and acute water quality criteria values, respectively. No VOCs exceeded water quality criteria in that sample. It is unknown whether the contaminants in this sample were adsorbed onto suspended particulates or in a dissolved state. However, it is likely they were bound to suspended particles because more water soluble PAHs that are much more abundant in the Site sediments (i.e., anthracene), were not detected. However, the physicochemical characteristics of the sediment previously sampled suggest that concentrations of contaminants in sediments would be higher than the concentrations in the overlying water column. The relatively high octanol-organic carbon partition coefficient (K_{oc}) will tend to concentrate most of the Site COPCs in the sediment. The level of COPCs is highest at the wood debris/sediment-water interface and generally decreases with depth, although exceptions were found at a few locations. The mode of contaminant transport to sediments was likely through disposal of liquid MGP waste in the open ravine.

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[25] A map provided by the City of Ashland showing the location of the current storm sewer network in the Site area is included in Appendix G of the Work Plan. During 2003, the City rerouted storm sewers along St. Claire Street at Prentice Avenue, 2nd Avenue East and 3rd Avenue East through a water quality treatment basin located at the north end of 5th Avenue East. This collected storm water is then discharged through the RV park area of Kreher Park (east of the Site) to Chequamegon Bay. One additional bypass is routed along Prentice Avenue through the Site to a discharge near the former WWTP (Appendix G). However, the City indicated this bypass does not flow except during large rainfall events.

[26] It is likely this estimate was based upon crest to trough height rather than wave height compared to lake surface.

disposal of liquid MGP waste through the clay tile and pipe network to the open sewer, backfilling, subsurface seeps, historic surface water runoff, or possible discharge of contaminants from one or more source areas (other possible industrial activities at the lakefront).

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As described in Section 2.1.4.2, surface water samples were collected during both low- and high-energy events to evaluate surface water impacts from contaminated soil in the Chequamegon Bay inlet area adjacent to Kreher Park. For the majority of samples, no contaminants were detected, including those collected during the high energy sampling event. VOCs including benzene, ethylbenzene, toluene and xylenes, along with fewer detections of PAHs were detected at very low levels in a few samples. Most of these detections were reported at estimated values because constituents were detected between the method detection limit (MDL) and limit of quantitation. Only one ecological sample and one human health sample yielded quantifiable values of benzene (ERA 07 1105-NB-FIL at 0.53 µg/l, and HHRA3-1105-UNF at 0.74 µg/l). All reported detections for PAHs were estimated concentrations; the highest estimated concentration for naphthalene was 2 µg/L. No reported concentrations exceeded U.S. EPA Region 9 ecological screening levels (ESLs) or comparable screening criteria. Sample results are included in the Surface Water Investigation report included in Appendix D of the BERA.

The WDNR received a report from a citizen on November 15, 2005 that high winds at the time likely caused several oil slicks to form in the affected area of the bay inlet. USEPA subsequently forwarded several photos taken of these slicks to NSPW. These observations confirm that free product within the bay and contaminants in sediment are released to surface water during high wind and storm events.

3.4 Sediment Stability

As described in Section 2.1, a SSA of near shore sediments at the Site was conducted to determine the degree of bed mixing and/or erosion of the sediment bed in the near shore area. However, the Sediment Stability Assessment did not include the stability of the free product within the sediments.

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The Ashland area has had a history of backfilling events, construction and demolition of numerous docks and causeways, and the development of shoreline protection. Historical backfilling events at the affected area led to large episodic sediment loads and the presence in the Site area of poorly sorted sediments comprised of wood chips, sawdust and a range of wood particles (collectively called wood mulch) that influence the cohesive behavior of the near shore sediments. Numerous construction and demolition activities disturbed local sediments and

altered the hydrodynamic conditions at the site. Contaminated sediments are confined to the area between the Prentice Avenue jetty and the Ashland Marina extension. Impacted sediments consist of lake bottom sand and silts, and are overlain by a layer of wood chips, likely originating from former lumbering operations at the lakefront. The wood chip layer varies in thickness from 0 to seven feet, with an average thickness of nine inches. This wood waste layer overlays approximately 95% of the impacted sediment. Based on current data, the area in which contaminated sediments are confined encompasses approximately ten acres.

This sediment stability analysis provided a likely explanation of the evolution of the sediment deposits and provides insight into the risk of future exposure of buried contamination. The analysis indicates that the Site is currently near equilibrium with the hydrodynamic climate. The findings and conclusions of this study are as follows:

- Historic deposits at one time grew in thickness, but have undergone erosion after sediment sources (particularly backfilling) were substantially reduced and the sheltering of the Site from waves was decreased.

- The risk associated with future releases of contaminated sediments is likely limited to wave induced erosion, and in very shallow areas of the Site by propeller wash-induced scouring. Risk associated with ice gouging and bioturbation are not considered significant at this time.

- In general the Site sediments are not significantly resuspended by waves. However, oil slicks have been documented in the bay area during high wind events. Erosion resulting from wave events is rare in waters deeper than six feet. Within the six-foot water depth, erosional events occur on average every three years. Above that threshold, the potential for sediment resuspension increases as the recurrence interval increases. This indicates there are prolonged periods of dormancy. For the deep water depths (greater than six feet) erosional events are associated with high wind-wave events resulting from wind-driven circulation across the Site. Any contaminated sediment resuspended during these events will be rapidly dispersed and mixed with clean sediments.

- The effect of the 1:24 year event (the maximum wave height considered) inside the six foot water depth could expose 5.6 cm of contaminated sediment to the water column. Comparing these erosion depths with the sediment chemistry data for the top 15 cm (~six

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inches) of sediment suggests these sediments would generally have low levels of contaminants.

- The risk of propeller wash-induced scour exists for certain water craft in the shallower depths at the Site. If vessels are allowed to "power up" in shallow depths, some contaminant exposure will likely occur.

- The results also show the importance of maintaining or improving the shoreline protection. This will likely limit recontamination of the near shore area by contaminants in historical fill along the shore.

3.5 Ecology

3.5.1 Sediment Bioassay

The primary objective of the sediment bioassays was to determine the levels of sediment contaminants that were associated with adverse effects to laboratory animals. A secondary objective was to determine whether UV light modulated this toxicity, and whether behavioral adaptations of test organisms decreased exposure and therefore effects from UV light in the laboratory.

Results of the sediment bioassays are described in detail in Appendix B of the BERA. The following summarizes the results of toxicity tests using Site sediment that were conducted from 2001 to 2006. This discussion uses only units of carbon normalized PAHs to better compare amongst tests.

Hyalella azteca

There was significant mortality to *H. azteca*, generally the most sensitive organism used in sediment bioassays, in all of the Reference Sand sediments collected in 2005-2006. The mortality was consistent in four different Reference Sand stations collected from four different locations in Chequamegon Bay and at two different times four months apart. In addition, this mortality was observed during three different bioassays with *H. azteca* during three different bioassays conducted months apart. This strongly suggests that there were unmeasured variables

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that affected the outcome of the bioassays and that not all of these adverse effects were attributable to Site-related contaminants.[27]

Observations by the bioassay laboratory personnel of a strong organic odor, described as "a strong odor of decaying organic matter" in the reference sediments suggests that additional organic chemicals or other confounding factors may be dispersed within Chequamegon Bay. Reference samples were analyzed for PAHs, SVOCs, VOCs, and metals, which were either detected at low concentration or were not detected in the samples. The laboratory also noted "slightly elevated levels of ammonia". Although both ammonia and sulfides were measured in these tests, neither appeared to be related to the elevated mortality.

Deleted: Observations by the bioassay laboratory personnel of a strong organic odor (potentially from decomposition or natural organic material or organic chemicals) in the reference sediments suggests that additional organic chemicals may be widely dispersed within Chequamegon Bay. Although both ammonia and sulfides were measured in these tests neither appeared to be related to the elevated mortality. ¶

When compared against the Reference Wood sediments and silica sand control treatments in 2005-2006, only Site sediment SQT1 and SQT7 showed significant and consistent mortality under normal laboratory light conditions. Based upon the three *H. azteca* bioassays the no observed effects concentration (NOEC) for *H. azteca* was 4536 µg PAH/g organic carbon (OC) (20.9 µg PAH/g dry weight). The lowest observed effects concentrations (LOEC) for *H. azteca* was 6084 µg PAH/gOC (22.5 µg PAH/g dry weight).

Pimephales promelas

As expected for a receptor that does not normally contact the sediment, fathead minnow larvae were relatively insensitive to PAHs in bulk sediments, with no mortality reported at 36,291 µg PAH/gOC (166.9 µg/g). However there was a growth effect at this station this was selected as the LOEC 36,291 µg PAH/gOC (166.9 µg/g). The NOEC for *P. promelas was* 6,084 µg PAH/gOC (22.5 µg/g).

Chironomous dilutus

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In the 2005-2006 bioassays, low survival with *C. dilutus* at all 6 reference stations made evaluation of Site sediment inconclusive due to additional unknown factors. This test was attempted twice and failed both times.

[27] Although the *C. dilutus* test conducted in 2006 was not successful, it should also be noted that there was significant mortality (or loss to the system) to *C. dilutus* at both Reference Sand and Reference Wood stations.

Lumbriculus variegatus Bioaccumulation Study

A bioaccumulation bioassay was conducted using the worm *Lumbriculus variegatus* to evaluate accumulation of PAHs from Site sediment by a benthic invertebrate. These data also were used in the wildlife food chain modeling to estimate dose to invertivorous wildlife. Preliminary 4-day bioaccumulation screening tests were first conducted with sediment from all of the Site stations. However, complete toxicity was found at stations SQT1 and SQT7. As a result, the full 28-day bioaccumulation tests were conducted with the formulated control, and at 4 Site Wood, 2 Site Sand, 2 Reference Sand and 2 Reference Wood stations.

At the end of the tests, levels of PAHs were measured in the worms. Tissue levels in worms tested with Site sediment ranged from 0.58 µg PAH/g wet weight at station SQT2 to 13.1 µg PAH/g at station SQT5 (Table 1.1). However, analysis of worms exposed to the formulated control and West Bearskin reference sediments also revealed the presence of relatively low levels of the LMW PAHs naphthalene, 1- and 2-methylnaphthelene, acenaphthene, acenaphthylene, and anthracene, and relatively high levels of phenanthrene, in these organisms.

Bioassays Using UV Light

In the studies reported here, UV light substantially increased the toxicity in the laboratory to *H. azteca* at concentrations of 9073 µg PAH/gOC (25% dilution), and increased the toxicity to a lesser extent at 4536 µg PAH/gOC (12.5% dilution). In addition UV light caused decreased survival at Site Wood stations SQT 4 and SQT5. In the 2005-2006 bioassays the availability of refugia, under which *H. azteca* could avoid UV exposure, led to substantial decreases in toxicity at the 12.5% and 25% dilution. The toxicity to fathead minnow larvae was significantly increased by UV light in 2005-2006 at 6308.8 µg TPAH/gOC (22.5 µg/g and 0.37% TOC). No effects endpoints are proposed for UV light as there is uncertainty as to how well laboratory results predict what happens in the field, particularly for UVB.

3.5.2 Benthic Community Investigation

As previously discussed benthic invertebrate community samples were collected during the period June 18 thru June 24, 2005 from eight Site Triad stations and four reference Triad stations. Two additional reference Triad stations were sampled on September 27, 2005. Benthic invertebrate community sampling and laboratory processing methodology were consistent with

Deleted: No effects endpoints were developed for UV light since results were not reproducible between bioassays conducted in 2001 by SEH (2002) and the RI studies and because there is substantial doubt as to how well laboratory results predict what happens in the field, particularly for UVB for which field conditions could not be reproduced in the laboratory. ¶
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the approved Field Sampling Plan. Procedures are described in SOPs 240 and 360 in the FSP. Details of the results of the benthic community investigation are provided in Appendix B: Attachment 3 to the BERA.

Approximately 133 taxa were identified from the benthic samples collected in this investigation. Abundances of all taxa are tabulated in Appendix B to the BERA. Benthic community metrics calculated for each sample replicate are also tabulated in Appendix B to the BERA. The abundance of the dominant taxonomic groups were plotted by sample replicate. These taxa included:

- The sabellid polychaete, *Manayunkia speciosa*;
- Total tubificid (an oligchaete) worms;
- Total nematodes;
- The amphipod, *Gammarus faciatus;*
- The isopod, *Caecidotea racovitzai*;
- Total chironomids (midgeflies);
- Total Ephemeroptera (mayflies);
- Total Trichoptera (caddisflies);
- Sphaerid clams (including *Pisidium* sp.), and
- The gastropod, *Amnicola limnosa.*

Dominant taxa were chironomids which made up an average 32.6% (maximum 84 to 91% in the five replicate samples from Sand Reference Station SQT12) of the abundance in each sample. In all, 58 taxa of chironomids were identified. The next most abundant taxa were a sabellid polychaete (*Manayunkia speciosa*), oligochaetes (primarily tubificids), nematodes, an isopod (*Caecidotea racovitzai*), amphipods (including *Gammarus fasciatus*), the unionid snail (*Amnicola limnosa*), sphaerid clams (including *Pisidium* spp.), mayflies, and caddisflies. Together these ten taxa made up approximately 94% of the total number of individuals (Appendix B: Attachment 1 to the BERA). Chironomids and tubificids alone made up approximately 50% total number of individuals. Aquatic insects made up 75% of the taxa; the majority of these were chironomid taxa.

The result of statistical analysis which employed both conservative hypothesis testing as well as multivariate statistics, including discriminant function and cluster analysis, indicated that there was no consistent differences in benthic macroinvertebrate structure between Site stations and reference stations that could be related to levels of PAHs. Substrate characteristics at the various

stations had a much greater influence on benthic community metrics than did the level of PAHs. However, the considerable variability encountered in both the site sample and reference sample results and questions on the appropriateness of reference locations imparts uncertainty to the statistical analysis.

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3.5.3 Fish Tissue

The fish tissue sampling results indicate that all fish species collected in the Site area during this investigation had elevated levels of PAHs in their tissue or possibly associated with their skin. This evidence indicates that fish caught at the Site were exposed to and in some manner incorporated PAHs from the Site into their tissue to levels that exceeded background. The potential risk to humans or ecological receptors that eat fish caught at the Site is discussed in the HHRA and the BERA, respectively.

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3.5.4 Upland Habitat

No wetlands on National Wetland Inventory or Wisconsin Wetlands Inventory maps were identified within the Site. The terrestrial habitat study included an evaluation of the cover and vegetation types, wildlife, and endangered and special species of concern. The following five main habitat types were identified at the Site:

1. Wooded/shrub,
2. Open field,
3. Developed/lawn,
4. Wetland, and
5. Lake edge.

In general, the site is fairly disturbed and provides minimal wildlife habitat for species other than those acclimated to an urban environment. Songbirds and small rodents are the primary extent of wildlife species diversity on the site. This is largely due to the disturbed nature of the site and the low diversity of vegetation on site.

WDNR and USFWS were contacted for information regarding known occurrences of threatened, endangered, or otherwise significant plant and animal species, natural plant communities, and other natural features. A URS environmental scientist made field observations of the site area on June 15, 2005 and concluded that no habitat is available for the listed species that the were listed by these agencies as threatened, endangered, or otherwise significant.

3.6 Meteorology

The regional climate of the Ashland area is mid-continental, being highly influenced by adjacent Lake Superior. The average daily high varies from 19.1 Fº during January to 79.2 Fº during July. Total annual precipitation averages nearly 33 inches. The highest precipitation levels occur during the summer months, although the total annual snowfall averages nearly 100 inches. The large snowfall is characteristic of the long winters. The average first frost occurs in mid-September and the average last frost does not occur until the end of May. Consequently, Chequamegon Bay is generally ice-bound between December and April.

These climatic conditions contribute to an affect on contaminant transport at the site. The source of contaminants at the site are historic, known to have been generated beginning in the 19th century, but were discontinued in the 1940's. The long winters likely retard contaminant mixing and dilution in surface waters during these seasonal conditions. Previous investigations at the site have shown high concentrations and free-product zones within the bay sediments and Kreher Park fill soils, which are highly permeable and contain a shallow water table, and are likely influenced by frost penetration. However, during the spring ice melt, ice scour may be a predominant mechanism responsible for disturbing sediment and releasing contaminants near the shore.

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3.7 Demographics and Land Use

Based on 2000 census results, the population of Ashland County is 16,866, and the population of the City of Ashland is 8,620. According to city-data.com, the median resident age for Ashland is 36.4, the median household income is $30,583, and the median house value is $64,000. The City population is 89-percent White Non-Hispanic, 8-percent American Indian, 2-percent mixed race, and 1-percent Hispanic; 1.3 percent of the population is foreign born. For the City population 25 years and over, 84.6-percent have a high school education or higher, 20.4-percent have a bachelor's degree or higher, and 7.6-percent have a graduate or professional degree. For the population 15 years and over, 30.4-percent have never been married, 48.3-percent are married, 1.4-percent are separated, 10.3-percent are widowed, and 9.6-percent are divorced.

Industries providing employment include educational, health, and social services (32.2-percent), retail trade (12.8-percent), manufacturing (12.4-percent), arts, entertainment, recreation, accommodation and food services (11.4 percent). An estimated 3,494 (86.2-percent of the work force) workers who work in the City also live in the City. The daytime population change due to commuting is estimated to be 2,388 (27.7-percent of the resident City population). Major

employers for the city include Bretting Manufacturing, Larson-Juhl, Memorial Medical Center, Northland College, St Mary's Duluth Clinic, Chequamegon Clinic, and Wisconsin Indianhead Technical College.

In addition to being the county seat for Ashland County, Ashland is a regional service center serving points to Ironwood, Michigan to the east, Superior, Wisconsin to the west, and Park Falls, Wisconsin to the south. Major services and retail shopping facilities within the city accommodate most daily requirements. Tourism in the Ashland area is a year-round enterprise. The area is a major destination during the spring and summer fishing seasons. The area is a draw during the fall for hunting for both small and large game. During the winter, winter sports especially snowmobiling and skiing are popular.

Ashland County is located in the Lake Superior basin. Land use in the basin is dominated by forestry and recreation. In Ashland County, approximately 85 percent of the land is forested, and much of this forest is in national, state or county forest or in large tracts of industrial forest. Agriculture also plays a role in the basin, but the cool temperatures and relatively infertile, highly erodible clay soils limit agricultural activities. Most farms are dairy, beef or poultry operations; in Ashland County agriculture accounts for approximately 9 percent of the land use. The northern portion of the County is located in the Lake Superior Lowland geographic province, and the southern portion of the County is located in the Northern Highlands geographic province. The Lake Superior Lowland province is characterized by flat to undulating topography underlain by red glacial clay (Miller Creek Formation). Uplands lie to the south of Ashland and are characterized by rolling hilly topography and underlain by sand and gravel soils (Copper Falls Formation).

The City of Ashland is located on the south shore of Chequamegon Bay (Lake Superior). Elevations in the City range from 601 feet MSL datum (Lake Superior surface elevation) to approximately 700 feet MSL. Regional slope is generally to the north. The City is approximately 13.4 square miles in size, and consists of a central downtown area, residential and commercial areas, and park areas along the shoreline This shoreline has historically been used for industrial purposes, lumber operations, and shipping. Residents of Ashland are served by the City's municipal water supply, which is provided from Chequamegon Bay surface water. The surface water intake is located approximately 1,900 feet offshore at Longitude 90° 50' 29" E and Latitude 46° 36' 25"N. The intake is located in approximately 23 feet of water and is approximately one mile northeast of the Site.

Site Physical Characteristics

The Site is bounded by Highway 2 (Lake Shore Drive) to the south, Ellis Avenue to the west, Prentice Avenue to the east, and the Chequamegon Bay inlet area to the north. This inlet area is located between the Ellis Avenue and Prentice Street piers. The Site consists of a relatively flat terrace (former lakebed and then landfilled wetlands) adjacent to the Chequamegon Bay inlet area, and an upland (upper bluff) area. The former lakebed area is currently owned by the City of Ashland, and is currently utilized as Kreher Park. Kreher Park contains the former City Wastewater Treatment Plant and buildings, lawn areas, Marina Drive, paths, and a gravel covered boat storage lot for the adjacent Ashland Marina located west of the Ellis Avenue pier. A 30 foot high bluff separates Kreher Park from the upper bluff. The upper bluff area of the Site consists of residential properties, NSPW's property (a former MGP), and Our Lady of the Lake church, school, and playground. Elevations of the terrace range from 601 MSL to approximately 610 MSL. The elevation of the upper bluff in the vicinity of the former ravine area is approximately 640 feet MSL.

4.0 NATURE AND EXTENT OF CONTAMINATION

The contaminants at the Site consist predominantly of VOCs and SVOCs. With regard to the SVOCs, the predominant subgroup includes PAHs. The most commonly occurring VOC is benzene; the most commonly occurring PAH is naphthalene. Metals (e.g., lead and arsenic) have been detected at varying concentrations and are associated with natural conditions, urban fill, and former MGP process wastes. Cyanides have also been detected and are associated with MGP process wastes.[28] The VOCs and PAHs were derived from the former industrial operation that occupied the Site during the late 19th through the early 20th centuries. The primary source of these contaminants is the former MGP. The sources of these organic compounds are primarily associated with the free-product zones that have been identified since investigations began at the Site in 1995, and further refined during the RI sampling performed in 2005. These free-product zones consist of both DNAPL and LNAPL consistent with MGP wastes.

All data described in this section was compiled from historic investigations and the 2005 RI in one Microsoft Access database. An electronic copy of this database in included in Appendix J. This information is available in electronic format with this report. For the discussion in this report, data is tabulated in summary tables by domain (i.e., Upper Bluff/Surface Soils, Upper Bluff/Subsurface Soils, Kreher Park/Groundwater, etc.). As described, a large dataset of organic compounds have historically been analyzed at the Site, with a smaller data set available for metals and inorganics. The 2005 RI Work Plan specified a selected list of VOCs, PAHs and metals/inorganics analytes common to all media (a slightly expanded list of PAHs was analyzed for sediments for purposes of ecological evaluation). During preparation of this Report, USEPA approved an amended list of compounds which included the analytes listed in the 2005 RI Work Plan and additional compounds previously analyzed for which regulatory limits were exceeded. These additional compounds were limited to those which were historically measured at least once in excess of 10 times an applicable regulatory standard. This final parameter list for each analyzed media is shown in Table 4-1. The associated standards for each compound by media are described in Tables 4-2 through 4-5.

A discussion of the findings of these analyses is presented in this section.

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[28] A discussion of metals and inorganic compounds is included within the separate area descriptions later in this section. Metals and inorganic compounds that meet the criteria for COPCs are addressed separately in the HHRA and BERA.

4.1 Contaminant Sources – Extent of Free Product

Free-phase hydrocarbon (free-product) is found within the four primary areas of concern, but at discrete locations within each area.

DNAPLs at the upland areas are found with an associated LNAPL (floating) fraction. Free-product zones in the Copper Falls Aquifer and upper bluff areas have been fairly well defined. In general, these combined DNAPL/LNAPL zones are associated with groundwater quality values with total VOC concentrations (primarily benzene) more than 50,000 µg/l (during the historic monitoring at the site wells were not sampled for groundwater quality if more than one-foot of DNAPL was measured). Although access restrictions (e.g., retaining walls near well TW-11) have limited complete characterization at Kreher Park, the combined DNAPL/LNAPL zones at the Park are limited. However, LNAPL zones devoid of associated DNAPL are extensive at the Park area. LNAPLs in the form of sheens have been observed in several monitoring wells and test pits advanced at the Park where DNAPLs have been absent. These separate LNAPL zones at Kreher Park, unlike those found associated with DNAPL, have yielded associated total VOC concentrations in groundwater more than an order of magnitude less (below 5,000 µg/l) than those areas where DNAPLs are present.

Free-product measurements in sediments have been less well-documented because of the limitations caused by sampling sediments with hollow-core and grab sampling techniques. Regardless, free-product in these samples has been observed in the form of emulsions. In general, these sediment samples where emulsions were observed correspond to both high VOC and PAH levels. Although the upland area relationship between high VOC levels in groundwater and free product measurements is not applicable to sediments because of matrix differences, emulsions observed in sediment samples generally correspond to total PAH levels greater than 1,000,000 µg/kg.

A description of each of these free- product areas is described below.

4.1.1 Ravine Fill

The primary free-product zone within the ravine exists at the base of the fill in a continuous area south of St. Claire Street. This zone was initially identified during investigations prior to the RI. Free-product has been measured at monitoring wells TW-13, MW-9 and MW-15 at depths

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ranging from a few inches to more than 10 feet since these wells were first installed.[29] This zone was further delineated with a detailed Geoprobe investigation during the RI.

The 2005 Geoprobe investigation identified free-product in borings extending south from the free-product removal system treatment building, beneath the east-west portion of the NSPW service center building, and in borings exterior to the south line of this building in the alley. Free-product was not encountered south, east or west of this area. It was found to the north in monitoring wells TW-13 and MW-2R. The free-product was measured from a few inches to several feet as observed on soil samples recovered from the borings. This variability in thickness is likely due to the preferential flow conditions caused by the differences in fill materials. The free-product is measurable as DNAPL below the shallow water table in the fill at the base of the ravine. The depths of the ravine where the free-product is found varies from approximately 12 feet at MW-15 to 20 feet at MW-2R. The extent of the product measured from the Geoprobe investigation and the most recent monitoring well measurements is shown on Figure 4-1. A summary of the Geoprobe findings is found in Table 4-6. A summary of the historic product measurements in Site monitoring wells is shown on Table 4-7.[30]

An investigation of the clay tile at the base of the ravine in the storage yard during 2001 (that previously discharged to the seep area) confirmed that the clay tile acted as a conduit from the MGP operation to the seep area and that free-product existed within the clay tile. The continuity of the tile was disrupted when sections of the tile were removed during this 2001 investigation. However, this same investigation appeared to alter the distribution of free-product near the base of the ravine at the MW-2 well nest. Free-product was not encountered at MW-2 prior to the clay tile investigation. It was first measured in June 2002 in replacement well MW-2R after the clay tile investigation was completed. Free-product was not measured again at this well until March 2003, when over two feet of product was found. Values less than two feet were then measured during successive quarterly events until March 2005, when the RI groundwater sampling program was completed. A declining trend in the free-product thickness is seen with these measurements between September 2003 (1.87 feet) and June 2005 (0.01 feet). The most recent measurement was made during November 2005, when 0.20 feet was found.

Deleted: Prior to June 2002, free-product was not measured in the ravine fill north of St. Claire Street in the NSPW storage yard.[31]

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[29] TW-13 was installed in 1995; MW-9 and MW-15 were installed in 1998.

[30] A small zone of free-product was found east of the ravine at the location of Geoprobe GP-103 (see Figure 4-1). This was an isolated area in fill from 6 – 8 feet in depth below the location of the original MGP. This free-product area is east of the ravine and likely separate from the mass associated with the former holders.

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Although the excavations during 2001 potentially increased free-product flow to the north, operation of extraction well EW-4 (installed during the spring 2002) on the north edge of the storage yard also may have enhanced free product flow to the north. This well was installed to intercept groundwater flow discharging at the seep, and convey it to the free-product recovery system. The downward trend in free-product thickness measured at MW-2R may indicate equilibrium conditions between the operation of the extraction well and the free-product distribution in this area of ravine following the 2001 excavations.

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As previously described, USEPA's technology branch approved the Ashland site for the SITE program in 2005. Part of the program's purpose is to evaluate the use of ISCO on the free-product mass and if application of this technology results in enhanced free-product recovery from the Copper Falls aquifer. To prevent biased results from discharges from well EW-4 screened in the ravine fill, the discharge from this well was re-routed during October 2006 prior to the start of the SITE demonstration project. This discharge was directed toward the air diffuser, away from the combined flow with the other three wells toward the gravity separator. Monitoring of the influent since the rerouting effort has shown no evidence of tar deposition in any of the treatment system components. Similarly, VOC levels analyzed from influent samples have remained consistent with those collected prior to October 2006. However, EW-4 may not be effective in the collection of all free product at the mouth of the ravine.

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4.1.2 Kreher Park

Free-product (DNAPL) at Kreher Park is isolated to an area adjacent (and predominantly north) of the seep, and near monitoring well TW-11 located northwest of the WWTP adjacent to the shoreline. The 2005 Geoprobe investigation further delineated both of these zones. These locations and the areal extent of DNAPL at Kreher Park are shown on Figure 4-2.

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As previously noted, Kreher Park includes free-product areas containing both DNAPL/LNAPL and separate LNAPL zones. LNAPL has been measured at well MW-3(NET), and observed as sheens in exploration test pits across the Park.[32] Figure 4-2 was prepared to show these individual monitoring points where information is available. These data confirm that LNAPLs are present across most of the Park area (Figure 4-2 utilizes field information from 2004 and

Comment [A1]: Only information from 2004 and 2005 have been used. Test pit T-5 showed present of oil consistency material, it has not been shown on the figure. Oily sheen was observed in TW-2. All historical information should be utilized for determining extent of free product

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[32] A trace of free-product, measured at its greatest thickness at 0.01 ft., was first measured at MW-3(NET) located in the southeast corner of Kreher Park in December 2003. These measurements were not consistent during the monitoring period. Based on historic groundwater quality data from this area, this is not considered a significant free-product source zone.

2005; historical data also indicates that earlier investigations at TP-5 exposed oily material, and an oily sheen was observed at temporary well TW-2.)

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At the seep area, both DNAPLs and LNAPLs were observed in Geoprobe samples (Table 4-6). Although DNAPL thicknesses could not be accurately measured, it was encountered below the water table at the base of the fill at depths between 8 and 15 feet in borings north of the seep. It has also been historically measured at monitoring well MW-7 (removed during the 2002 seep remediation), TW-9 and MW-7R. The DNAPL thickness measurements in these wells have varied from a few inches to more than 10 feet (Table 4-7).

At monitoring well TW-11, DNAPL did not appear at this well until June 2003, when it was measured at approximately 0.5 feet in thickness. Since that time it has averaged about one foot in thickness. Because of these findings, the 2005 Geoprobe investigation included borings surrounding TW-11 to determine horizontal extent. DNAPL was observed in borings surrounding the well and along a line adjacent to the shoreline in a southwest-northeast direction.[33] It was not found in borings in the southeast direction further from the shoreline. This product was found at the base of the fill where the wood waste contacts the coarse-grained sediment layer at depths of 12 to 15 feet. The extent of the DNAPL extends into Chequamegon Bay and is continuous with the sediment contamination discussed below.

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4.1.3 Sediments

The observations of free-product in the sediments have not been as accurately measured as those at the upland areas due to limited offshore sampling methods. Sampling methods have been restricted to grab samples (for the 0 – 0.5 foot depth) and core samples in two-foot depth increments to sediment depths up to 12 feet. Despite these restrictions, free-product is known to exist parallel to the shoreline between the intersection of the marina and Kreher Park shoreline, and the western shoreline of the Prentice Avenue boat launch. The free-product is found nearly along this entire length at the historic lake bed, but is covered by a variable thickness of wood waste. Although the presence of the wood debris layer has complicated these measurements, both the 1996 and 2001 investigations indicate that total PAH levels up to 1,000 mg/kg extend up to 100 feet offshore between the marina and the WWTP covered by wood waste to depths of four feet. Total PAH levels up to 300 mg/kg extend nearly 300 feet offshore in a larger zone between the marina and an area northwest of the WWTP to sediment depths of two feet. A separate zone of similar PAH concentrations is found at depths to 10 feet between the marina and

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[33] Concrete structures associated with the former WWTP prevented further investigation toward the southwest.

the boat launch. However, this zone also contains the greatest wood waste thickness (more than six feet), indicating that the actual depth of product in the sediments at this area may be within four feet of the base of the wood debris. These zones are graphically shown in Appendix A of the Work Plan.

4.1.4 Copper Falls Aquifer

Free-product in the Copper Falls aquifer is potentially restricted to areas south of the bluff and within the upper reaches of the aquifer. The areal distribution of the free-product within the aquifer tends to follow the buried ravine beginning at the alley behind the NSPW service center in the south, terminating at its leading edge midway between St. Claire Street and the bluff face in the north (the product is separated from the ravine by the Miller Creek aquitard). Free-product has been measured at piezometers MW-15A, (installed in December 2003), and at MW-4B (abandoned in March 2006), MW-13A and -13B, MW-2AR, and extraction wells EW-1, -2 and -3 installed for the interim recovery system. Its greatest thickness has historically been measured at EW-1. Product thicknesses approaching 20 feet were measured at this well before regular tar removal began with the installation of the recovery system in 2000.[34] This well, along with extraction wells EW-2 and EW-3, are located immediately south of St. Claire St. in the vicinity of the MW-13 well nest, near the entrance to the NSPW service center.

A thin lobe of free-product, at the top of the Copper Falls aquifer, extends west of the trace of the ravine toward the north end of the Our Lady of the Lake parking area. Free product has migrated laterally along the base of the Miller Creek Formation, which rises in elevation in this area (see Figures 3-4 and 3-6). The maximum thickness of DNAPL measured at this area was 2.6 feet at MW-10B in December 2003. The maximum distance DNAPL has been found in this direction is at MW-21A, where 0.02 feet was measured during the same event. MW-21A is the most distant piezometer from the former MGP, where product has been measured in the Copper Falls aquifer. This well is located 350 feet west of the former gas holder area. The closest downgradient well from MW-21A (MW-23A) is at least 200 feet away and the full extent of this free product lobe can not be defined. However, MW-23A has not shown evidence of the close proximity of DNAPL; benzene levels are generally an order of magnitude greater at MW-21A. Consequently, this lobe of free product likely dissipates between these two wells.

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[34] Well EW-1 was installed for a pump test during 1998.

The upper surface of the free-product plume in the Copper Falls aquifer is found within the aforementioned "footprint" (Figure 4-1) at its interface with the Miller Creek aquitard. The depth to the free-product varies from approximately 20 feet at the south periphery to 35 feet at the north periphery. As previously mentioned, its greatest thickness has been measured in the area of the MW-13 well nest (EW-1), where it is also found at its greatest depth of 70 feet at MW-13B. Because of this free-product configuration, the interim free-product removal system was constructed utilizing existing well EW-1 (screened between 35 and 55 feet bgs) along with wells EW-2 (50 – 70 feet bgs) and EW-3 (30 – 50 bgs).

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Historic free-product measurements for all wells are included in Table 4-7. A plan view of the extent of the free-product in the Copper Falls aquifer is shown on Figure 4-1. Graphical representations of the extent of free-product in the Copper Falls aquifer are shown on cross-sections on Figures 3-2 through 3-6.

Extensive monitoring for dissolved phase compounds and the presence of free product in Site wells was performed as part of the quarterly monitoring program for the interim treatment system prior to the formal NPL listing. During the implementation of this program, wells were added and removed from the monitoring program as data was generated. A WDNR approved procedure was followed stipulating that wells yielding more than one-foot thickness of free-product (DNAPL) not be sampled for water quality. This monitoring allowed evaluation of the presence/proximity of free-product in Site wells (i.e., increases in VOC levels at MW-2R, MW-4B, MW-10B and MW-21A prior to free-product incursion). The historic free-product levels in Table 4-7 shows these trends. This experience established the site specific guideline mentioned earlier that free-product presence/proximity is associated with VOC levels in groundwater greater than 50,000 µg/l. As discussed in Section 4.3, several wells have yielded values that approach these levels (e.g., MW- 5A, MW-5B, MW- 19A), but no DNAPL at these wells has been measured (note that MW-19A yielded a trace measurement during one event). During November 2005, the final event during which water levels were collected, all wells were accessed for free product and water level measurements. The only exceptions were AW-1, AW-2, MW-1, MW-5 and MW-9. These five were not measured because of access restrictions at that time. Consequently, the horizontal and lateral extent of free-product shown on the figures and described in this report is accurate to the extent available.

4.2 Soils and Vadose Zone

Soil investigations at the Site have been performed several times since 1994. Figure 4-3 shows the locations of samples collected during these separate mobilizations. The primary focus of

these investigations was on the organic contaminant sources and their extent in soil associated with the free-product/tars previously described. The 2005 RI included a background soil sampling task to provide a baseline comparison to the organic COPCs as well as metals and inorganic compounds. This section discusses contaminants in surface soil as well as subsurface soil found at the upper bluff and Kreher Park. Upper bluff soils include both the ravine fill and native near surface soils above the water table in the Miller Creek Formation; Kreher Park soils include fill materials used to fill the former lakebed.

Tables 4-8A (surface soils) and 4-8B (subsurface soils) provide summaries of the results for the approved list for subject metals, inorganic and organic compounds measured in soil samples collected at the Site. This table was derived from the historic Site analytical database. The depths for each boring location corresponding to the respective analyte for each sample are shown. These are compared to seven individual soil regulatory action levels for the subject analytes established by the State of Wisconsin (ch. NR 720, Wisconsin Administrative Code (WAC) and for PAH compounds, WDNR draft guidance RR519) and USEPA Regions 3 and 9. The USEPA action levels are the most extensive compound lists.

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Each individual compound result is compared to the most stringent applicable and appropriate regulatory standard, which is highlighted on Tables 4-8A and 4-8B; the sample values which show exceedances are also highlighted in the associated column. This comparison provides a basis for the determination of the nature and extent of the contaminant.

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4.2.1 Surface Soils/Upper Bluff/Filled Ravine

For purposes of this RI, surface soils constitute samples collected from 0 – 1.0 feet in depth. All soils within this depth range at the upper bluff were collected during the 2005 investigations. Four samples from background locations outside the ravine fill were collected and analyzed for the specified list of metals, inorganics and organics per the Work Plan. These four samples (SS-22 through SS-25) were collected from residential areas within or close to the proximity of the Site boundary, but beyond the influence of known contaminant sources (Figure 2-4 shows background soil sample locations). Sample SS-24 was collected from residential property south of the NSPW service center, but near the edge of the filled ravine.

Surface soil data at the upper bluff/filled ravine is limited because site buildings and paved areas limited the number of surface soil samples collected. The entire surface soil data set consists of five samples from the upper bluff area outside the ravine fill, and three samples from the ravine fill area.

Metals and Inorganics

Applying the most stringent (residential) action levels to this data indicates that only arsenic, lead and iron concentrations exceed their respective action levels in surface soil samples. None of the remaining inorganic compounds (beryllium, cadmium, manganese and vanadium) were detected above any standards in either background or filled ravine/upper bluff surface soil samples. Although the upper bluff/filled ravine sample set is limited because of access, a summary of the arsenic, lead and iron exceedances follows:

- Arsenic exceeds the 0.039 mg/kg Wisconsin standard (nonInd) in each of the four background samples; concentrations range from 1.4 – 2.9 mg/kg;
- Arsenic exceeds the standard in four of the five upper bluff samples; concentrations range from 1.9 – 8.5 mg/kg;
- Arsenic exceeds the standard in two of the three filled ravine samples; concentrations range from 1.6 – 3.6 mg/kg.
- Lead exceeds the 50 mg/kg Wisconsin standard (nonInd) in three of the four background samples (the exception is SS-23 located west of 2nd Avenue West); values range from 85–440 mg/kg;
- Lead exceeds the standard in one of the five upper bluff samples (SS-14, on the east side of the NSPW service center outside the flanks of the ravine); the level is 140 mg/kg.
- Lead does not exceed the standard in any of the three filled ravine samples;
- Iron exceeds the 23,463 mg/kg Region 3 standard in one background sample; SS-23, at 24,000 mg/kg;
- Iron does not exceed the standard in any of the five upper bluff samples;
- Iron exceeds the standard in two of the three filled ravine samples; values range from 25,000 – 26,000 mg/kg.

Figures 4-4, 4-5, and 4-6 show the contaminant distribution patterns for arsenic, lead and iron respectively**,** for the upper bluff/filled ravine surface soils.

The levels of arsenic, lead, and iron indicate these metals may represent background conditions but may also be associated with urban fill, and MGP process wastes. The extent of arsenic appears to be ubiquitous throughout the upper bluff and ravine fill. The extent of lead above regulatory standards is undefined and sporadic. The extent of iron above regulatory standards is

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undefined at the upper bluff soils, and appears to be confined to the area of SS16 and SS18 in the ravine fill.

Organics-VOCs

The organic compounds yield similar values in relationship to regulatory standards as the metals and inorganics. The only VOCs detected in background samples are trimethylbenzenes (TMB), toluene and xylenes in samples SS-22, SS-24 and SS-25. Toluene is the only VOC found to exceed the Wisconsin RCL.[35] None of the surface soil samples were analyzed for trichlorobenzene (TCB). No VOCs are found in samples collected from the filled ravine. Low levels of ethylbenzene, 1,2,4-TMB, toluene and xylenes are present in surface sample SS-14, east of the NSPW service center. Toluene was found in two other samples outside the ravine (SS-15 and -20); none of these detections are in excess of regulatory criteria.

Toluene is the only compound found to exceed a regulatory standard in one background sample. The extent appears to be limited, and may be associated with urban fill material.

Organics - SVOCs

Naphthalene, the most common PAH at the Site and a low molecular weight (LMW) compound, is only found in background sample SS-24, at trace levels (51 µg/kg), less than the most stringent standard of 400 µg/kg (Wisconsin groundwater path) . The heavy molecular weight (HMW) PAHs benzo(a)anthracene (BaA), benzo(a)pyrene (BaP), and benzo(b)fluoranthene (BbF), show exceedances compared to the most stringent standards (Wisconsin non industrial path) in the four background samples (BaA did not exceed its standard in SS-25.) None of the other SVOCs are at levels exceeding standards in background samples. The range of values for the HMW PAHs in these four background samples are as follows:

- BaA ranges from 82 to 160 µg/kg compared to the standard of 88 µg/kg;
- BaP ranges from 85 to 170 µg/kg compared to the standard of 8.8 µg/kg;
- BbF ranges from 120 to 240 µg/kg compared to the standard of 88 µg/kg

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Figures 4-4 4-5, and 4-6 show the contaminant distribution patterns for arsenic, lead and iron respectively, for the upper bluff/filled ravine surface soils.¶

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[35] Toluene has yielded abnormally high values in all media at the Site. The laboratory performed a detailed QA review on this compound, and concluded it was characteristic of the Site. The very high levels reported are considered anomalous and are not considered accurate (see Appendix F.4.5).

The upper bluff samples outside the ravine yield low levels of PAHs below the individual compound standards; only sample SS-14 yields values for the three HMW PAHs (BaA, BaP and BbF) above the respective standards, but at levels comparable to the background samples. None of the other upper bluff soils yield detections of PAHs above standards.

Similar levels to those found in the surface soil background samples for the HMW PAHs are found in sample SS-18 collected from within the ravine; an exceedance for BbF was also measured for sample SS-17. No other PAHs from ravine surface soil samples are measured in excess of the most stringent standards.

Figures 4-7 through 4-10 show the distribution of the individual Site VOCs (toluene) and SVOCs in surface soils at the upper bluff/filled ravine. The extent of these constituents is not clearly defined; however, some of the samples located within the ravine exceed regulatory standards. As with the inorganic compounds, the PAHs may be associated with urban fill material.

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4.2.2 Subsurface Soils/Upper Bluff

Subsurface soils at the Site consist of all analyses below one foot in depth. At the upper bluff these include a larger data set than that for the surface soils. This sampling program includes data collected from both above and below the water table.

Three subsurface background sample points were collected during the 2005 RI. Geoprobe samples GP-159, -160 and -161 were collected at the same locations as background surface soil samples SS-25, SS-23 and SS-22, respectively (see Figure 2-4).

Metals and Inorganics

Subsurface soil background results are similar to surface soil background results. Exceedances for metals in background samples were limited to arsenic and iron as follows:

- Arsenic exceeds the Wisconsin non industrial (nonInd) standard in samples from GP-159 (1.1 - 1.3 mg/kg) and GP-161 (1.1 - 2 mg/kg);
- Iron exceeds the Region 3 standard in a sample from GP-161 (24,000 mg/kg).

Subsurface results for the remaining samples were derived largely from those collected from the ravine, but include a significant data set from samples collected outside the flanks of the ravine on the NSPW property (upper bluff). For these samples, arsenic, lead, iron and vanadium

concentrations exceed standards. A summary of these upper bluff exceedance measurements are as follows:

- Arsenic exceeds the Wisconsin nonInd standard in 32 of 38 samples. Exceedance values range from 1.0 - 21.6 mg/kg;
- Lead exceeds the Wisconsin nonInd standard in 3 of 38 samples. Values range from 59 - 210 mg/kg;
- Iron exceeds the Region 3 standard in 5 of 38 samples; Values range from 24,000 – 31,000 mg/kg;
- Vanadium exceeds the 78.2 mg/kg Region 9 standard in one of 22 samples (GP-120 at 0-2 feet); the value is 110 mg/kg.

Arsenic results range from values similar to background values to values an order of magnitude greater than background values. The extent of arsenic above regulatory standards is ubiquitous throughout the upper bluff area and may be associated with natural conditions, urban fill, and MGP process wastes. Iron measurements are not significantly greater than the regulatory standards and the background concentrations found in the subsurface soil. The extent of iron above regulatory standards is defined as shown on Figure 4-13. The three lead exceedance measurements were made in shallow samples (0 – 2 feet) near the former MGP facilities. High lead values were measured at GP-120 and GP-122 installed outside the ravine, but in fill in the area of a former gas holder and at GP-137 installed near the edge of the southwest flank of the ravine south of the NSPW service center. The extent of lead above regulatory standards is limited to the locations listed above. The vanadium exceedance is considered anomalous, because no other vanadium exceedances were measured at the upper bluff area. The extent of vanadium above regulatory standards appears to be limited to the one exceedance at GP-120.

Samples from the filled ravine yield exceedances for arsenic, iron, lead, iron and beryllium. A summary of these detections follows:

- Arsenic exceeds the standard in 72 of 83 samples; exceedance values range from 1.6 – 21.7 mg/kg;
- Lead exceeds the standard in 17 of 83 samples; values range from 62 – 4,000 mg/kg;
- Iron exceeds the standard in 10 of 83 samples; values ranged from 24,100 – 40,000 mg/kg;
- Beryllium exceeds the 154 mg/kg Region 9 standard in one sample in 72 measurements (GP-106 at 10 – 12 feet);

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As described above, arsenic results range from values similar to background values to values an order of magnitude greater than background values. The extent of arsenic above regulatory standards extends throughout the ravine fill and is likely associated with urban fill, and MGP process wastes. The iron exceedance measurements are located in several locations within the ravine fill as shown on Figure 4-13. The extent of these exceedances is not fully defined; however, they may be associated with the urban fill material located in the ravine. The lead exceedances are, in instances, significantly greater than regulatory standards and the concentrations detected in background samples. The lead exceedances are also from samples collected in proximity to known free-product areas. These lead detections are likely associated with the former MGP and the extent is defined as shown on Figure 4-12. The beryllium exceedance may be associated with fill material; however, this location (GP-106) is located within the former MGP production area. The extent of beryllium above regulatory standards is limited to sample location GP-106.

Figures showing the contaminant distribution of the metals for the upper bluff/filled ravine subsurface soils are shown on Figures 4 – 11 through 4 - 15.

Organics - VOCs

Background samples analyzed for VOCs yielded no detections except for toluene measured in three separate samples. These measurements were made in GP-159, -160 and -161 at depths of 12 - 14, 8 – 10 and 12 - 14 feet, respectively. Corresponding measurements were 9,300, 55 and 4,000 µg/kg (the Wisconsin GW path standard is 1,500 µg/kg). These borings were advanced northeast and southwest of the former MGP facility. Although toluene is an identified COC at the Site, its frequency of occurrence in samples has been problematic (as described in the lab assessment in Appendix F.4.5). Based on the background sample location and depth, the lab assessment indicates these detections are not associated with background conditions.

VOCs found above the regulatory limits in subsurface soil samples from the upper bluff data set (outside the filled ravine) included benzene, ethylbenzene, toluene and xylene. A summary of these detections follows:

- Benzene exceeds the 5.5 µg/kg Wisconsin GW path standard in 22 of 46 samples; values range from 18 – 52,000 µg/kg;
- Ethylbenzene exceeds the 2,900 µg/kg Wisconsin GW path standard in one sample; the value is 6,490 µg/kg;

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- Toluene exceeds the Wisconsin standard in 4 of 46 samples; values range from 2,600 to 72,000 µg/kg;
- Xylene exceeds the 4,100 µg/kg Wisconsin GW path standard in one sample; the value is 33,600 µg/kg.

The highest benzene and toluene levels are found in the same sample, B-31 at 2 – 4 feet, at an area of an identified free-product mass east of the ravine at the former MGP. The ethylbenzene and xylene exceedances (and the second highest toluene value) are in the same sample, GP-39 at 20.5 – 22.5 feet, a sample southwest of the ravine within a former gas holder. The other two toluene exceedances are in samples with no other VOC detections. The extent of benzene at the upper bluff subsurface soils is defined with the exception of the area to the west of boring SS-21 where no further data is available, as shown on Figure 4-16. The extent of ethylbenzene, toluene, and xylenes are defined as shown on Figure 4-17 through 4-19.

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VOCs that exceed regulatory limits in subsurface samples from within the filled ravine include benzene, ethylbenzene, 1,2,4-TCB, 1,2,4- and 1,3,5-TMB, toluene and xylenes. A summary of these detections follows:

- Benzene exceeds the Wisconsin GW path standard in 64 of 95 samples; values range from 16 – 230,000 µg/kg; the highest levels of these exceedances were measured south of St. Claire Street in areas where free-product has been identified.
- Ethylbenzene exceeds the Wisconsin standard in 25 of 88 samples; values range from 3,300 – 170,000 µg/kg; the highest levels are found south of St. Claire Street, but elevated values from 10,000 – 22,000 µg/kg are present in samples along the ravine axis north of the St. Claire Street;
- 1,2,4-TCB exceeds the 62,160 µg/kg Region 9 standard in three of 17 samples; values range from 62,900 – 120,000 µg/kg; The highest levels are south of St. Claire Street within free product areas;
- 1,2,4-TMB exceeds the 51,608 µg/kg Region 9 standard in two of 72 samples, both south of St. Claire Street; values range from 54,000 – 100,000 µg/kg;
- 1,3,5-TMB exceeds the 21,253 µg/kg Region 9 standard in four of 92 samples, each located south of St. Claire Street; values range from 22,600 – 560,000 µg/kg;
- Toluene exceeds the Wisconsin standard in 30 of 95 samples; values range from 1,500 – 320,000 µg/kg; the highest levels are centered near MW-9, but elevated levels are also found at GP-39 near the southwest gas holder, and along the axis of the ravine north of St. Claire Street.

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- Xylene exceeds the Wisconsin standard in 22 of 95 samples; values range from 4,500 – 320,000 µg/kg; the xylene distribution is similar to that of toluene.

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The distribution of these data indicate that the greatest contaminant levels correspond to free product zones south of St. Claire Street, as well as other areas near the former gas holders/gas plant. The extent of VOC contamination includes the ravine fill from the MGP production area and north as well as an area in the vicinity of B-31. The extent of contamination is shown on Figures 4-17 through 4-22.

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Organics-SVOCs

Background subsurface soil samples analyzed for PAHs yield no detections for any of the subject analytes. However, upper bluff samples collected from outside the ravine fill yield several exceedances as follows:

- Acenaphthylene exceeds the 700 µg/kg (Wisconsin GW path) standard in four of 46 samples; values range from 1,000 – 280,000 µg/kg; The highest level is found at sample B-31, east of the ravine where free product has been identified;
- BaA exceeds the 88 µg/kg (Wisconsin nonInd) standard in 11 of 46 samples; values range from 110 – 20,000 µg/kg;
- BaP exceeds the 8.8 µg/kg standard in 14 of 46 samples; values range from 60 – 170,000 µg/kg;
- BbF exceed the 88 µg/kg standard in 12 of 46 samples; values range from 100 – 170,000 µg/kg.
- B(ghi)P exceeds the 1,800 µg/kg standard in one of 46 samples; the value was 4,100 µg/kg;
- BkF exceeds the 880 µg/kg standard in three of 46 samples; values range from 1,100 – 170,000 µg/kg;
- Chrysene exceeds the 8,800 µg/kg standard in one of 46 samples; the value is 220,000 µg/kg;
- Di(ah)A exceeds the 8.8 µg/kg standard in two of 46 samples; values range from 120 – 300 µg/kg;
- Fluoranthene exceeds the 500,000 µg/kg (Wisconsin GW path) standard in one of 46 samples; the value is 790,000 µg/kg;
- Fluorene exceeds the 100,000 µg/kg (Wisconsin GW path) standard in one of 46 samples; the value is 320,000;

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(The distribution of the detections of the above three HMW PAHs are all very similar.)¶
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- Indeno(123) exceeds the 88 µg/kg (Wisconsin nonInd) standard in seven of 46 samples; values range from 150 – 100,000 µg/kg;
- Methylnaph2 exceeds the 20,000 µg/kg (Wisconsin GW path) standard in one of 46 samples; the value is 380,000;
- Naphthalene exceeds the 400 µg/kg standard in 11 of 46 samples; values range from 414 – 2,220,000 µg/kg
- Phenanthrene exceeds the 1,800 µg/kg standard in six of 46 samples; values range from 2,500 – 1,200,000 µg/kg
- Pyrene exceeds the 500,000 µg/kg (Wisconsin nonInd) standard in one of 46 samples; the value is 520,000.

Inspection of the upper bluff data indicates these PAH exceedances predominantly correspond to samples collected from shallow fill. The extent of the PAH exceedances is primarily associated with source areas in the area of the free product mass east of the ravine (at the former MGP), the southeast gas holder,and a smaller source area present at the large southwest gas holder.

The highest levels and greatest number of PAH exceedances are found in fill soils recovered and analyzed from the filled ravine. The following summarizes the ravine fill SVOC exceedances:

- Acenaphthene exceeds the 38,000 µg/kg (Wisconsin GW path) standard in 13 of 90 samples; values range from 40,000 – 670,000 µg/kg;
- Acenaphthylene exceeds the 700 µg/kg standard in 38 of 95 samples; values range from 790 – 910,000 µg/kg;
- Anthracene exceeds the 300,000 µg/kg standard in two of 95 samples; values range from 310,000 – 750,000;
- BaA exceeds the 88 µg/kg (Wisconsin nonInd) standard in 52 of 95 samples; values range from 160 – 520,000 µg/kg;
- BaP exceeds the 8.8 µg/kg standard in 55 of 95 samples; values range from 45 – 340,000 µg/kg;
- BbF exceeds the 88 µg/kg standard in 48 of 95 samples; values range from 110 – 410,000 µg/kg;
- B(ghi)P exceeds the 1,800 µg/kg standard in 19 of 95 samples; values range from 2,400 – 190,000 µg/kg;
- BkF exceeds the 880 µg/kg standard in 24 of 95 samples; values range from 1,000 – 130,000 µg/kg;

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- Chrysene exceeds the 8,800 µg/kg standard in 17 of 95 samples; values range from 11,000 – 470,000 µg/kg;
- Di(ah)A exceeds the 8.8 µg/kg standard in eight of 90 samples; the values range from 97 – 10,600 µg/kg;
- Dibenzofuran exceeds the 145,263 µg/kg (Region 9) standard in one of 72 samples; the value is 280,000 µg/kg;
- Fluoranthene exceeds the 500,000 µg/kg (Wisconsin GW path) standard in one of 95 samples; the value is 1,400,000 µg/kg;
- Fluorene exceeds the 100,000 µg/kg standard in eight of 95 samples; values range from 100,000 – 1,200,000 µg/kg;
- Indeno(123) exceeds the 88 µg/kg (Wisconsin nonInd) standard in 30 of 95 samples; values range from 95 – 61,000 µg/kg;
- Methylnaph1 exceeds the 23,000 µg/kg (Wisconsin GW path) standard in 20 of 81 samples; values range from 24,000 – 3,800,000 µg/kg;
- Methylnaph2 exceeds the 20,000 µg/kg (Wisconsin GW path) standard in 25 of 95 samples; the values range from 21,000 – 3,800,000 µg/kg;
- Naphthalene exceeds the 400 µg/kg standard in 53 of 97 samples; values range from 470 – 1,400,000 µg/kg;
- Phenanthrene exceeds the 1,800 µg/kg standard in 43 of 95 samples; values range from 2,100 – 3,700,000 µg/kg
- Pyrene exceeds the 500,000 µg/kg (Wisconsin nonInd) standard in four of 95 samples; values range from 545,000 2,000,000 µg/kg.

The extent of contamination of SVOCs at the upper bluff and filled ravine subsurface soils is presented on Figures 4-23 through 4-41. The extent of contamination is fairly well defined and resembles the extent identified for the VOCs. This includes the ravine fill from the MGP production area and north, and the area near B-31.

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Figures identifying the contaminant distribution of the VOCs and SVOCs for upper bluff/filled ravine subsurface soils are included as Figures 4-16 through 4-41. ¶

4.2.3 Surface Soils/Kreher Park

A set of 37 samples comprises the surface soil data analyses for Kreher Park. Results are included in Table 4-8A . The majority of samples were collected in 2005; approximately 25 percent were collected before and during 1997. Per the approved work plan, background samples were not collected at Kreher Park. Because the entire area is man-made land background samples were not considered applicable.

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Nature and Extent of Contamination

Metals and Inorganics

Metal and inorganic results are similar to comparable samples collected from upper bluff/filled ravine soils. Exceedances were measured for arsenic, cadmium, lead, and iron (compared to the Wisconsin nonInd standard). A summary of the exceedances for these compounds follows:

- Arsenic exceeds the 0.039 mg/kg Wisconsin nonInd standard in 33 of 36 samples; values range from 1.1 – 13.9 mg/kg;
- Cadmium exceeds the 8.0 mg/kg Wisconsin nonInd standard in one sample (TP-101); the value is 12 mg/kg;
- Iron exceeds the 23,463 mg/kg Region 9 standard in eight of 35 samples; values range from 24,000 – 94,000 mg/kg;
- Lead exceeds the 50 mg/kg Wisconsin nonInd standard in 18 of 36 samples; values range from 53 – 950 mg/kg.

The arsenic results range from values similar to background values to about seven times greater than background. The extent of arsenic above regulatory standards is ubiquitous throughout Kreher Park and is likely associated with urban fill and MGP process wastes. With the exception of three samples clustered at the base of the ravine, iron exceedances do not show any particular pattern or clustering and are likely to be associated with fill material used to fill in the former lakebed. The highest lead levels are found near the shoreline between the WWTP and the marina. The extent of lead concentrations above regulatory standards includes much of the Kreher Park area, and like iron, does not show any pattern or clustering and is likely associated with fill material. The one cadmium exceedance is likely associated with fill material encountered in test pit TP-101 near the shoreline. This is also a location where a high lead concentration was identified.

Figures 4-42 through 4-45 show the metals contaminant distribution and the extent of contamination for metals in the Kreher Park surface soils..

Organics

A larger set of samples was collected from surface soil at Kreher Park compared to the upper bluff, and detections for each of the subject VOCs were measured in at least one of these samples. Toluene and xylenes were detected most often, with fewer detections of TCB,

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ethylbenzene, n-butylbenzene and TMB. However, benzene is the only VOC measured that exceeds its respective standard, as follows:

- Benzene exceeds the 5.5 µg/kg Wisconsin GW path standard in four of 35 samples; values range from 23 – 495 µg/kg.

Each of these samples was collected from the area of the seep, where high levels of contaminants/free product have been observed, as shown on Figure 4-46. The extent of VOC contamination in surface soils at Kreher Park is limited to benzene at the seep area .

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Organics-SVOCs

PAH exceedances in surface soils at Kreher Park are limited primarily to the HMW PAHs, although a few exceedances of acenaphthylene naphthalene, and phenanthrene were measured. A summary of these detections follows:

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- Acenaphthylene exceeds the 700 µg/kg (Wisconsin GW path) standard in 4 of 35 samples; values range from 1,700 – 27,000 µg/kg;
- BaA exceeds the 88 µg/kg (Wisconsin nonInd) standard in 16 of 35 samples; values range from 240 – 25,000 µg/kg;
- BaP exceeds the 8.8 µg/kg standard in 17 of 35 samples; values range from 290 – 68,000 µg/kg;
- BbF exceeds the 88 µg/kg standard in 17 of 35 samples; values range from 330 – 53,000 µg/kg;
- B(ghi)P exceeds the 1,800 µg/kg standard in five of 35 samples; values range 3,240 – 57,000 µg/kg;
- BkF exceeds the 880 µg/kg standard in three of 35 samples; values range from 1,500 – 15,000 µg/kg;
- Chrysene exceeds the 8,800 µg/kg standard in one of 35 samples; the value is 32,000 µg/kg;
- Indeno(123) exceeds the 88 µg/kg standard in 9 of 35 samples; values range from 190 – 33,000µg/kg;
- Naphthalene exceeds the 400 µg/kg (Wisconsin GW path) standard in two of 35 samples; values range from 1,768 – 2,144 µg/kg;
- Phenanthrene exceeds the 1,800 µg/kg standard in two of 35 samples; values range from 2,600 – 6,800 µg/kg.

The distribution of exceedances and the extent of contamination of the PAHs in Kreher Park surface soils are shown on Figures 4-47 through 4-56. The predominant exceedances are from HMW PAHs. The majority of the exceedances are found in the area of the seep and the former coal tar dump. Samples from TP-117, TP-118, SS-9 and SS-10 yield the highest levels of these detections. However, exceedances of BaA, BaP, and BbF are widespread through Kreher Park.

4.2.4 Subsurface Soils/Kreher Park

Metals and Inorganics

Exceedances for metals and inorganics in subsurface soils at Kreher Park are limited to arsenic, cadmium, iron, lead and manganese. A summary of these detections are as follows:

- Arsenic exceeds the 0.039 mg/kg Wisconsin nonInd standard in 33 of 66 samples; values range from 0.83 – 36 mg/kg;
- Cadmium exceeds the 8.0 mg/kg standard in one of 94 samples (TW-8); the value is 24.8 mg/kg;
- Iron exceeds the 23,463 mg/kg Region 9 standard in six of 65 samples; values range from 24,000 – 31,000 mg/kg;
- Lead exceeds the 50 mg/kg Wisconsin nonInd standard in 21 of 95 samples; values range from 50 – 1,321 mg/kg.
- Manganese exceeds the 1,564 mg/kg Region 3 standard in one of 34 samples; the value is 2,000 mg/kg.

The arsenic results range from values similar to background values to values more than an order of magnitude greater than background values. The extent of arsenic above regulatory standards is widespread throughout Kreher Park, but not evident at all sampling locations. The arsenic concentrations are likely associated with urban fill and MGP process wastes. The one cadmium exceedance is likely associated with Kreher Park fill material and the extent in subsurface soil is limited to this one location. The iron exceedances and extents are clustered in samples collected from the seep area at the base of the ravine, and at the area north of the former WWTP near TW-11.

The manganese exceedance, which is the only exceedance in soil across the entire Site, does not appear to be associated with known COPCs. This detection was made at the seep in a sample

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The distribution of exceedances for benzene and the above SVOCs for Kreher Park surface soils are shown graphically on Figures 4-46 through 4-56

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from 4 – 6 feet in GP-156; the lack of other manganese exceedances in other samples indicates it is not associated with known contaminant sources at the Site.

The extent of lead exceedances above regulatory standards is clustered at the seep at the base of the ravine, and at various locations across Kreher Park, as shown on Figure 4-60. The high lead concentrations are associated with Site source material, at the seep area, and potentially other sources, such as the Kreher Park fill material. The highest lead measurements are in a sample from TW-8, which also yielded the highest cadmium value. This sample point is along the shoreline, about 100 feet from a surface soil sample where high lead and cadmium concentrations are detected. High lead levels are also found in samples at locations where free product has not been observed (e.g., TP-2, TP-7, the later a high lead in a surface sample); these locations are where no free product (sheens) were observed, but high lead levels were measured. These samples were collected in the area north and east of the solid waste area. Although elevated lead is also found in samples from free product areas (e.g., TP-2), the highest lead levels at Kreher Park do not appear associated with tar materials.

The distribution and extent of these metal exceedances in subsurface soils at Kreher Park are shown on Figures 4-57 through 4-61.

Organics-VOCs

VOC exceedances in subsurface soils at Kreher Park include benzene, ethylbenzene, n-butylbenzene, toluene, TCB, 1,3,5-TMB and xylenes. The summary of these exceedances follows:

- Benzene exceeds the 5.5 µg/kg (Wisconsin GW path) standard in 23 of 78 samples; values range from 11 – 645,000 µg/kg;
- Ethylbenzene exceeds the 2,900 µg/kg (Wisconsin GW path) standard in 7 of 94 samples; values range from 4,000 – 2,973,000 µg/kg;
- n-butylbenzene exceeds the 240,000 µg/kg (Regions 3 and 9) standards in one of 60 samples; the value is 648,000;
- 1,2,4-TCB exceeds the 62,160 µg/kg (Region 9) standard in two of 60 samples; the values range from 157,000 – 2,994,000 µg/kg;
- 1,3,5-TMB exceeds the 21,253 µg/kg (Region 9) standard in one of 94 samples; the value is 742,000 µg/kg;

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- Toluene exceeds the 1,500 µg/kg (Wisconsin GW path) standard in eight of 94 samples; values range from 1,500 – 2,007,000 µg/kg;
- Xylene exceeds the 4,100 µg/kg (Wisconsin GW path) standard in seven of 130 samples; values range from 4,400 – 4,981,000 µg/kg.

The highest measurement for benzene in soil across the entire site (including upper bluff/filled ravine as well as surface soils) is present in a sample collected at TP-4 at 4-6 feet in 1997. This sample was collected from the northern portion of the former coal tar dump and yielded a value of 645,000 µg/kg. The distribution of the remaining benzene exceedances at Kreher Park are concentrated at the seep area, former coal tar dump and solid waste areas. Each of these areas has been documented as free-product areas (both DNAPL and separate LNAPL source zones). The exceedance values at these locations include 22 samples that range between 11 – 8,380 µg/kg.

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Ethylbenzene exceedences are found with less frequency than benzene, but at similar areas. The seep, coal tar dump and solid waste area yield the highest values. The same sample from TP-4 at the coal tar dump with the highest benzene also yields the highest site-wide ethylbenzene (2,973,000 µg/kg). This number is higher by more than an order of magnitude above the next highest value (276,000 µg/kg) at TW-6 (the highest ethylbenzene at the filled ravine is 176,000 µg/kg).

The single exceedances of n-butylbenzene and 1,3,5-TMB are in the same sample from TP-4 that yield maximum values for benzene and ethylbenzene discussed above. Similarly, the highest TCB, toluene and xylene exceedances are in this TP-4 sample. The only other TCB exceedance is at TW-6 near the open sewer in the solid waste area.

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Toluene exceedances are potentially restricted to the seep area, the coal tar dump and the TW-11 area. Xylene exceedances are restricted to four locations: TP-4 (coal tar dump), TW-5/TW-6 (solid waste area), TP-5 (east of seep) and TW-9.(seep area).

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These VOC exceedances are from locations where free product has been observed, either as DNAPL or LNAPL. The extent of these exceedances is shown on Figures 4-62 through 4-68.

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Organics-SVOCs

Exceedances for all the SVOC compounds on the analyte list are present in subsurface soils as follows:

- Acenaphthene exceeds the 38,000 µg/kg (Wisconsin GW path) standard in 18 of 110 samples; values range from 46,400 – 8,200,000 µg/kg; 12 of these exceedances range between 750,000 – 8,200,000 µg/kg and are found within the area of the coal tar dump, along the pipe found at the bluff face, and the solid waste area (the highest measured value for this compound at the upper bluff/filled ravine is 670,000 µg/kg at GP-122);
- Acenaphthylene exceeds the 700 µg/kg standard in 34 of 110 samples; values range from 827 – 9,700,000 µg/kg; exceedances are found at the coal tar dump, the pipe at the bluff, the solid waste area, with lower values near the WWTP and TW-11; the highest levels are measured at the coal tar dump and along the pipe trace (1,300,000 – 9,700,000 µg/kg); the highest level at the upper bluff/filled ravine is 910,000 µg/kg (GP-122);
- Anthracene exceeds the 300,000 µg/kg standard in 12 of 110 samples; values range from 324,000 – 4,100,000 ug/kg; the distribution of the exceedances are nearly the same as acenaphthene; nine exceedances in samples from the coal tar dump and the pipe trace range from 1,500,000 – 4,100,000 µg/kg; the highest at the upper bluff is 750,000 µg/kg (GP-122);
- BaA exceeds the 88 µg/kg (Wisconsin nonInd) standard in 67 of 110 samples; values range from 110 – 2,400,000 µg/kg; the exceedance distribution is similar to acenaphthylene; only areas west of the solid waste area and east of the coal tar dump yield no exceedances;
- BaP exceeds the 8.8 µg/kg standard in 61 of 110 samples; values range from 21.9 – 1,800,000 µg/kg; the exceedance distribution is nearly the same as acenaphthylene and BaA;
- BbF exceeds the 88 µg/kg standard in 53 of 93 samples; values range from 158 – 1,200,000 µg/kg; the distribution is nearly the same as acenaphthylene, BaA, and BaP;
- B(ghi)P exceeds the 1,800 µg/kg standard in 30 of 110 samples; the values range from 2,440 – 1,200,000 µg/kg; the distribution is the same as the acenaphthylene, BaA, BaP, and BbF compounds, with the exception that there are few exceedances in the TW-11 area;
- BkF exceeds the 880 µg/kg standard in 34 of 110 samples; values range from 972 – 1,500,000 µg/kg; the distribution is the same as the acenaphthylene, BaA, BaP, BbF, and B(hgi)P compounds;
- Chrysene exceeds the 8,800 µg/kg standard in 20 of 110 samples; the values range from 12,000 – 2,300,000 µg/kg; the distribution is the same as the acenaphthylene, BaA, BaP, BbF, B(hgi)P, and BkF compounds;

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- Di(ah)A exceeds the 8.8 µg/kg standard in 20 of 93 samples; the values range from 253 – 290,000 µg/kg; the distribution shows exceedances tend to be limited to the coal tar dump and the pipe trace for this compound;
- Dibenzofuran exceeds the 145,263 µg/kg (Region 9) standard in 9 of 67 samples; the values range from 160,000 to 1,400,000 µg/kg; exceedances are found at the coal tar dump and along the pipe trace; the exceedance distribution is similar to that of Di(ah)A;
- Fluoranthene exceeds the 500,000 µg/kg (Wisconsin GW path) standard in 10 of 110 samples; the values range from 605,000 – 5,400,000 µg/kg; the exceedance distribution is limited to the coal tar dump and pipe trace;
- Fluorene exceeds the 100,000 µg/kg standard in 15 of 110 samples; the values range from 113,000 – 4,600,000 µg/kg; the exceedance distribution is similar to dibenzofuran;
- Indeno(123) exceeds the 88 µg/kg (Wisconsin nonInd) standard in 43 of 110 samples; values range from 96 – 1,200,000 µg/kg; the exceedance distribution is similar to B(ghi)P;
- Methylnaph1 exceeds the 23,000 µg/kg (Wisconsin GW path) standard in 12 of 67 samples; the values range from 200,000 – 21,000,000 µg/kg; exceedances are found at the coal tar dump, the pipe trace, the seep, near the WWTP, and near TW-11;
- Methylnaph2 exceeds the 20,000 µg/kg (Wisconsin GW path) standard in 20 of 96 samples; the values range from 30,000 – 30,000,000 µg/kg; this distribution is similar to methynaph1, with additional exceedances within the solid waste area;
- Naphthalene exceeds the 400 µg/kg standard in 46 of 110 samples; values range from 504 – 37,000,000 µg/kg; naphthalene exceedances are found across the entire Kreher Park area, with the highest levels at the coal tar dump. Lower concentrations and fewer exceedances are found at the solid waste area;
- Phenanthrene exceeds the 1,800 µg/kg standard in 42 of 110 samples; values range from 1,900 – 14,000,000 µg/kg; the exceedance distribution is similar to B(ghi)P and Indeno(123); and
- Pyrene exceeds the 500,000 µg/kg (Wisconsin nonInd) standard in 13 of 110 samples; values range from 616,000 - 7,600,000 µg/kg; the exceedance distribution is similar to fluoranthene.

The distribution and extent of these SVOC exceedances in subsurface soils at Kreher Park are shown on Figures 4-62 through 4-87. In general, the extent of SVOC exceedances includes much of Kreher Park. The exceedances are associated with free-product, which is also located throughout much of Kreher Park.

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4.2.5 Soil Results Summary

The soil data demark the sources of contamination at the Ashland/NSP Site. Free-product (DNAPL/LNAPL) zones have been defined within the fill at the former ravine in the area of the former gas holders and other MGP appurtenances. The geologic conditions at the MGP along with likely human intervention as a result of excavation has permitted free product to encroach the deep Copper Falls aquifer. Separate free product zones have also been defined at the seep area and TW-11 north of the WWTP, as well as in the bay sediments. Additionally, a distinct and separate LNAPL phase has been observed across much of the Park area.

This free product is the primary source of organic contamination. Inorganic contamination in the form of metals are also present. The elevated arsenic and iron concentrations are likely associated with natural background conditions and urban fill; however, due to the distribution of the greatest arsenic and iron concentrations, it is likely that these metals are also associated with the former MGP process wastes.[37] The one manganese exceedance measured at Kreher Park is likely the result of filling activities at that location. Single exceedance measurements for beryllium and vanadium in the fill in the ravine/upper bluff are not readily explained; however, the exceedances are not significantly greater than the regulatory standards. Elevated lead levels in the ravine fill may be associated with historic site use. Although there is a lack of information on production and waste streams to confirm this source, high lead levels above background occur in several samples in the free product zones in the ravine. Elevated lead and cadmium are also found along the lakeshore at Kreher Park. However, these compounds are found in areas devoid of free product, both DNAPL and LNAPL, indicating that a separate, unknown source of lead may exist.

The organic compounds measured in soil denote the MGP as a significant source of contamination. With the exception of one sample collected in the area of the coal tar dump, the highest levels of VOCs are found consistently at the upper bluff/filled ravine. The benzene levels characteristic of the tar produced as a waste material indicate the gas holders and other MGP appurtenances as the primary source for these VOCs. However, there is a significant disparity between PAH levels at Kreher Park compared to those collected at the upper bluff/filled ravine. This difference is greater than an order of magnitude for the suite of compounds analyzed when comparing the data sets collected at the different areas. The difference may be

[37] Review of the site-wide arsenic soil data shows that the three highest levels are found in fill east of Prentice Avenue at the RV Park. Additionally, of the 13 highest arsenic measurements, five are found at this area, five at the upper bluff outside the ravine, and three within the filled ravine. Similarly, review of the site-wide soil data for iron show that the highest concentrations are generally found near the WWTP near the shoreline. Six of the 12 highest iron values are found in samples from this area. Three of the other six are found in samples from the filled ravine, one of these six from the upper bluff south of the former MGP, and the final two from Kreher Park in shallow soils. Similar to arsenic, this pattern of iron measurements is likely associated with fill and as well as high background.

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related to MGP processes, whether from spills of feedstocks over time, process inputs, process area of the waste stream, or transport mechanisms. It is likely due from weathering or spills from MGP fuel off loading operations leading to comingling. The samples from free-product zones at the MGP site include the complete historical remnant of the concentrated fraction of the waste stream. This data set is large and comprehensive, as is the data set from free product areas at Kreher Park. As described in Section 6.0, the MGP likely contributed to most of the contamination at the Park and affected sediments. As stated in NewFields ENVIRONMENTAL FORENSIC INVESTIGATION report (Feb. 2006, page 9) "Many subsurface soil and NAPL samples within the Kreher Park Area contained tar in various states of weathering. Lightly weathered tars have high levels of naphthalene and other volatile aromatic compounds (Figure 6a). Environmental weathering preferentially removes these more labile substances primarily by evaporation, dissolution, biodegradation, and other processes…. These high resolution hydrocarbon fingerprints identified comingling with non-tar derived materials such as diesel and heavy range petroleum (Figure 6c). The variable presence of petroleum among tar contaminated samples indicated that the petroleum and tar were independently released. Mixtures of tar and petroleum were observed towards the middle of the former Coal Tar Dump while samples around the boundary of the Coal Tar Dump contained primarily tar".

4.3 Groundwater

Groundwater has been studied extensively at the Site beginning with the first samples collected during 1994. Historic samples have been collected from test pits, soil borings, temporary wells (since abandoned), two artesian wells installed at Kreher Park prior to these investigations, as well as permanent monitoring wells. A well network consisting of 70 permanent wells remains. This historic data is included in the access database that accompanies this report. Existing monitoring well locations are shown on Figure 2-1. Historic monitoring wells (abandoned) and one time sample points are shown on Figure 4-88.

Similar to the previous discussion regarding the contaminant distribution in Site soils, the following discussion regarding groundwater quality is arranged by domain. Groundwater quality at the upper bluff/filled ravine is first described, recognizing that the hydrogeologic and water quality conditions in the ravine are distinct from those in the saturated areas in the water table aquifer outside the flanks of the ravine (the Miller Creek Formation). A separate discussion of the groundwater quality at Kreher Park is also presented. Although groundwater discharges through the mouth of the ravine to Kreher Park, the differences in the hydrogeologic conditions between the ravine fill/upper bluff and Kreher Park allow for segmenting these areas for description purposes. The final groundwater domain described is the Copper Falls aquifer.

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4.3.1 Upper Bluff/Filled Ravine

All groundwater data at the upper bluff/filled ravine have been collected via monitoring wells. Because groundwater flow is north, well MW-16 is considered an up gradient well for the upper bluff and is screened at the water table outside the ravine and south of the NSPW service center. MW-6 is considered an up gradient well for the filled ravine and is screened at the water table at the head of the ravine along Lake Shore Drive.

The long groundwater sampling history at the Site has resulted in a comprehensive data set. Table 4-10 provides a summary of all metals, inorganic and organic compounds measured in groundwater samples collected at the upper bluff/filled ravine. Data are compared to standards/action levels specified by ch. NR 140, WAC (PAL), Federal MCLs and USEPA Regions 3 and 9.

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Metals and Inorganics - Upper Bluff

In general, the Wisconsin ch. NR 140 standards yield the most stringent limits (with a few exceptions), although the USEPA standards are more inclusive. Concentrations of all the metal parameters on the Table 4-1 list were measured at levels above the most stringent sample in at least one sample collected from wells at the upper bluff, with the exception of beryllium, cyanide, mercury selenium and zinc. The upper bluff well network includes MW-8, -10, -11, -12, -16 and -17. A summary of these detections follows:

- Antimony exceeds the 1.2 µg/l (Wisconsin PAL) standard in six of 20 samples; values range from 3.2 - 17 µg/l; two of these were measured at MW-8 located north of the former MGP east of the filled ravine;
- Arsenic exceeds the 0.04 µg/l (Regions 3 and 9) standard in 13 of 32 samples; values range from 1.8 – 30 µg/l; multiple exceedances were measured at MW-8, -10, -11, -16 and -17. The only consistent trend can be seen at MW-8 (slightly upward for four events), which also yields the highest levels;
- Barium exceeds the 400 µg/l (Wisconsin PAL) standard in eight of 20 samples; values range from 490 – 1,800 µg/l; the highest levels were measured during four successive events at MW-8;
- Cadmium exceeds the 0.5 µg/l (Wisconsin PAL) standard in four of 22 samples; values range from 0.98 – 6.3 µg/l; the three highest levels are from MW-8;

- Chromium exceeds the 10 µg/l (Wisconsin PAL) standard in 14 of 32 samples; values range from 11 – 490 µg/l; multiple exceedances were measured at MW-8 (which shows the highest levels and an upward trend), -10, and -16;
- Cobalt exceeds the 8 µg/l (Wisconsin PAL) standard in nine of 20 samples; values range from 16 – 160 µg/l; multiple exceedances were measured at MW-8, which shows the highest levels and a slight upward trend;
- Copper exceeds the 130 µg/l (Wisconsin PAL) standard in six of 32 samples; values range from 142 – 470 µg/l; multiple exceedances were measured at MW-8, which yields the highest levels and a slight upward trend;
- Iron exceeds the 150 µg/l (Wisconsin PAL) standard in 25 of 32 samples; values range from 200 – 310,000 µg/l; elevated levels were measured during multiple events at every well, the only trend can be seen at MW-8 (slightly upward) which also yields the highest levels.
- Lead exceeds the 1.5 µg/l (Wisconsin PAL) standard in 21 of 32 samples; values range from 1.55 – 110 µg/l; multiple exceedances were measured at every well; MW-8 yields the highest levels and an upward trend;
- Manganese exceeds the 25 µg/l (Wisconsin PAL) standard in 19 of 20 samples; values range from 120 – 5,700 µg/l;
- Nickel exceeds the 20 µg/l (Wisconsin PAL) standard in 10 of 30 samples; values range from 24 – 340 µg/l; MW-8 yields the highest levels and four exceedance measurements with a slightly upward trend; MW-16 shows two exceedances with no discernable trend;
- Silver exceeds the 10 µg/l (Wisconsin PAL) standard in one sample, MW- 8 during one event (20 µg/l);
- Thallium exceeds the 0.4 µg/l (Wisconsin PAL) standard in one sample, MW-16 during one event (5.7 µg/l);
- Vanadium exceeds the 6 µg/l (Wisconsin PAL) standard in 18 of 20 samples; all wells show multiple exceedences; the only trend is at MW-8 (slightly upward) which also yields the highest levels.

The data from MW-8, located along St. Claire Street east of the ravine appear anomalous. The levels of arsenic, chromium, iron, lead, manganese and vanadium found regularly (but at random levels) in the well network across the upper bluff area east and west of the former MGP likely indicate background conditions associated with the Miller Creek Formation. MW-8, however, shows the highest levels and upward trends for many compounds. There are no other wells with the same pattern of metals detections (with the exception of MW-7B screened in the Copper

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Falls and discussed in Section 4.3.3). These detections may be the result of historic filling along St. Claire Street, which was reconstructed during 2003.

Metals and Inorganics – Filled Ravine

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The filled ravine data for the metals and inorganics group do not yield significant variations from the upper bluff. Exceedances are found for 17 of the 19 metals compounds from the approved list. Concentrations of arsenic, iron, lead, manganese and vanadium are again the dominant metals that exceed standards. An additional compound frequently detected but not found in the upper bluff network wells is cyanide. The filled ravine network includes wells MW-1 through -6, -9, -14, -15 and TW-13. A summary of the metals detections at this network follows:

- Antimony exceeds the 1.2 µg/l (Wisconsin PAL) standard in 14 of 32 samples; values range from 2.4 - 13 µg/l; multiple exceedances are found at wells MW-1, -4, -5 and -15; slight upward trends can be seen at MW -1 and -15 (historically a well with free product), and slight downward trends at MW- 4 and -5;
- Arsenic exceeds the 0.04 µg/l (Regions 3 and 9) standard in 42 of 78 samples; values range from 1.16 – 77 µg/l; multiple exceedances were measured at all wells with the exception of MW-5 at the down gradient edge of the ravine, and MW-6 at the up gradient edge; no trends can be observed in any of the wells, although the highest consistent levels are at MW-4 at the south edge of the NSPW service center;
- Barium exceeds the 400 µg/l (Wisconsin PAL) standard in 15 of 32 samples; values range from 430 – 1,600 µg/l; multiple exceedances were measured at MW-4 (which showed a slight downward trend), -14 and -15 which yield constant values;
- Cadmium exceeds the 0.5 µg/l (Wisconsin PAL) standard in 17 of 52 samples; values range from 0.5 – 5.3 µg/l; multiple exceedances were measured at MW-1, -5, -9, -15 and TW-13; no trends can be observed, but the highest and most consistent measurements are at MW-5;
- Chromium exceeds the 10 µg/l (Wisconsin PAL) standard in 19 of 76 samples; values range from 12 – 236 µg/l; multiple exceedances were measured at MW-1, -3, -4, -9 and -15; no trends can be observed; the highest levels were measured at MW-3 on the west flank of the ravine;
- Cobalt exceeds the 8 µg/l (Wisconsin PAL) standard in nine of 32 samples; values range from 8.5 – 42 µg/l; multiple exceedances were measured at MW-1, -3 (which both show slight upward trends), and MW-4, (which shows a slight downward trend);

- Copper exceeds the 130 µg/l (Wisconsin PAL) standard in three of 76 samples; values range from 150 – 327 µg/l; single exceedances were measured at MW-2, -3 and -4; no trends can be observed;
- Cyanide exceeds the 40 µg/l (Wisconsin PAL) standard in 30 of 50 samples; values range from 44 – 5,340 µg/l; multiple exceedances were measured at MW-2, -3, -9, -14, -15 and TW-13; no distinct trends can be observed, but the highest levels are consistently found at MW-3 and -15;
- Iron exceeds the 150 µg/l (Wisconsin PAL) standard in 66 of 76 samples; values range from 340 – 150,000 µg/l; variable levels were measured during multiple events at every well, the only consistent trend can be seen at MW-15 (constant) which also yields the highest levels.
- Lead exceeds the 1.5 µg/l (Wisconsin PAL) standard in 41 of 75 samples; values range from 1.6 – 1,160 µg/l; multiple exceedances were measured at every well, but trends are variable across the network; concentration "spikes" are present for 1998 at MW-2 and -5, which account for the highest measurements (1,160 µg/l and 224 µg/l respectively)
- Manganese exceeds the 25 µg/l (Wisconsin PAL) standard in 32 of 32 samples; values range from 380 – 16,000 µg/l;
- Mercury exceeds the 0.2 µg/l (Wisconsin PAL) standard in three of 32 samples; these were slight exceedances measured at MW-1, -5 and -14;
- Nickel exceeds the 20 µg/l (Wisconsin PAL) standard in 12 of 50 samples; values range from 20 – 152 µg/l; multiple exceedances were measured in MW-2, -3, -4 and -5; the only discernible trends are seen in MW-3 (upward) and -5 (constant);
- Selenium exceeds the 10 µg/l (Wisconsin PAL) standard in three of 49 samples, values range from 12 – 19 µg/l; two detections were made at MW-1, which shows a downward trend;
- Silver exceeds the 10 µg/l (Wisconsin PAL) standard in one sample, MW- 15 during one event (11 µg/l);
- Thallium exceeds the 0.4 µg/l (Wisconsin PAL) standard in three of 32 samples, values range from 3.3 – 5.1 µg/l; each exceedance was measured at different wells;
- Vanadium exceeds the 6 µg/l (Wisconsin PAL) standard in 22 of 32 samples; values range from 6 – 170 µg/l; multiple exceedances were measured at MW-1, -3, -4, -9, -14 and -15; upward trends can be seen at each well with the exception of -15, which is constant; the highest levels were measured at MW-4.

As described earlier, one compound not found at significant levels at the upper bluff groundwater but measured in the ravine fill groundwater at consistent levels in excess of the

standard is cyanide. Although cyanide is a minor contaminant at water gas MGPs[38], it is only found in the ravine fill groundwater in excess of the standards. It is not found at levels exceeding standards in any other media at the Site. The elevated levels in the ravine fill groundwater (including the highest levels at MW-15) indicates a likely release from former MGP operations.

Although up gradient well MW-6 did not yield multiple exceedances, single elevated detections of barium, cobalt, iron, manganese, nickel, thallium and vanadium were measured at this well. Lower levels of cadmium, copper and selenium were also measured at this well. Although the data set for MW-6 is small, the majority of the metals found in the ravine are likely indicative of the fill. This also is true for antimony, arsenic and lead (the later yielded high levels in soil near free product areas; however, elevated lead levels in groundwater were measured at wells not proximate to free product, including other upper bluff wells screened in the Miller Creek Formation (i.e., MW-16)). Other waste materials in the ravine fill (e.g., ash and cinders) may contribute to high contaminant levels in groundwater in the ravine. Regardless, review of both data sets for the upper bluff and filled ravine consistently show the highest metal levels (for all compounds) in groundwater have been collected from MW-8, screened east of the ravine along St. Claire Street. Additionally, high levels of arsenic, antimony, barium, cadmium, chromium, iron, thallium and vanadium have been measured at water table wells screened in the Miller Creek formation away from the ravine fill. This indicates that metals contamination is likely associated in part with natural conditions and urban fill, and may not solely derived from the MGP.

Figures 4-89 through 4-105A show plan views of the maximum concentrations for the above inorganic compounds at upper bluff/filled ravine wells, along with selected time-concentration plots.

Organics – VOCs - Upper Bluff

Exceedances for VOCs on the approved parameter list at the upper bluff well network are limited to benzene and chloroform. A summary follows:

- Benzene exceeds the 0.34 µg/l (Region 3) standard in eight of 31 samples; values range from 0.49 – 120 µg/l; multiple exceedance measurements were made at MW-8, -10 and -

[38] Water gas MGPs did not produce high levels of nitrogen bearing compounds (i.e, cyanides & phenols); however, low levels are associated with historic purifier box waste.

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As described earlier, one compound not found at significant levels at the upper bluff groundwater but measured in the ravine fill groundwater at consistent levels in excess of the standard is cyanide is cyanide. Although cyanide is a minor contaminant at water gas MGPs[39], it is only found in the ravine fill groundwater in excess of the standards. It is not found at levels exceeding standards in any other media at the Site. The elevated levels in the ravine fill groundwater (including the highest levels at MW-15) indicates a likely release from former MGP operations.¶
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16, but no trends can be seen; the highest level is a one time measurement at MW-12, an abandoned well located adjacent to the east flank of the ravine in the NSPW service center courtyard.

- Chloroform exceeds the 0.2 µg/l (Region 3 and 9) standard in one of four samples; the exceedance was measured at MW-8 (4.7 µg/l);

Organics – SVOCs – Upper Bluff

Exceedances for PAHs at the upper bluff well network are limited to BaP, BbF and naphthalene. A summary follows:

- BaP exceeds the 0.003 µg/l (Region 3) standard in one of 38 samples; the detection was made at MW-10 (0.23 µg/l); MW-10 is located in the Our Lady of the Lake parking lot;
- BbF exceeds the 0.02 µg/l (Wisconsin PAL) standard in one of 38 samples; the detection was made at MW-10 (0.12 µg/l);
- Naphthalene exceeds the 6.2 µg/l (Region 9) standard in six of 39 samples; values range from 9.3 – 570 µg/l; multiple detections were made at MW-10 and -12; the only trend can be seen at MW-12 (upward) which also yields the highest levels.

The only measurements of these organic data likely related to the MGP are those found at MW-12. Based on its proximity, the elevated naphthalene and benzene concentrations measured in this well are associated with the MGP source. The other PAH detections are very low and found either up gradient or distantly cross-gradient from the MGP appurtenances, indicating these detections may be related to another source, such as urban background. The origin of the chloroform detection in MW-8 is unknown.

Organics – VOCs - Filled Ravine

Six VOCs from the approved parameter list were measured above regulatory standards during multiple events at the filled ravine well network These include benzene, ethylbenzene, styrene, TMB, toluene, and xylenes. The summary follows:

- Benzene exceeds the 0.34 µg/l (Region 3) standard in 74 of 92 samples; values ranged from 0.34 – 86,000 µg/l; multiple exceedance measurements were made at all the wells in the network with the exception of MW-6, which yielded only a single exceedance during one event; most of the levels show variable trends; the highest levels were measured at MW-15 (known free-product) and slightly lesser values at TW-13; the lowest levels were

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measured at MW-5; an unexplainable trend is observed at MW-1 which shows elevated levels until 1997, followed by several rounds with no detections;

- Ethylbenzene exceeds the 140 µg/l (Wisconsin PAL) standard in 41 of 84 samples; values range from 140 – 3,400 µg/l; the same general pattern as that shown for benzene exceedances are shown for ethylbenzene, although no exceedances were made at MW-3; the highest levels are found at TW-13, the lowest at MW-5;
- Styrene exceeds the 10 µg/l (Wisconsin PAL) standard in four of 44 samples; values range from 17 – 890 µg/l; three measurements were made at MW-9, which shows a declining trend;
- TMB exceeds the 96 µg/l (Wisconsin PAL) standard in eight of 18 samples; values ranged from 111 – 5,000 µg/l; this is a small sample set preventing a trend evaluation, but multiple exceedances were measured in MW-4 and -14; the highest level is a one time measurement at MW-15;
- Toluene exceeds the 200 µg/l (Wisconsin PAL) standard in 37 of 93 samples; values range from 490 – 36,000 µg/l; multiple exceedance measurements were made at MW-4, -9, -14, -15 and TW-13; no exceedances were measured at MW-3, -5 and -6; the highest levels were measured at MW-15 (constant trend); a downward trend can be seen at MW-9; the other wells show varying concentrations with no discernable trends;
- Xylenes exceed the 206 µg/l (Region 9) standard in 44 of 89 samples; values range from 207.7 – 11,500 µg/l; multiple exceedances were measured at MW-1, -2, -4, -9, -14, -15 and TW-13; single exceedances were measured at MW-5 and -2R; no exceedances were measured at MW-3 and MW-6; no trends can be seen, but the highest levels are found at MW-15;

The occurrence and frequency of the greatest VOC concentrations correspond to wells in proximity of free product areas (MW-12, MW-15, TW-13). There are few trends owing to the variability in groundwater flow away from the free-product plumes; however, concentrations are shown to decline to the north, in the direction of groundwater flow with the lowest concentrations in MW-5, near the base of the ravine.[40]

Organics – SVOCs – Filled Ravine

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[40] MW-5 is located at the mouth of the ravine down gradient from the primary free-product mass south of St. Claire Street. As shown, this well historically yielded low levels of VOCs, both before and after extraction well EW-4 began operating. Although screened near the buried clay tile (which provided a conveyance for tars to Kreher Park), these data confirm that the well has not been exposed to high levels of contaminants associated with the MGP tars.

Exceedances were measured at the filled ravine well network for each of the SVOCs (PAHs and PCP) included on the approved parameter list. The summary is as follows:

- Anthracene (LMW PAH) exceeds the 600 µg/l (Wisconsin PAL) standard in nine of 93 samples; values range from 950 – 120,000 µg/l; multiple exceedances were measured at MW-9 and TW-13, single measurements were made at MW-14 and -15; no trends are evident; recent events show no detections for this compound at all wells, including those that earlier yielded high levels (MW-9, -15, TW-13)
- BaP (HMW PAH) exceeds the 0.003 µg/l (Region 3) standard in 36 of 93 samples; values range from 0.028 – 71,000 µg/l; multiple exceedance measurements were made in all the wells except for MW-6, -14 and -15, which each yield single exceedances; wells MW-6 and -14 yield very low levels; MW-15 a single high value; no trends can be seen, but MW-9 yields the highest levels, and MW-4 the lowest; as with anthracene, the most recent events yield no detections at all wells;
- BbF (HMW PAH) exceeds the 0.02 µg/l (Wisconsin PAL) standard in 35 of 93 samples; values range from 0.11 – 31,000 µg/l; the pattern and trend of exceedances are nearly identical to that of BaP;
- Chrysene (HMW PAH) exceeds the 0.02 µg/l (Wisconsin PAL) standard in 25 of 98 samples; values range from 0.14 – 66,000 µg/l; exceedances were measured at all wells, with multiple measurements at MW-1, -2, -3, -9, -14 and TW-13; the highest levels are found at MW-9, no trends can be seen, and the most recent events show no detections at all wells;
- Fluoranthene (HMW PAH) exceeds the 80 µg/l (Wisconsin PAL) standard in 15 of 98 samples; values range from 110 – 140,000 µg/l; multiple exceedance measurements were measured at MW-3, -9 and TW-13; the highest levels were measured at MW-9; no exceedances were measured at MW-4, -5 and -6; as with the previous PAHs, no detections were made at all wells during the most recent events;
- Fluorene (LMW PAH) exceeds the 80 µg/l (Wisconsin PAL) standard in 16 of 98 samples; values range from 83 – 150,000 µg/l; multiple exceedance measurements were made in MW-1, -5, -9, -14 and TW-13; single exceedance measurements were made at MW-2, -3 and -4; no exceedances were made at MW-6; the highest levels are at MW-9; no trends can be seen;
- Naphthalene (LMW PAH) exceeds the 6.2 µg/l (Region 9) standard in 75 of 104 samples; values range from 14 – 1,700,000 µg/l; multiple exceedances were made at all wells in the network except MW-6 which yielded a single exceedance; the highest levels were measured at MW-9, but these are comparable with MW-15 and TW-13; no trends can be

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seen, but recent events show no detections at MW-1, -3 and -5 (adjacent to extraction well EW-4);

- PCP exceeds the 0.1 µg/l (Wisconsin PAL) standard in one of 12 samples; the measurement was made at MW-4 (76 µg/l);
- Phenol exceeds the 1,200 µg/l (Wisconsin PAL) standard in one of 78 samples; the measurement was made at MW-4 (4,500 µg/l);
- Pyrene (HMW PAH) exceeds the 50 µg/l (Wisconsin PAL) standard in 25 of 98 samples; values range from 54 – 180,000 µg/l; multiple exceedances were measured at MW-1, -3, -5, -9, -15, and TW-13; single exceedances were measured at the remaining wells except for MW-6, which yielded a single low detection; the highest levels were measured at MW-9; trends are variable early during the monitoring period but recent events show no detections for all wells except for a single low level detection at MW-3 during the most recent event;
- Pyridine exceeds the 2 µg/l (Wisconsin PAL) standard in two of 14 samples; this is a small sample set, but the measured values are 5.9 µg/l (MW-3 on 9/4/1997) and 20 µg/l (TW-13 on 6/4/1996).

With the exception of naphthalene, the majority of these compounds show sharp declines in their concentrations during the recent sampling. Inspection of the historical record indicates that although different laboratories were utilized during past events, the recent declines do not appear to be associated with high detection limits created by masking from other compounds.

Figures 4-106 through 4-123 show plan views of the maximum concentrations and the extent of contamination (as applicable) for the VOCs and SVOCs detected at upper bluff/filled ravine wells, along with selected time-concentration plots. The extent of VOC and SVOC contamination at the upper bluff and filled ravine can not be fully defined; however, it is clear that the bulk of the groundwater contamination is located within the filled ravine from the source area (near MW-4 and MW-15), to the north including the entire ravine.

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4.3.2 Kreher Park

Water quality data from Kreher Park has been compiled from samples collected from monitoring wells, test pits, Geoprobe borings and diffusion bags. Table 4-10 provides the summary of all metals, inorganic and organic compounds measured in groundwater samples collected from Kreher Park. As discussed earlier, groundwater discharges from the mouth of the ravine to the park area. Although much of this discharge has recently been captured (since 2002) by

extraction well EW-4, the discharge of groundwater through the ravine as well as other up gradient groundwater discharge between the upper bluff and Kreher Park continues. However, because of the filling history, the flat water table surface, the highly permeable fills, and the perturbations in water levels induced by Chequamegon Bay, the groundwater conditions at the park area within the Site boundary have been subdivided for discussion purposes in this report.

Metals and Inorganics

This compound group yields data similar to that found in the ravine fill groundwater. These levels reflect the persistence of these particular compounds in the fill. The other compounds from this group, which yielded anomalous detections at the upper bluff (i.e., MW-8), are found less frequently at the Park. A summary of the exceedances of metals and inorganics in groundwater at Kreher Park is as follows:

- Antimony exceeds the 1.2 µg/l (Wisconsin PAL) standard in 8 of 32 samples; values range from 2.3 – 4.6 µg/l; all the exceedance measurements were made during the most recent event (March 2005) across the well network, with only one additional measurement at MW-3(NET) during September 2004; prior to that time (with the exception of MW-3(NET) (located near the bluff face and Prentice Avenue) the compound was not detected.
- Arsenic exceeds the 0.04 µg/l (Regions 3 and 9) standard in 45 of 112 samples[41]; values range from 1.18 – 24.6 µg/l; multiple exceedances were measured at nearly all the permanent wells in the network with the exception of TW-11 and TW-9; both single and multiple exceedance measurements were made at temporary wells abandoned early in the monitoring history of the site (many of the TW series of wells at Kreher Park were abandoned in the mid 1990s); the highest levels were measured at TW-3 northeast of the seep area (abandoned), and along the shoreline (MW-24 and -26); the majority of wells show no trends except for MW-3(NET), which yielded no detections early during the monitoring period (early 1990s) followed by constant detections during later events;
- Barium exceeds the 400 µg/l (Wisconsin PAL) standard in eight of 32 samples; values range from 420 – 1,100 µg/l; multiple exceedances were measured in MW-7R and MW-26, and a single exceedance was measured in MW-24; no trends were observed, however, constant levels including values below regulatory limits were found at all wells where barium was measured;

[41] The total does not include 12 samples collected from the MSA wells for arsenic, cadmium, chromium, copper, iron, lead, nickel and zinc; these wells are outside the site boundary east of Prentice Avenue; the data for these wells is included in Table 4-10 .

- Cadmium exceeds the 0.5 µg/l (Wisconsin PAL) standard in eight of 107 samples; values range from 0.51 – 60.8 µg/l; the 60.8 µg/l value was from a one-time sample in the southwest area of the Park; the next highest value is 9.4 µg/l from the seep; four exceedances were found along the shoreline (MW-24, -25 and -26); another measurements was at MW-3(NET) and at TW-6, an abandoned well on the south side of the solid waste area;
- Chromium exceeds the 10 µg/l (Wisconsin PAL) standard in 26 of 112 samples; values range from 10 – 250 µg/l; multiple exceedances were measured at MW-2(NET), -3(NET, -7R, -24, -25, and -26; the highest levels were measured at MW-2(NET) (a high spike during one event but no discernible trend); no trends are seen at the wells with multiple exceedances with the exception of MW-3(NET), which shows an increasing trend during later events;
- Cobalt exceeds the 8 µg/l (Wisconsin PAL) standard in 14 of 32 samples; values range from 8.1 – 51 µg/l; multiple exceedances were measured at MW-3(NET), -7R -24, -25 and -26; the highest level was measured at MW-24; no trends are seen, except at MW-25 which shows a slight downward trend;
- Copper exceeds the 130 µg/l (Wisconsin PAL) standard in one of 112 samples; the exceedance was measured in one sample, MW-3(NET) during one event (200 µg/l);
- Cyanide exceeds the 40 µg/l (Wisconsin PAL) standard in one of 67 samples; the sample was collected at the seep (125 µg/l);
- Iron exceeds the 150 µg/l (Wisconsin PAL) standard in 64 of 112 samples; values range from 190 – 70,000 µg/l; the highest levels were measured at wells along the shoreline (MW-26); no distinct trends that can be seen;
- Lead exceeds the 1.5 µg/l (Wisconsin PAL) standard in 47 of 112 samples; values range from 1.5 – 120 µg/l; multiple exceedances were measured at MW-2(NET), -3(NET), -24, -25, -26, and temporary wells TW-2 through -6 prior to abandonment; the highest levels were measured at wells along the shoreline; no trends can be seen;
- Manganese exceeds the 25 µg/l (Wisconsin PAL) standard in 32 of 32 samples; values range from 660 – 3,400 µg/l; values are highest along the shoreline; no trends can be seen;
- Nickel exceeds the 20 µg/l (Wisconsin PAL) standard in 13 of 37 samples; values range from 20 – 340 µg/l; multiple exceedances were measured at MW-3 (NET), -7R, -24, -25 and -26; the highest values were measured at MW-3(NET); no trends can be seen;
- Selenium exceeds the 10 µg/l (Wisconsin PAL) standard in one of 83 samples; the sample was collected at the seep (790 µg/l);

- Thallium exceeds the 0.4 µg/l (Wisconsin PAL) standard in two of 32 samples, values range from 2.6 – 2.7 µg/l; both exceedances were measured at MW-3(NET);
- Vanadium exceeds the 6 µg/l (Wisconsin PAL) standard in 24 of 32 samples; values range from 7.7 – 220 µg/l; multiple exceedances were measured at all wells except MW-1(NET) and TW-12; the highest levels were measured at wells along the shoreline; no trends can be observed;
- Zinc exceeds the 2,500 µg/l (Wisconsin PAL) standard in one of 124 samples; the sample was collected at the seep (3,600 µg/l);

The majority of these compounds yield levels comparable to those found in the ravine fill. With the exception of cyanide (found only at the seep), and lead (found at one-tenth of the highest values in the ravine fill), these compounds appear to originate as components of the fill. Localized high values detected along the shoreline for many of these inorganics (including lead) indicate the concentrations may be associated with the fill material used to fill this area. This finding in groundwater is likely associated with similar elevated concentrations of metals detected in soil from this area.

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Figures 4-124 through 4-139 show plan views of the maximum concentrations for the above inorganic compounds at Kreher Park wells as well as the extent of contamination (as applicable), along with selected time-concentration plots. The extent of contamination can not be fully defined for all of the inorganics, because some compounds, such as iron, are found throughout Kreher Park at concentrations greater than regulatory standards. However, the elevated concentrations of a number of these inorganics are clustered near the base of the ravine, near the seep area.

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Organics –VOCs – Kreher Park

Six VOCs from the approved parameter list exceed groundwater standards at Kreher Park. The summary of these measurements is as follows:

- Benzene exceeds the 0.34 µg/l (Region 3) standard in 105 of 126 samples; values range from 0.8 – 36,000 µg/l; multiple exceedance measurements were made at all the wells in the network; the highest levels were measured at MW-7R, where free product has been detected (a high detection of 24,000 µg/l was measured at MW-2(NET) during 2000, which approached the levels at MW-7R; however, the other events at this well show

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values no higher than 950 µg/l)[42]; benzene is widespread across the Park area, but with the exception of the aforementioned wells, the highest measured level is 4,280 µg/l from a single sample on the west side of the solid waste area; no sample points indicate trends, with the exception that the one time passive diffusion bag data show increasing benzene concentrations toward the shoreline at the east line (PDB-1, -2.and -3); the west line shows one detection at the shoreline (PDB-4) but no detections at the more distant samples; this data indicates that this mobile compound is dispersed in groundwater across the Park, and is subject to tidal variations from free product source areas in the sediments (see Table 4-10 for PDB data);

- Ethylbenzene exceeds the 140 µg/l (Wisconsin PAL) standard in 54 of 127 samples[43]; values range from 173 – 4,400 µg/l; multiple exceedances were measured at every well except for MW-3(NET), MW-24, -26 and TW-12, which show no exceedances; the highest levels were measured at MW-7R, which indicates a slightly upward trend (free product was measured), but the other wells indicate no trends;
- Styrene exceeds the 10 µg/l (Wisconsin PAL) standard in five of 38 samples; values range from 29 – 1,300 µg/l; four of the exceedances were measured at MW-7R, which shows no trend; the other exceedance was measured at MW-2(NET); the remaining samples show no detections;
- TMB exceeds the 96 µg/l (Wisconsin PAL) standard in three of eight samples; values range from 97 – 440 µg/l; this is a small sample set preventing a trend evaluation; exceedances were measured at MW-1(NET), -2(NET) and TW-11, which yields the highest value (the later measurement was made in 1997; free product first appeared at this well beginning in 2003);
- Toluene exceeds the 200 µg/l (Wisconsin PAL) standard in 13 of 126 samples; values range from 200 – 16,000 µg/l; multiple exceedance measurements were made at MW-2(NET) and MW-7R; the highest levels were measured at MW-7R (a high detection of 12,000 µg/l was measured at MW-2(NET) during the same high benzene event); the only trends are downward for MW-1(NET) and TW-6; each yield single exceedance values;
- Xylenes exceed the 206 µg/l (Region 9) standard in 39 of 134 samples; values range from 238 – 4,800 µg/l; multiple exceedances were measured at MW-1(NET), -2(NET), -7R, TW-6, -9 and -11; exceedances were also measured at several single sample locations; the highest levels were measured at MW-7R; no trends can be seen;

[42] Detailed inspection of the historic data at the MW-2 well nest indicates that during the subject sampling event (September 2000) the measurement resulted from mislabeling MW-2B(NET) as MW-2(NET)

[43] This total does not include analyses for ethylbenzene, TMB, toluene, and xylenes from 12 MSA samples collected east of Prentice Avenue; the data for these wells is included in Table 4-10.

Similar to the findings in the filled ravine, these data show the highest levels in proximity to the free product areas. Total VOCs approaching 50,000 µg/l (primarily benzene) are found near the DNAPL zones. However, several areas at the Park where free-product is limited to LNAPL show groundwater total VOCs an order of magnitude less than the DNAPL areas.

The extent of VOC contamination in Kreher Park is shown on Figures 4-140 through 4-145. These figures show that VOCs are located throughout most of Kreher Park. This distribution correlates directly with the distribution of DNAPL and LNAPL. LNAPL is also located in most locations throughout the Park.

Organics – SVOCs – Kreher Park

Exceedances were measured at Kreher Park in groundwater for each of the SVOCs included on the approved parameter list with the exception of PCP and phenol. The summary is as follows:

- Anthracene (LMW PAH) exceeds the 600 µg/l (Wisconsin PAL) standard in 22 of 119 samples; values range from 700 – 16,100 µg/l; multiple exceedances were measured at TW-9, but the majority of exceedances (and the highest levels) were predominantly found in one time sample points; these are found in the solid waste area and along the bluff pipe trace;
- BaP (HMW PAH) exceeds the 0.003 µg/l (Region 3) standard in 73 of 119 samples; values range from 0.388 – 7,754 µg/l; multiple exceedance measurements were made at MW-2(NET), MW-3(NET), TW-9, and TW-11; no detections were made at MW-1(NET) and the shoreline wells (MW-24 through -26). As with anthracene, many of these detections were made in single sample points; the highest levels are found at the seep, MW-7 (prior to its abandonment; MW-7R shows no detections) and TW-9; the latter are free product zones; there are no trends;
- BbF (HMW PAH) exceeds the 0.02 µg/l (Wisconsin PAL) standard in 70 of 119 samples; values range from 0.096 – 6,260 µg/l; as with the ravine fill, the pattern of exceedances are nearly identical to that of BaP;
- Chrysene (HMW PAH) exceeds the 0.02 µg/l (Wisconsin PAL) standard in 71 of 119 samples; values range from 1.19 – 7,298 µg/l; the relative strength of concentrations and the pattern of exceedances were the same as for BaP and BbF;
- Fluoranthene (HMW PAH) exceeds the 80 µg/l (Wisconsin PAL) standard in 49 of 119 samples; values range from 80.5 – 32,400 µg/l; the pattern of exceedances are similar to

BaP, BbF, and chrysene; the highest levels are found at the seep, the solid waste area and along the pipe trace;

- Fluorene (LMW PAH) exceeds the 80 µg/l (Wisconsin PAL) standard in 42 of 119 samples; values range from 80.1 – 20,200 µg/l; the strength of contaminant levels and the pattern of exceedances are similar to that for BaP, BbF, chrysene, and fluoranthene with the exception that there are few detections at MW-3(NET);
- Naphthalene (LMW PAH) exceeds the 6.2 µg/l (Region 9) standard in 103 of 128 samples; values range from 8.6 – 39,749 µg/l; exceedances were measured across the entire Park area; the highest levels were measured at the free product areas (the seep, MW-7R, TW-9 and TW-11); there appear to be no trends, although low levels are found at MW-3(NET);
- Pyrene (HMW PAH) exceeded the 50 µg/l (Wisconsin PAL) standard in 60 of 111 samples; values range from 51.5 – 56,200 µg/l; the pattern of exceedances are similar to BaP, BbF, chrysene, fluoranthene, and fluorene.

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The concentrations of these compounds have the same relative relationship and indicate a potential similar source as that found in the ravine fill. However, these values are approximately an order of magnitude below the concentrations found in the ravine fill groundwater. These conditions show the dilution effects occurring at Kreher Park, and the influence of the isolated DNAPL free-product source areas. Groundwater quality at Kreher Park shows widespread contaminant distribution, but the highest levels again correspond to the approximate locations where free-product (primarily DNAPL) has been measured.

Figures 4-146 through 4-153 show plan views of the maximum concentrations and the extent of contamination of the SVOCs at Kreher Park wells, along with selected time-concentration plots. In general, SVOC contamination is prevalent throughout most of Kreher Park, with elevated concentrations directly correlated to the free-product (both DNAPL and LNAPL) found throughout the Park.

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4.3.3 Copper Falls Aquifer

The Copper Falls Aquifer has been extensively studied since investigation at the Site began. It also includes the most comprehensive and largest data set of all the various media. For purposes of this report, the aquifer includes groundwater samples screened below the Miller Creek Formation, including the MW-2C bedrock well. A summary of the water quality data for the Copper Fall aquifer is presented below.

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Metals and Inorganics

The inorganic water quality in the Copper Falls aquifer is generally less impacted when compared to the upper bluff, ravine fill or Kreher Park. However, unlike the organic compounds, analyses of the majority of inorganic compounds on the approved parameter list have only been performed since the remedial investigation began. Exceedance measurements for the inorganic compounds on the list were found with the exception of mercury, selenium, silver and zinc. A summary of these exceedances follows:

- Antimony exceeds the 1.2 µg/l (Wisconsin PAL) standard in 23 of 201 samples; values range from 2 – 19 µg/l; similar to the measurements at Kreher Park, all the exceedance measurements were made during the most recent event (March 2005), with two exceptions: one during June 2004 at MW-7A (16 µg/l), and the other during September 2004 at -13D (19 µg/l); there are no other detections; excluding these two highest values the maximum detected concentration is 5.4 µg/l; because of the March 2005 data, all the wells yield recent upward trends;
- Arsenic exceeds the 0.04 µg/l (Regions 3 and 9) standard in 163 of 237 samples; values range from 1.45 – 14 µg/l; multiple exceedances were measured at all the wells in the network; the highest level was measured at MW-4B during one event, but there is little spread in the data; no trends can be seen, with the exception of an upward trend at -4B prior to free product incursion and a slightly upward trend at -7B;
- Barium exceeds the 400 µg/l (Wisconsin PAL) standard in 42 of 201 samples; values range from 420 – 1,100 µg/l; multiple exceedances were measured at MW-2B(NET). 4A, -5A, -5B, -6A, -8A, -9A, -9B, -9C, -10B, -21A, -21B, and -22A; the highest levels were measured at -4A and -22A; there are no trends in the data, except for a slight upward trend at -7B;
- Beryllium exceeds the 0.4 µg/l (Wisconsin PAL) standard in two of 201 samples; one was measured at MW-2C during December 2003 (0.66 µg/l), the other at -21B during June 2004 (0.71 µg/l); there are no trends in the data;
- Cadmium exceeds the 0.5 µg/l (Wisconsin PAL) standard in six of 219 samples; values range from 0.52 – 1.75 µg/l; the six exceedances were measured at separate wells during different events across the entire study area; there are no trends in the data;
- Chromium exceeds the 10 µg/l (Wisconsin PAL) standard in 17 of 236 samples; values range from 10 – 140 µg/l; multiple exceedances were measured at MW-4B, -7B, -17A, -20A, -21B, and -22A. A downward trend is seen at -21B, upward trends at -4B prior to

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free product incursion and -7B, and a slightly upward trend at MW-20A; there are no trends in the remaining data;

- Cobalt exceeds the 8 µg/l (Wisconsin PAL) standard in 13 of 201 samples; values ranged from 8.2 – 60 µg/l; multiple exceedances were measured at MW-4B, -7B, -17A; -20A, -21B and -22A; the pattern and trends in exceedances are nearly identical to chromium, although only a single exceedance was measured at -17A;
- Copper exceeds the 130 µg/l (Wisconsin PAL) standard in four of 238 samples; values range from 130 – 500 µg/l; single exceedances were measured at MW-4B, -7B, -21B and -13C (which yielded the highest value); there are no trends in the data, except for -4B and -7B which show upward trends;
- Cyanide exceeds the 40 µg/l (Wisconsin PAL) standard in 37 of 367 samples; values range from 40 – 360 µg/l; multiple exceedances were measured at MW-2A, -4A, -5B, -9A, -9B, -10B, and -22A; the highest levels were measured at -9A, -9B and -10B; the only discernible time patterns are an upward trend at -10B, and a recent upward trend at MW-9B;
- Iron exceeds the 150 µg/l (Wisconsin PAL) standard in 145 of 236 samples; values range from 190 – 110,000 µg/l; the maximum levels appear to be clustered in the area of the former MGP; the only distinct trends are increases at MW-7B and -20A and decreases at -19A and -21B;
- Lead exceeds the 1.5 µg/l (Wisconsin PAL) standard in 81 of 239 samples; values range from 1.5 – 70 µg/l; multiple exceedances were measured at MW-2B(NET), -2BR, -2C, -4A, -4B, -5B, -5C, -6A, -7B, -8A, -9A, -10A, -13A, -15B, -17A, 0-18A, -18B, -20A, -21A, -21B, and -22A; the highest levels were measured at -4B, which shows an increasing trend prior to free product incursion; maximum levels are similar to iron, which are clustered in the area of the former MGP; an increasing trend is also seen at -7B, but declines can be seen at -19A and -21B; no other wells show trends;
- Manganese exceeds the 25 µg/l (Wisconsin PAL) standard in 191 of 201 samples; values range from 25 – 3,200 µg/l; the only samples less than the standard were from MW-2A(NET), which shows a single exceedance, -5C, and -25A, which also shows a single exceedance; the highest values were measured at -4A; the only trends can be seen at -21A (downward) and -7B (upward);
- Nickel exceeds the 20 µg/l (Wisconsin PAL) standard in 13 of 214 samples; values range from 20 – 120µg/l; multiple exceedances were measured at MW-4B, -7B, -17A, -20A and -21B; increasing trends can be seen at -4B prior to free product incursion, -7B and -20A; declines can be seen at 19B and -21A; no other trends are present;

- Thallium exceeds the 0.4 µg/l (Wisconsin PAL) standard in four of 201 samples, values range from 2.6 – 8.3 µg/l; the exceedances were measured during a single event at MW-8A and -18A and during another event at -5B and -10A; there are no other detections,
- Vanadium exceeds the 6 µg/l (Wisconsin PAL) standard in 37 of 201 samples; values range from 6.5 – 230 µg/l; multiple exceedances were measured at MW-2C, -4B, -6A, 7B, -8A, -17A, -20A, -21B and -22A; the highest levels were measured at -7B and -21B; declines can be seen at -21B and -19A; increases can be seen at -4B and -7B; no other trends are present;

These data indicate that inorganic groundwater quality has been impacted in the area of the MGP. Although the full extent of inorganic contamination can not be delineated, due to the ubiquitous nature of several constituents (e.g., arsenic and iron), it is evident that the greatest inorganic concentrations detected occur in areas associated within the dissolved phase halo surrounding the DNAPL plume (e.g., MW-7B, MW-10A, MW-19A, MW-21B and MW-22B). Inorganic COPCs appear to be limited to cyanide, iron and lead. Cyanide is not measured beyond the wells in the immediate vicinity of the MGP. Arsenic, iron and lead are measured beyond the MGP and not all measurements are associated with releases from the MGP. However, much higher levels of arsenic, iron, and lead are measured at the MGP wells indicating that these metals are likely released into solution as a result of contact with Site source material. The high metals content at MGP wells may be caused by cation exchange with soil in the presence of the primary contaminant plume and may be associated with MGP process wastes.

Figures 4-154 through 4-168A show plan views of the maximum concentrations and the extent of contamination for the above inorganic compounds at Copper Falls Aquifer wells, along with selected time-concentration plots.

Organics-VOCs

Eight VOCs included on the approved list were measured at Copper Falls wells in excess of the most stringent standards. The summary of these data follows:

- Benzene exceeds the 0.34 µg/l (Region 3) standard in 376 of 497 samples; values range from 0.34 – 63,000 µg/l; multiple exceedance measurements were made at all the wells in the network with the exception of the two artesian wells, MW-2C, -6A, -24A, -25A and -26A; the highest levels were measured at wells proximate to or containing free product (MW-2A, -2AR, -4B, -5B, -10B, -13A, -13B -18A, and -22A); these data confirm the

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earlier descriptions of the relationship between the benzene levels and the measurement of free-product (DNAPL) in groundwater; review of the time-concentration plots indicates there are essentially no trends; the only exceedances measured at MW-2C, -24A and -25A were the initial values shortly following well installation (MW-26A also shows an initial value below the standard); these measurements were likely caused by drilling artifacts because subsequent values are just at or below detection limits;

- Chloroform exceeds the 0.2 µg/l (Regions 3 and 9) standard in four of 28 samples; values range from 0.66 – 9.4 µg/l; no other detections were made; the measurements were made during three separate events in 1996 and 1997 at two wells (MW-6A and MW-9A); the highest measurements were made at MW-6A, the up gradient well;
- Ethylbenzene exceeds the 140 µg/l (Wisconsin PAL) standard in 206 of 497 samples; values range from 140 – 5,300 µg/l; multiple exceedances were measured at the wells in proximity of the free-product plume, but the lower mobility of ethylbenzene (compared to benzene) shows declining levels with distance from the free product; the highest levels were measured at MW-2A(NET), -2B(NET), -4A, -5A and -18A; although free product has never been measured at -4A, this location is near former USTs that appear on historic Sanborn maps; these persistent high levels of ethylbenzene at this well may indicate a source material associated with these tanks as compared to the larger mass of MGP tar; there are no trends;
- Methylene chloride exceeds the 0.5 µg/l (Wisconsin PAL) standard in six of 10 samples; values range from 3.2 – 920 µg/l; the measurements were made on six separate samples during the same event in 2001 (June); these data were flagged by the laboratory as lab contamination; the other four samples collected also measured this compound, but below the standard; these samples were collected during the same event and flagged accordingly;
- Styrene exceeds the 10 µg/l (Wisconsin PAL) standard in 103 of 221 samples; values range from 15 – 5,300 µg/l; multiple exceedances were measured at MW-2A(NET), -2B(NET), 2BR, -4A, -4B, -5B, -7A, -9B, -9C, -13A, -15B, -18A, -19A, -19B, -21A, -21B, -22A, -23A and -23B; the highest levels were measured at -5B and -21A; there are no trends;
- TMB exceeds the 96 µg/l (Wisconsin PAL) standard in 31 of 98 samples; values range from 98 – 980 µg/l; the highest levels were measured at -10B and -4A; the exceedances at MW-4A may be from the USTs discussed above for ethylbenzene; multiple exceedances were measured at MW-2A, -4A, -5A, -7A, -9A, -9B, -9C, -13A, -15B, -18A, -19A, -19B, -21A, -21B, -22A, -23A and -23B; there are no trends;

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- Toluene exceeds the 200 µg/l (Wisconsin PAL) standard in 244 of 497 samples; values range from 220 – 30,000 µg/l; multiple exceedance measurements were made in MW-2A(NET), -2B(NET), -2BR, -4A, -4B, -5A, -5B, -7A, -8A, -9A, -9B, -9C, -10A, -13A, -18A, -19A, -19B, -21A, -22A, -23A, and -23B; the highest levels were measured at wells containing or near free product zones; there are no trends;
- Xylenes exceed the 206 µg/l (Region 9) standard in 224 of 487 samples; values range from 220 – 9,700 µg/l; the pattern and occurrence of exceedances is essentially the same as toluene; there are no trends;

The VOC data in the Copper Falls aquifer identifies a dissolved phase "halo" surrounding the free-product plume. Figures 4-169 through 4-174 present the distribution and extent of VOC contamination, along with selected time-concentration plots. Figure 4-169, benzene distribution, shows that contamination associated with the MGP sources is widespread throughout the Copper Falls aquifer. However, detailed review of the benzene data shows that the figures, which represent the maximum detection at any location, represent worst-case conditions. Low level, single benzene PAL exceedances were measured at MW-2C, the deep bedrock well, and MW-24A and MW-25A; only one trace level measurement (at the detection limit) was made at MW-26A. Wells MW-24A, -25A and -26A are the most distant Copper Falls wells along the shoreline. Additionally, the benzene levels at wells screened downgradient from the free product plume at the interface of the Miller Creek/Copper Falls contact (MW-5B and MW-18A) show high benzene levels (approaching solubility limits) indicating close proximity to free product/DNAPL. More distant wells screened at the contact (MW-2BNET and MW-23A) show progressively lower benzene levels.[44] These water quality conditions suggest that the movement of the dissolved phase constituents may be controlled by the flow conditions in the aquifer.

Organics-SVOCs

Exceedances were measured at Copper Falls wells for each of the SVOCs included on the approved parameter list with the exception of PCP. The summary is as follows:

- Anthracene (LMW PAH) exceeds the 600 µg/l (Wisconsin PAL) standard in seven of 489 samples; values range from 1,200 – 28,000 µg/l; multiple exceedances were

[44] Figures 3-3 and 3-4 show that the water level at MW-23A is about 10 feet higher than that at MW-2BNET. As discussed in Section 3, the MW-2BNET location is a potential stagnation zone where the downgradient free product plume converges with flow from the upper reaches of the aquifer. Although discharge through the clay aquitard at this potential stagnation zone likely occurs, the quantity of flow is low due to the low permeability of the Miller Creek Formation.

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measured at MW-10B; single exceedances were measured at EW-1 and MW-13B; MW-10B shows an increasing trend until more than one foot of free product was measured in September 2002 (subsequent sampling was not performed); similarly, MW-13B analytical data was developed during one event prior to free product incursion;

- BaP (HMW PAH) exceeds the 0.003 µg/l (Region 3) standard in 28 of 486 samples; values range from 0.121 – 14,000 µg/l; multiple exceedance measurements were made at MW-4A, -9B, -10B, and -22A; the highest levels were measured at -10B; trends show declines at -4A, -9B and -22A, while -10B shows an increase;
- BbF (HMW PAH) exceeds the 0.02 µg/l (Wisconsin PAL) standard in 20 of 498 samples; values range from 0.06 – 10,300 µg/l; the pattern of exceedances are nearly identical to BaP, except no detections were measured at MW-22A;
- Chrysene (HMW PAH) exceeds the 0.02 µg/l (Wisconsin PAL) standard in 26 of 498 samples; values range from 0.13 – 13,000 µg/l; multiple exceedances were measured at MW-4A, -9B, -10B, and -22A; the highest levels were measured at MW-10B (except that the single highest value was measured at MW-4B prior to free-product incursion); the pattern of exceedances is essentially the same as that for BaP;
- Fluoranthene (HMW PAH) exceeded the 80 µg/l (Wisconsin PAL) standard in nine of 498 samples; values range from 100 – 28,000 µg/l; multiple exceedances were measured at MW-10B which showed the same trend as that for the other HMW PAHs; the single highest value was measured at -4B prior to free product incursion; single exceedances were measured at -2A, -22A and EW-1;
- Fluorene (LMW PAH) exceeds the 80 µg/l (Wisconsin PAL) standard in 13 of 498 samples; values range from 93 – 39,000 µg/l; multiple exceedances were measured at MW-10B and -22A; the single highest value was measured at -4B; the pattern of exceedances is similar to that for fluoranthene, with the exception that a single high value of 13,000 µg/l was measured during one event at -13B when fluoranthene was not detected;
- Naphthalene (LMW PAH) exceeds the 6.2 µg/l (Region 9) standard in 340 of 515 samples; values range from 6.2 – 493,000 µg/l; multiple exceedances were measured at all the wells except for the artesian wells, MW-2C, -6A, -7B, and MW-24A, -25A and -26A; the highest levels are found at MW-4B, -10B, -13A and -13B prior to free product incursion; there are no trends in the data except that MW-18A and -10B show declines from low levels to non-detect;
- Phenol exceeds the 1,200 µg/l (Wisconsin PAL) standard in nine of 469 samples; values range from 1,200 – 3,300 µg/l; multiple exceedances were measured at MW-2A, -5B and -10B; the highest levels were measured at -2A; the only trend is a decline at -2A;

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- Pyrene (HMW PAH) exceeds the 50 µg/l (Wisconsin PAL) standard in 13 of 493 samples; values range from 54 – 36,000 µg/l; the highest levels are found at –MW-4B, -10B and -13B prior to free product incursion; there are no trends;
- Pyridine exceeds the 2 µg/l (Wisconsin PAL) standard in three of 30 samples; values range from 18 – 24 µg/l; the exceedances were measured at MW-4A, -4B and -13B during one event (June 1996); there are no trends;

Figures 4-175 through 4-184 present the distribution and extent of SVOC contamination, along with selected time-concentration plots. The maximum extent of PAHs is based on the distribution of naphthalene shown on Figure 4-181. The pattern of naphthalene exceedances is similar to that for benzene. Although naphthalene is much less soluble than benzene, water quality data shows the same relative relationship for wells screened at the contact of the Miller Creek/Copper Falls. Additionally, only single PAL exceedances were measured at MW-2C, MW-24A and MW25A; no exceedances were measured at MW-26A. The extent of contamination of the other SVOCs is much smaller due to the less soluble, and therefore less mobile nature of these SVOCs. However, a data gap does exist along the shoreline due to the absence of deep wells in the Copper Falls aquifer.

Flow of the dissolved phase plume beyond the halo surrounding the free product/DNAPL zone is potentially restricted by the flow conditions in the aquifer.

4.3.4 Free Product Removal System

NSPW installed the free product removal system as an interim groundwater treatment system for the Copper Falls Aquifer during 2000. The system was initially constructed with three extraction wells screened at depths between 70 and 30 feet below the Miller Creek Formation. The three wells are screened within the greatest measured thickness of the free product plume. The wells are located between the MW-9 and -13 wells nests in the courtyard of the NSPW service center south of St. Claire Street.

The system consists of a combined low flow pneumatic pumping operation that is set at regular cycles to optimize product recovery. The mixture is conveyed to a gravity separator; product is delivered to a 1,000 gallon holding tank, and the separated groundwater sent through an air diffuser and liquid phase carbon treatment system before discharge to the sanitary sewer. The volatilized contaminants removed in the diffuser are captured by a separate vapor phase carbon system.

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Deleted: Fewer PAHs than VOCs are measured in the Copper Falls network wells primarily because of solubility and mobility. However, naphthalene (an LMW PAH) is widely found across the network similar to benzene (low levels of both benzene and naphthalene at MW-7B indicate this well is less contaminated than the inorganic water quality shows; this indicates that the increasing values of inorganic parameters at that well are likely unrelated to the free product source). The distribution of PAHs confirm the flow conditions in the aquifer.¶

Deleted: Figures 4-169 through 4-184 show plan views of the maximum concentrations for the above organic compounds at Copper Falls Aquifer wells, along with selected time-concentration plots.¶
¶

As part of the 2002 seep remediation, extraction well EW-4 was installed at the mouth of the filled ravine to capture groundwater flow and residual free product no longer conveyed by the clay tile (crushed/removed the previous year during the 2001 excavations) or through the ravine itself. The flow from EW-4 is routed to the combined influent flow to the gravity separator. The combined flow varies because of precipitation and infiltration, but the average total flow is less than 0.5 gallons/minute. EW-4 contributes generally about 10 percent of this total.

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The treated discharge is permitted by the City of Ashland. In accordance with the permit, the treated effluent is monitored monthly for VOCs (BTEX), quarterly for PAHs and semi-annually for a suite of inorganic compounds. The separated influent following the gravity separator and again following the air diffuser is tested for VOCs to evaluate the treatment system efficiency. This routine operation and maintenance is performed to determine liquid phase carbon replacement. Additionally, the vapor phase effluent is tested monthly for VOCs as part of the same maintenance procedures.

The collected free product is regularly removed from the holding tank and sent off site for permitted disposal. It is classified as a hazardous waste because its flash point is less than 100º F. More than 8,300 gallons of free product has been collected since startup as of early 2007. Additionally, more than 1.5 million gallons of groundwater have been treated and discharged. However, operation of the extraction system has resulted in a decline in water levels in the area of the pumping wells, reducing the confining conditions in the aquifer. Reductions in the potentiometric surface approaching 10 feet have been measured (see Figure 3-6). Based on the most recent water quality data from the well network, this reduction has not resulted in significant migration of contaminants beyond the area of the dissolved phase or free product plumes.

The treatment system monitoring data are part of the historical analytical database that accompanies this RI report. These data are recorded beginning with the December 2003 event, following the signing of the AOC the previous month. Because the influent is highly contaminated, the total VOCs (primarily benzene and naphthalene) have approached 50,000 µg/l. The data on Table 4-10 indicates that the BTEX values are all exceeding their respective standards, consistent with the data measured at nearby monitoring wells. These data also show two detections of methylene chloride during this monitoring period. No other detections for this compound have been made. A review of the database indicates both these measurements were flagged as lab contaminants. These data confirm that methylene chloride is not a COPC at the Site.

4.3.5 Groundwater Results Summary

This evaluation of groundwater contaminant conditions identifies the extent of the primary VOCs and PAHs at the Site. The inorganic compound cyanide also appears to be associated with releases from the MGP. Additionally, the metals lead and iron show elevated levels near the former MGP exceeding the levels at up gradient wells. These lead and iron data indicate an impact at the former MGP site. However, these data also indicate that the iron and lead measured at Kreher Park may also be associated with filling at the Park area.

Contaminants at the former MGP site are largely confined to the filled ravine and the shallow fill overlying the Miller Creek aquitard. Groundwater flow from the former MGP site discharges through the filled ravine to Kreher Park. Groundwater flow at the Park is minimal, and varies/fluctuates in flow direction. It is controlled in part by the highly permeable wood waste fill and fluctuations in lake levels.

The groundwater within the study area at the Park is widely contaminated. The highest levels of contaminants are found at the seep area, along the bluff pipe trace, the former coal tar dump, the solid waste area, and north of the WWTP (TW-11). Contaminant movement is likely minimized by the very flat horizontal gradient. However, because of the presence of free product in the near shore sediments, the PDB data indicate that fluctuations in lake levels may have resulted in a mixing zone where contaminants from the sediments migrated during the 30-day RI monitoring period within the fill along the existing shoreline in Kreher Park.

The distribution of contaminant levels in the Copper Falls aquifer are depicted on the plan view figures in Section 4 as well as the cross-sections on Figures 3-2, 3-3, 3-4 and 3-6. These data were developed using the most recent water level measurements (November 2005) and most recent water quality measurements (March 2005). As previously described, the VOC isoconcentration lines define a halo around the perimeter of the free product plume. Figures 4-169 and 4-181 show the benzene and naphthalene distribution in the Copper Falls aquifer, respectively, and are the basis for defining the lateral extent of VOC and PAH contamination in the Copper Falls. The potential stagnation zone located beneath Kreher Park may restrict some of the groundwater and contaminant migration within the Copper Falls just beneath the Miller Formation; however, it is unknown whether contaminants are migrating beneath Chequamegon Bay within the deeper portions of the Copper Falls.

At the MW-13 nest, free product has migrated to its greatest measured depth of 70 feet. At the MW-9 nest, the dissolved phase plume has correspondingly migrated to its greatest measured

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Deleted: Figures 4-169 and 4-181 show the benzene and naphthalene distribution in the Copper Falls aquifer, respectively, and are the basis for defining the lateral extent of VOC and PAH contamination in the Copper Falls.

depth of 170 feet as shown by the concentration of about 1,000 µg/l detected at MW-9C, located approximately 75 feet up gradient of MW-13. A discussion of the origination of this plume and its resultant disposition is included in Section 5.

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Deleted: Based on the apparent convergent flow beneath Kreher Park, and the need for this groundwater to flow somewhere, the likelihood that contaminants are migrating parallel to the shoreline (northeast or southwest) from the area beneath Kreher Park is good. This results in the mitigation of contaminant migration toward the shoreline.

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4.4 Sediments and Surface Water

The off-shore sediments at the Site have been studied extensively since 1996. Detailed investigations for sediment chemistry were performed through 2001 on the vertical and horizontal extent of the primary organic contaminants at the affected area. Initial studies on the ecological impact of these contaminants began in 1998 and continued through 2003. The 2005 RI collected additional data primarily directed toward the bioactive zone, within the first six inches of sediment depth. The 2005 investigations included detailed reference sample data well beyond the affected area that had not previously been collected. The 2005 RI also collected data for sediment stability, benthic invertebrate and bioassay studies.[45]

Limited surface water analyses were historically collected prior to 2005. However, a comprehensive data set of surface water analyses were collected during the 2005 RI.

4.4.1 Sediments

The spatial and vertical distribution of contaminants within aquatic portions of the Site has been significantly affected by two factors: 1) the alteration of the shorelines by historical backfilling on the three sides of the affected inlet, and 2) as shown by exploratory borings extensive amounts of wood waste are interbedded and overlie the natural sediments. A detailed description of this surface and subsurface sediment conditions was presented in the Sediment Stability Assessment Report; a discussion of the contaminant fate and transport is presented in Sections 5.1 through 5.3. The following discussion summarizes sediment chemistry**.** However, the Sediment Stability Assessment did not include the stability of the free product within the sediments. Table 4-9 summarizes the results by depth.[46]

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[45] The findings of these studies are discussed in detail in the Sediment Stability and Baseline Ecological Risk Assessment (BERA) reports.

[46] The tables include the entire suite of analytes developed for the various sediment studies, with the exception of the ecological data. Several of these suites of analytes (e.g., organo-phosphate pesticides) were included specifically for ecological impact, which are discussed in the BERA. This discussion is confined to the approved list of Site analytes for metals/inorganics and organics, as previously described for soils and groundwater

Nature and Extent of Contamination

The tables compare the data summaries for the various analytes against the consensus based sediment quality guidelines (CBSQG) adopted by the State of Wisconsin (Interim Guidance, December 2003). The two guidelines shown include the lower Threshold Effects Concentrations (TEC) and upper Probable Effects Concentration (PEC) for potential toxicity to benthic invertebrates for the chemicals for which guidelines are established.[47] For purposes of this evaluation, these values are used to provide a baseline comparison of compound concentrations measured at the Site to define the degree and extent of contamination. As with the previous discussions for soil and groundwater, the comparison is used to evaluate degree and extent of contamination. This comparison is not intended to define cleanup levels for the Site.

Metals and Inorganics

Inspection of the data summary tables indicates that the average concentrations in the 0 – 6 inch interval are greater than the average concentrations in the 0 – 24 inch interval; however, the majority of metals and inorganic compounds yield concentrations less than the TEC.[48] A summary of the exceedances for inorganic sediment quality, all collected at separate sampling stations from 0 – 0.5 feet,[49] is as follows:

- Antimony exceeds the 2 mg/kg TEC in nine of 91 samples; values range from 2 – 5.1 mg/kg; three samples were from reference stations outside the affected area;
- Arsenic exceeds the 9.8 mg/kg TEC in three of 101 samples; values range from 10 – 30 mg/kg;
- Cadmium exceeds the 0.99 mg/kg TEC in two of 101 samples; values range from 1 – 1.1 mg/kg;
- Copper exceeds the 32 mg/kg TEC in 39 of 101 samples; values range from 33 – 700 mg/kg; three were at reference stations outside the affected area;
- Iron exceeds the 20,000 mg/kg TEC in 11 of 91 samples; values range from 20,000 – 93,000 mg/kg;
- Lead exceeds the 36 mg/kg TEC in 20 of 101 samples; values range from 36 – 200 mg/kg;

[47] WDNR sediment guidelines are normalized to 1 percent organic carbon.

[48] There is a significantly larger dataset for the 0 -4 foot interval because of data collected from that interval by SEH in 1996 and data collected from 0 – 2 foot/ 2 – 4 foot intervals by URS in 2001. However, the URS data did not include many samples from 0 – 2 feet because of poor recovery. The 0 – 6 inch intervals were collected during separate mobiliziations in 2003 and the 2005 RI.

[49] All reference station samples were collected from the 0 – 6 inch depth zone.

- Manganese exceeds the 460 mg/kg TEC in one of 91 samples; the value was 460 mg/kg,
- Mercury exceeds the 0.18 mg/kg TEC in 12 of 91 samples; values range from 0.18 – 1.3 mg/kg;
- Nickel exceeds the 23 mg/kg TEC in three of 101 samples; values range from 23 – 52 mg/kg;
- Silver exceeds the 1.6 mg/kg TEC in one of 91 samples; the value was 2.5 mg/kg;
- Zinc exceeds the 120 mg/kg TEC in four of 101 samples; values range from 130 – 140 mg/kg;

Only copper, lead and mercury show a significant number of samples within a range containing values greater than five times the standard. The copper exceedances are widespread across and beyond the affected area. However, the three highest values are located immediately west of the marina; the fourth was a reference station. The lead exceedance measurements are clustered near the north edge of the marina, although three samples were collected near the shoreline between the WWTP and the marina. Four mercury exceedances were measured between the WWTP and the marina. The remaining eight samples were measured to the west and north and east of the marina beyond the affected area. These data indicate that the disposition of these compounds may be caused by runoff or other deposition from nearby filled areas, but are not associated with releases of organics from the Site. The extent of metals contamination can not be fully delineated; however, one area near the shoreline, where organic contaminants are also prevalent, is likely associated with Site sources (near PDB-04).

Figures 4-185 through 4-195 show the distribution of these inorganic compounds for sediment in the 0 – 0.5 foot depth.

Organics – VOCs

Four VOCs that were analyzed as part of the approved parameter list are included on the WDNR sediment guidance. These parameters are benzene, 1,2,4 TCB, toluene and xylenes. Each of these compounds were detected at levels exceeding the respective TEC. The summary of these exceedances follow:

- Benzene exceeds the 57 µg/l TEC in 63 of 454 samples; values range from 57 – 55,000 µg/l; the exceedances are clustered in the area south of the 2400N line between the WWTP and the marina, and south of the 2300 N line between the Prentice Avenue boat launch and the marina; a lobe also extends northwest from the WWTP to 2700N between 1800E and 2000E; the highest of these measured values are immediately northwest of the

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WWTP; the majority of these samples were collected from the 0 – 4 foot depth, although many also were collected between 4 – 6 feet and 6 – 8 feet;

- 1,2,4 TCB exceeds the 8 µg/l TEC in two of 216 samples; the values were measured at 2 – 4 feet and 4- 6 feet at the same station (2300N-1300E) during the 2001 sampling event; all other samples yielded no detections;
- Toluene exceeds the 890 µg/l TEC in 37 of 453 samples; values range from 1,200 – 220,000 µg/l, the second maximum; the maximum was measured at the same 2400N-1700E station as benzene); the majority of exceedances are found south of 2400N between the WWTP and the marina; the highest values are immediately offshore from the WWTP, although there are few samples east of the WWTP; the majority of samples were collected from 0 – 4 feet in depth;
- Xylenes exceed the 25 µg/l TEC in 133 of 454 samples; values range from 43 – 590,000 µg/l; the distribution is similar to that for benzene, although there are a greater number of exceedances; the highest levels are found offshore from the WWTP; exceedances were measured across all sample intervals to depths of 10 feet, but the majority of exceedances were measured between 0 – 4 feet.

The extent of VOC exceedances follows the shoreline. The highest concentration of contaminants are found immediately offshore from the WWTP. This distribution generally parallels the zones where wood waste is thickest (greater than two feet).

Organics – SVOCs

The WDNR guidance lists standards for LMW and HMW PAH compounds listed on Table 4-1, as well as pentachlorophenol, dibenzofuran, and phenol. For the LMW and HMW PAHs, the guidance describes TEC and PEC standards in terms of total PAHs. The following summarizes the exceedances measured in sediments for the SVOC compounds (there were no exceedances measured for pentachlorophenol or phenol):

- Dibenzofuran exceeds the 150 µg/kg TEC in 29 of 276 samples; values ranged from 160 – 130,000 µg/kg; the highest levels were measured in one sedflume core sample collected northwest of the WWTP, it is also found south of 2400N, at a sample cluster near the northeast corner of the marina, and along the 2300E line parallel to the Prentice Avenue boat launch; one reference station collected outside the affected area yielded a value of 330 µg/kg;
- Total PAHs exceed the 1,610 µg/kg TEC in 272 of 636 samples; values range from 1,630 – 10,100,000 µg/kg (values are not normalized for 1 percent organic carbon);

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exceedances are found across the affected area at the majority of stations, including those at the northwest periphery of the affected area (3500N); three reference stations yielded levels between 1,640 – 57,230 µg/kg; the highest levels are found offshore from the WWTP to the west and north; the distribution of exceedances above 10,000 µg/kg is essentially the same as that for benzene and xylene (these measurements are found south of the 2400N line, along a lobe northwest of the WWTP, and east of the WWTP south of the 2300N line); this indicates the highest levels correspond to that area where more than two feet of wood waste has been measured; exceedances are measured in the full range of sample depths to 10 feet.

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The distribution and extent of the above described organic compounds for sediment are shown on Figures 4–196 through 4-212 These figures represent sample depths from 0 – 0.5 feet, 0 – 2 feet and all sample depths. In addition, the distribution of total PAHs with and without the overlying wood waste are shown on plan view and cross section on Figures 4-213 through 4-216.

Comment [A3]: Does this mean samples were taken from the wood waste zone ("with" wood), and from deeper zones ("without" wood)? This needs to be explained

In general, the extent of contamination is located south of a line drawn from the north end of the Ellis Avenue Marina to the north end of the Prentice Avenue boat launch.

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4.4.2 Surface Water

Prior to the 2005 RI, a limited number of samples were collected for surface water analyses. These were collected as part of the initial ecological studies during 1998. A selected list of VOCs (BETX), PAHs, and inorganic parameters were analyzed for this sampling. The 2005 RI collected additional samples for the BERA and HHRA studies. An expanded list of VOCs (petroleum VOCs), PAHs and selected inorganics were analyzed. Samples were collected at mid-depth and near the sediment/water column interface. Figure 2-7 shows all historic surface water sample locations.

The summary of surface water results is included on Table 4-11. Included on this table are the Ashland surface water screening values developed for the 2005 investigations. The majority of these screening values were taken from the USEPA Region 5 ecological screening values. A few parameter screening values are from USEPA Region 4 Water Management Screening values, ECOSAR values (structure activity relationships using chronic values for fish), and OSWER Tier 2 values. Exeedance measurements for surface water compared to the most stringent standards are as follows:

- Benzene exceeds the 0.34 µg/l Region 3 standard in six of 45 samples; values range from 0.37 – 0.88 µg/l; two of the samples were collected near the shoreline near the former solid waste area, one near the shoreline east of the WWTP, and the other three offshore in an approximate line from 2400N-1660E to 2900N-1800E;
- Exceedances for anthracene and seven HMW PAHs were measured in one sample of 50, collected at 2400N-1400E; the exceedances corresponded to the Region 3 standards except for anthracene, BaA and chrysene, which corresponded to Ashland surface water screening values (Table 4-11); This sample was collected during the earlier (1998) investigation reportedly during a period of high wave activity as an unfiltered analysis. Consequently, it is likely these detections have resulted from suspended sediment influencing the results.

Figures showing the distribution of the exceedance measurements for benzene and anthracene in surface water are shown on Figures 4-217 and 4-218 respectively.

4.4.3 Sediments and Surface Water Results Summary

The distribution of inorganic contaminants in sediment confirm that these compounds are unrelated to the source of organic compounds. Although copper is widespread, the elevated detections of this compound as well as lead and mercury near the marina are not associated with the VOCs and PAHs found in sediments. The highest levels of organic compounds are found parallel to the entire shoreline between the marina and Prentice Avenue. These measurements correspond to some of the thickest zones where wood waste was measured during exploratory drilling. These data confirm (and show on Figures 4-213 through 4-216) contaminants were measured at several stations within the wood waste. Although these areas are not extensive, these conditions are the result of contaminant discharge contemporaneous with and after placement of the wood waste. During these investigations free product was observed in sediments both as sheens and emulsions. Because of the age of the release of these compounds to sediments, weathering and other natural environmental conditions would have likely reduced these contaminant levels. However, the presence of high contaminant levels in sediments corresponding to thick zones of wood waste confirms their persistence.

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The extent of contamination can not be evaluated for a dynamic system such as the surface water in and around the inlet; however, the presence of benzene and PAHs in near-shore locations associated with high sediment contaminant concentrations, shows a correlation between the sediment and surface water impacts.

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4.5 Vapor Probes and Air

As part of the RI in 2005, air samples were collected and analyzed as described in sections 2.1.3 and 2.2.3. The following presents an evaluation of the results.

4.5.1 Soil Vapor Probe Results

In accordance with the Final RI/FS Work Plan, the results of soil gas samples collected from probes were evaluated using the most recent revision of the Johnson and Ettinger models (U.S. EPA, 2002). Indoor air samples were also collected from the NSPW service center building to further characterize potential vapor intrusion. The soil gas data were then compared to the indoor air sample results and relevant indoor air quality criteria.

The laboratory data from the 12 vapor probes installed at the Site in 2005 included detection of 14 compounds. Table 4-12 list the concentrations reported for the various samples collected at the site. Figure 2-2 shows the sampling locations. Most of the compounds detected were aromatic VOCs, but some chlorinated compounds were also detected in indoor air samples. As shown in Table 4-12, detected aromatic hydrocarbons include, benzene, ethylbenzene, o- and m,p-xylene, toluene, styrene, and 1,2,4-TMB and 1,3,5-TMB. Chlorinated VOCs include carbon tetrachloride, chloroform, chloromethane, 1,4-dichlorobenzene, dichlorodiflouromethane, methylene chloride, 1,1,1-trichloroethane (TCA), trichloroethene (TCE), and trichloroflouromethane.

Soil vapor concentrations from vapor probes were compared to the most stringent Generic Screening Levels[50] (GSL) per Vapor Intrusion Guidance (USEPA, November 2002). Compounds that exceed the GSL's are as follows:

- Benzene in the March 2005 VP-3D, VP-9, VP-10, April 2005 VP-10 , and the July VP-3D and VP-08 samples;
- Carbon tetrachloride in the March and April 2005 VP-10 samples;
- Chloroform in the March and July 2005 VP-8 and July 2005 VP-9 samples;
- Ethylbenzene in the July 2005 VP-8 sample, and
- TCE in the July 2005 VP-8 sample.

[50] Target indoor air concentration equivalent risk = 10-6 (hazard index = 1), and target shallow gas concentration air attenuation factor = 0.1.

In general, the highest VOC concentrations in soil gas were measured in March 2005. During this sampling event each vapor probe contained measurable VOCs. In March 2005, the highest total VOC concentrations were measured in VP-10 (109.89 ug/m^3), VP-9 (84.06 ug/m^3), and VP-3D (28.16 ug/m^3). However, in July 2005 the highest total VOC concentrations measured at VP-8 (657.32 ug/m^3), VP-3D (57.47 ug/m^3), and VP-9 (56.56 ug/m^3) exceeded total VOC concentrations at VP-10 (48.21 ug/m^3). Probe VP-10 is located as a sub slab probe beneath the NSPW service center and VP-2S is located on the south side of St. Claire Street; both probes are installed in the filled ravine. VP-8 and VP-9 are located near the intersection of St. Claire and 3rd Street East west of the filled ravine (see Figure 2-3). Hydrocarbon concentrations detected in soil probes VP-8 and VP-9 may be associated with storm sewers or other subsurface corridors in this area.

4.5.2 Evaluation of Soil Gas Intrusion

As an additional evaluation of potential soil vapor intrusion to buildings, several iterations of the Johnson and Ettinger model were performed using the soil gas data collected from the vapor probes at the Site. The models developed originally by Johnson and Ettinger (1991) were used to evaluate subsurface vapor intrusion into NSPW buildings at the Site. In November 2002, U.S. EPA revised the models to incorporate default values and a series of new models were added. Model revisions included new values of intermediate variables for estimating the soil vapor migration and the degree of water saturation in the capillary zone above the water table. In addition, new human health benchmarks were added for some chemicals and revised for others. These models were constructed using Microsoft Excel spread sheets.

Two new models were added allowing evaluation of vapor intrusion into buildings from measured soil gas data. These models are also constructed in Microsoft Excel. Both screening-level and advanced models allow the user to calculate steady-state indoor air concentrations and incremental risks from user-defined soil gas concentration data. The models do not allow for reverse-calculation of a risk-based soil or groundwater concentration. As with the soil and groundwater screening-level models, the soil gas model operates under the assumption that the soil column properties are homogeneous and isotropic from the soil surface to an infinite depth. In addition, the soil gas model uses the same default values for the building properties as used for the soil and groundwater models. The advanced model allows the user to specify up to three different soil strata from the bottom of the building floor in contact with the soil to the soil gas sampling depth, and also allows the user to specify values for all of the model variables.

Because GSLs for benzene and carbon tetrachloride were exceeded in VP-10 samples, the Johnson and Ettinger screening model for soil gas was used to evaluate the potential vapor intrusion into the NSPW building. March sample results were used because benzene and carbon tetrachloride concentrations were higher in this sample compared to the April and July samples. Other constituents (1,4-dichlorobenzene, m-xylene, 1,2,4-trimethylbenzene, and toluene) were detected in that samples were also screened. Model results are included in Appendix D2, and results are summarized below.

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Constituent	Concentration (Ug/M^3)	Incremental Risk From Vapor Intrusion To Indoor Air, Carcinogen (Unitless)	Hazard Quotient From Vapor Intrusion To Indoor Air, Noncarcinogen (Unitless)
Benzene	10.22	1.2×10^{-7}	1.2×10^{-3}
Carbon tetrachloride	2.71	5.9×10^{-8}	NA
1,4-Dichlorobenzene	72.12	NA	3.1×10^{-4}
m-Xylene	19.07	NA	6.2×10^{-4}
1,2,4-TMB	4.71	NA	2.5×10^{-3}
Toluene	52.71	NA	4.6×10^{-4}

Based on current EPA criteria, the model output does not appear to indicate a significant risk due to vapor intrusion to buildings at the Site.

4.5.3 Indoor Air Sampling Summary

Air samples were collected from the NSPW Service Center as described in Section 2.1.2. Laboratory analytical results for these samples are included in Table 4 -12.

Indoor air quality sampling results were compared to USEPA Region 9 preliminary remediation goals (PRG) and Region 3 risk based concentrations (RBC) for ambient air. The following constituents were detected in indoor air samples above PRG and RBC standards as follows:

- Benzene exceeds the PRG and RCB in the April and July 2005 samples;
- Carbon tetrachloride exceeds the PRG and RCB in the April 2005 sample;
- 1,4-Dichlorobenzene exceeded the PRG and RCB in the April and July 2005 samples;[51]
- Methylene chloride exceeds the PRG and RCB in the April 2005 samples;
- TCE exceeds the PRG and RCB in the April 2005 sample; and

[51] 1,4-dichlorobenzene exceeded the PRG and RCB in the April and July 2005 background samples.

- 1,2,4-TMB and 1-3,5-TMB exceeds the PRG in the July 2005 sample;

Indoor air sample results were also compared to the GSLs, and the following constituents exceed the indoor target concentration:

- Benzene in the April and July 2005 samples;
- Carbon tetrachloride in the April 2005 sample;
- Chloromethane in the April and 2005 sample;[52]
- Ethylbenzene in the April and July 2005 samples; and
- TCE in the April and 2005 sample.

Indoor air sampling results indicate that vapor intrusion into NSPW buildings may be occurring. Petroleum constituents including benzene, ethylbenzene, o- and m,p-xylenes, 1,2,4- and 1,3,5-trimethylbenzene, and toluene were detected in indoor air samples and are likely related to subsurface contamination from historic MGP operations. Of these detected VOCs, benzene, 1,2,4-TMB, 1-3,5-TMB and 1,4 dichlorobenzene are the only constituents to exceed ambient air quality standards (ethylbenzene also exceeded a generic screening level) in indoor air samples.

Vapor probe soil gas samples indicate vapor migration from identified sources areas is not occurring. No shallow gas concentrations exceed screening standards in soil vapor samples collected from probes VP-5, VP-6, and VP-7 located west of the filled ravine, and in VP-1 samples located south of the former MGP facility. However, benzene exceeds shallow soil gas screening standards in samples collected from VP-3D, VP-8, VP-9, and VP-10, and carbon tetrachloride also exceeds the shallow soil gas screening standard in VP-10 samples. VP-3D, and VP-10 are located in the filled ravine; VP-10 is located beneath the NSPW service center building, and VP-3D is located in the NSPW storage yard on the north side of St. Claire Street. VP-8 and VP-9 are located on the west side of 3rd Avenue West. VOCs (chloroform, ethylbenzene, TCE) detected in VP-8 and VP-9 samples likely indicate an off-site source.

Chlorinated VOCs (carbon tetrachloride, chloroform, chloromethane, 1,1,1-trichloroethance, and trichloroethene) were also detected in soil vapor and indoor air samples. Because these constituents are not characteristic of MGP waste, these results indicate another source for these contaminants. On the NSPW property, detectable concentrations of chlorinated hydrocarbons are likely associated with NSPW Service Center activities. Chlorinated VOCs detected in soil

[52] Chloromethane exceeded the GSL in the April and July 2005 background samples.

gas samples collected from VP-8 and VP-9 may be from an off-site source; VP-8 and VP-9 are located on the west side of 3rd Avenue near sanitary and storm sewers west of the buried ravine outside the contaminant source area.

The sole detection of methylene chloride in the April 2005 indoor air sample may be attributed to laboratory contamination. Given the relatively frequent detection of freon-related compounds (dichlorodifluoromethane and trichlorofluoromethane), these compounds may be the result of laboratory contamination; methylene chloride and these chlorofluorocarbons are not related to MGP waste.

5.0 CONTAMINANT FATE AND TRANSPORT

The lateral and vertical extent of the free-product sources at the Site are well-defined. The associated soil, groundwater and sediment contamination within the four areas of concern are fairly well delineated, with exceptions. The discussion in this section describes the historical and present disposition of the contaminant sources, the migration pathways, and the trends indicated by the data record.

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5.1 Contaminant Characteristics and Persistence

Metals and Inorganics

Section 4.0 discussed the results of seven inorganic compounds in soil and 19 in groundwater (the seven measured in soil were also evaluated in groundwater). Twelve of these compounds were discussed for sediment. These compounds were selected for the final approved list (Table 4-1) based on exceedance measurements recorded in the Site database. Although movement of these compounds is controlled by solubility and flow, the fate and transport of these compounds is separate from the organic compounds as shown by their extent described in the previous section. Many of these compounds may be unrelated to the primary contaminant source areas defined by the free product zones. They are likely present in the filled materials on site and in part may be attributed to background conditions. The following discusses the exceedance measurements for these compounds and the likely sources:

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- Antimony exceeds the groundwater standard at wells in all domains; nine sediment samples exceed the TEC; groundwater samples from MW-17D and -7A in the Copper Falls yield 19 and 16 µg/l respectively; a sample from MW-8 at the upper bluff yields 17 µg/l; MW- 4 in the filled ravine yields a sample at 13 µg/l; one sample from the upper bluff (up gradient well MW-16) and two samples from the ravine yield 6.5, 6.5 and 6.8 µg/l, respectively; the other 42 samples that exceeded the PAL at the Site are between the PAL (1.2 µg/l) and the Wisconsin enforcement standard (6 µg/l); the remaining samples analyzed for this compound yield no detections; MW-8 appears to be a source of metals contamination in groundwater, and recent trends for antimony show increases in both background and down gradient wells (it is also found at elevated levels at the up gradient Copper Falls well MW-6A); this distribution indicates it is likely a background metal at these low levels, but also associated with fill materials;

- Arsenic exceeds the soil and groundwater standards across the Site; three sediment samples exceed the TEC; the highest levels in soil are found in MSA borings several hundred feet east of Prentice Avenue; within the Site boundary, the highest levels in soil are found in the filled ravine at levels an order of magnitude greater than background levels; one surface soil sample from the filled ravine yields an arsenic concentration about two times the highest background surface soil sample concentration; the remaining surface soil samples from the upper bluff are essentially the same as surface soil background; the highest levels in groundwater are found in samples from filled ravine and upper bluff wells, and elevated levels are found across the entire Site including the artesian wells;

- Barium exceeds the groundwater standard at wells in all domains; the highest levels are found in samples from the upper bluff (MW-16) and the filled ravine (i.e., up gradient well MW-6), and elevated levels are found in samples from Copper Falls wells MW-22A, -2A, -2B(NET) and up gradient well -6A; the compound is part of the Site background;

- Beryllium exceeds the soil standard in one sample in the ravine (GP-106); it exceeds the groundwater standard in two samples (MW-2C and -21B) in the Copper Falls; no other detections are found in these wells; there is insufficient data to fully evaluate beryllium;

- Cadmium exceeds the soil standard in two samples at Kreher Park, and exceeds the TEC in three sediment samples; the highest level in groundwater is from a one-time sample in the southwest corner of the Park; an elevated but lower value is found at the seep; elevated levels are present at MW-5 in the ravine and MW-8 on St. Claire Street; lower but elevated measurements are found in other ravine wells (-13, 4, 9 and TW-13), although groundwater sources may be present near MW-8 and MW-5, data from other wells indicate these two potential sources are not linked; recent trends indicate cadmium levels are declining at all wells except at MW-2C and AW-1 (these levels are below the standard); cadmium appears to be associated with fill materials;

- Chromium exceeds the groundwater standard at wells in all domains; no TEC exceedance were measured in sediment; the highest groundwater values are found at MW-8; slightly lower values were measured at upper bluff wells -2, -3, -16 and -17, and Kreher Park wells MW-2(NET) and -3(NET); lower but elevated values were measured at Copper Falls wells MW-7B and -21B; this compound is widespread at persistent levels just above the PAL across the entire Site; the data indicates a possible groundwater source at MW-8

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(along with other metals), but there are high background levels in wells screened in the Miller Creek formation (-16 and -17) as well as deep wells in the Copper Falls; recent trends show increasing concentrations at MW-3 in the filled ravine, MW-3(NET) in the southeast corner of the Park, and MW-7B in the Copper Falls; chromium sources for these three wells are hydraulically separated; this compound is part of the Site groundwater background but is also likely associated with the filled materials;

- Cobalt exceeds the groundwater standard at upper bluff, Kreher Park and a few well samples from the Copper Falls; the highest levels are at MW-8; elevated levels are found at Copper Falls wells MW-21B and -7B, and Kreher Park well MW-24; it is also found at upper bluff wells -16 and -17; it may be associated with the same condition causing high metals at MW-8, but similar to chromium it is also part of the Site groundwater background;

- Copper exceeds the groundwater standard at upper bluff, filled ravine and a few Copper Falls wells; copper exceeds the TEC in 39 sediment samples; a total of 14 groundwater samples exceed the PAL; the only well that yields multiple measurements is MW-8 (four samples); four wells in the Copper Falls show exceedances (MW-4B, -7B, -13C and -21B); three wells in the ravine (-2., -3 and -4), two wells at the upper bluff (-16 and -17) and one at Kreher Park (-3(NET)); the highest levels in sediments are found west of the marina; similar to antimony, cadmium, chromium and cobalt, copper is found at low levels in the Site background but is also associated with the fill materials;

- Cyanide exceeds the groundwater standard in the filled ravine and Copper Falls wells; the highest levels are from areas of free product; the only sample at Kreher Park that exceeds the standard is at the seep; it is associated with releases from the MGP;

- Iron exceeds both soil and groundwater standards across the Site; it also exceeds the TEC in 11 sediment samples; the highest levels in soil are found at Kreher Park, elevated but lower levels are found in the filled ravine; the highest levels in groundwater are found at the upper bluff (MW-8), but elevated levels are found in well samples from the filled ravine and the Copper Falls within the dissolved and free product plumes; elevated levels are found in up gradient background samples, and at areas at Kreher Park beyond the influences of the primary contaminant plume (MSA wells); iron is a background contaminant, but is potentially released to groundwater in the presence of organic contamination;

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- Lead exceeds both soil and groundwater standards across the Site; it also exceeds the TEC in 20 sediment samples; elevated levels in soil are found in the filled ravine and Kreher Park; the highest levels in groundwater are found in samples from the filled ravine, but elevated levels are also found at Kreher Park. These data indicate source areas in the ravine as well as at Kreher Park that are associated with MGP contamination.

- Manganese exceeds the soil standard in one soil sample; it exceeds the TEC in one sediment sample; it exceeds the groundwater PAL in 274 of 285 groundwater samples (the only well samples where it does not exceed the standard is MW-5C); the highest level is found at MW-6A, the up gradient shallow well along US Highway 2; elevated levels are found in the filled ravine, upper bluff and Copper Falls wells; the time-concentration plots indicate no trends; it is part of the Site background;

- Mercury exceeds the groundwater standard in three samples; it exceeds the TEC in 12 sediment samples; groundwater samples collected at MW-5, at the mouth of the ravine, and MW-14 in the courtyard of the service center show slightly elevated mercury concentrations above the PAL; the data trends for these wells are downward, and recent data are below the standard; other data indicates mercury at levels below the standard in random samples in all groundwater domains; the distribution of the compound in sediment indicates it is likely unrelated to the groundwater measurements; it is part of the Site background;

- Nickel exceeds the groundwater standard at wells in all domains; it exceeds the TEC in three sediment samples; the highest levels in groundwater are found at MW-8 (upper bluff), -3(NET) (Kreher Park), and -7B (Copper Falls); increasing trends are seen at each of these wells which are hydraulically separated; an increasing trend is also seen at up gradient well MW-16; it is part of the Site background, but also likely associated with filled materials,

- Selenium exceeds the groundwater standard in four samples; the highest at the seep; three other samples at levels 40 times less are from the filled ravine (two samples form MW-1, one from MW-4); lower levels below the standard are found at wells in all domains; the trends at the wells where the exceedances were measured are downward; selenium is part of the Site background, but the exceedance measurements are likely associated with the filled materials;

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- Silver exceeds the groundwater standard in two samples (MW-15 and MW-8); it exceeds the TEC in one sediment sample; it is found across the entire Site at wells in all domains at low levels; the data show increasing concentrations in all domains; the compound is part of the Site background;

- Thallium exceeds the groundwater standard in 10 of 285 samples; no detections were made in 275 samples; the exceedances were measured at wells in all domains; increasing trends are shown for Copper Falls wells (MW-5B and -10B), upper bluff well MW-16 and filled ravine well MW-3; these data indicate this compound is part of the Site background;

- Vanadium exceeds the soil standard in one sample; it exceeds the groundwater standard at wells in all domains; the highest levels are at MW-8, and elevated levels are found at upper bluff wells (MW-16, -17), Copper Falls wells (-7B, -21B) and Kreher Park wells (-24); trends show increases at MW-8, -7B and -24, but a decrease at -21B; these wells are widely dispersed; this indicates the compound is part of the Site background, but is also likely associated with the filled materials;

- Zinc exceeds the groundwater standard in one sample (the seep); all other detections are below the standard; it exceeds the TEC in four sediment samples; the compound is part of the Site background.

Several of these compounds indicate background conditions showing no Site source areas. These include barium, manganese, silver, thallium and zinc. Two compounds yield such few detections that further evaluation is unnecessary (beryllium and mercury[53]). Several other compounds are part of the Site background as shown by exceedances at up gradient wells and/or low levels at wells across the network, but potential source areas at the Site are shown by contaminant distribution patterns. These patterns indicate likely sources associated with the filled materials. These include antimony, cadmium, chromium, cobalt, copper, nickel, selenium and vanadium. One compound (iron) is associated with the Site background, but may be showing increases in groundwater levels in the presence of the organic contaminant plume because of cation exchange. Arsenic and lead appear to be associated with releases from the

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[53] Several exceedances of mercury were measured in sediments; these values are likely related to either runoff or atmospheric deposition.

former MGP but also releases from the fill. The final compound (cyanide) is associated with releases from the MGP and is not associated with other sources.

The migration of contaminants to Kreher Park via the groundwater pathway in the ravine fill is clearly visible via the cyanide distribution. The highest cyanide level was measured at the seep. Similarly, arsenic and lead appears to follow a similar pathway with high soil and groundwater levels corresponding to free product areas in the ravine, Kreher Park and the Copper Falls aquifer. However, elevated lead levels are also found (with elevated cadmium) along the shoreline indicating a likely separate source.

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Elevated metals are found at MW-8 unlike any other well in the entire network. The latest data show increasing trends for many metals at this well. It is likely that a localized source exists for these compounds. Down gradient from this well in the filled ravine, the majority of these same compounds are found at levels below their respective standards. Based on these data, the migration of compounds from this potential source area does not appear to be impacting downgradient groundwater.

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Elevated metals and increasing trends are also present at MW-7B, a deep well at the down gradient periphery of (and below) the dissolved phase plume in the Copper Falls aquifer. This well has shown very low levels of organic contaminants, but increasing levels of inorganic compounds. The well is located north of the seep area, but screened below the higher levels of organic compounds found just below the aquitard. The majority of inorganics each show increasing trends excepting cyanide, which has not been detected. This may be due to a localized phenomena at this well (i.e., oxidation-reduction), or may be associated with nearby organic reactions in groundwater with the nearby leading edge of the dissolved phase plume.

VOCs

The individual VOCs discussed in Section 4.0 included eight for soil, nine for groundwater and four for sediment. These compounds are associated with the free product source areas, although a few were measured as potentially laboratory artifacts or at isolated locations. A summary of these compounds follows:

- Benzene exceeds soil, groundwater and sediment standards at all domains; the highest levels in soil and groundwater are found at the free product sources in the filled ravine and Copper Falls aquifer; the highest levels in sediment are found west and north of the WWTP; benzene is the most commonly occurring VOC, and exceeds the standards at

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upper bluff soils and groundwater near the MGP, throughout the filled ravine down gradient from the MW-15 and -4 well nests, across all of Kreher Park, and in sediments as far north as 2900N; the benzene "halo" near free product areas in the Copper Falls aquifer is shown on plan view and cross section on the figures; it is a major component of the free product and prevalent in all of the environmental Site media.

- Ethylbenzene exceeds the soil standard in filled ravine and Kreher Park samples, and the groundwater standard at filled ravine, Kreher Park and Copper Falls wells (ethylbenzene has no sediment standard); soil exceedances are found at the coal tar dump, TW-11, and solid waste area at Kreher Park, and from the MW-4 and -15 well nests to the north; the groundwater standard is exceeded north of the same well nests but decrease in concentration along the ravine axis, elevated levels are again measured at the seep, the solid waste area, the coal tar dump and TW-11; ethylbenzene is also found at the Copper Falls wells proximate to free product; it is less mobile and less soluble than benzene, but is a component of the free product.

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- Styrene exceeds the groundwater standard at primarily Copper Falls wells; it is found at filled ravine well MW-9, along with a single exceedance at MW-5; it is also found at Kreher Park at elevated levels at MW-7R; single measurements were made at MW-2(NET) and -3(NET); it is persistently found at Copper Falls wells proximate to the free product.

- Toluene exceeds soil, groundwater and sediment standards in samples from all domains; it exceeds soil standards throughout the filled ravine and at upper bluff samples near the MGP ; it exceeds the soil standard at Kreher Park at the seep, coal tar dump and TW-11 areas; it exceeds the groundwater standard at Copper Falls wells proximate to free product, at wells in the ravine from MW-15 and -4A to the north (decreasing toward the mouth), and at Kreher Park wells at the seep, coal tar dump and solid waste areas; it exceeds sediment standards in samples as far as 2900N; it is a component of free product and associated with free product source areas;

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- 1,2,4-TMB and 1,3,5-TMB exceed soil standards in the filled ravine; a single exceedance for 1,3,5 is found at the coal tar dump; total TMB exceeds groundwater standards at ravine wells MW-15 and -4, Kreher Park wells -1(NET), -2(NET) and TW-11 and Copper Falls wells proximate to free product zones; it is associated with free product source areas;

- Xylenes exceed soil, groundwater and sediment standards at all domains; the majority of soil samples are from the filled ravine; a few samples are from the seep and coal tar dump areas; the highest levels in groundwater are found in the filled ravine at TW-13 and MW-15; the levels decrease in strength toward the ravine mouth, but are again elevated at the seep and solid waste area, with lower concentrations at the coal tar dump and TW-11; the highest levels at Copper Falls wells are proximate to the free product; elevated levels are found in sediment north to the 2900N line, with a distribution similar to benzene; it is a component of free product.

- 1,2,4-TCB exceeds the soil standard in three filled ravine samples (MW-9, TW-13 and B-25) and two Kreher Park samples collected from the coal tar dump and solid waste areas (TP-4 and TW-6, respectively); it exceeds the sediment standard at two samples collected from the same station near the southwest corner of the affected area (2300N-1300E); it is likely associated with free product, but is a rarely detected and isolated compound.

- Chloroform, chloromethane and methylene chloride exceed groundwater standards in isolated samples; as described earlier, they are not associated with Site sources.

- n-butyl benzene exceeds the soil standard in one sample from the coal tar dump; it was found at lower concentrations in other samples, the majority of which were collected at Kreher Park; a few of these detections were made in soil samples collected from the filled ravine; it is likely associated with the free product, but its persistence and strength in Kreher Park samples indicates it may be derived as a recombinant VOC.

Analysis of a sample of the free-product recovered from the Copper Falls aquifer was performed in 2000 prior to the installation of the recovery system. A summary of this analysis is included in Appendix D3. The elemental data from the Copper Falls product sample is likely the most representative candidate of virgin tar released from the MGP. The deep aquifer is an environment where the degradation of contaminants occurs at a slow rate relative to the shallow fill aquifers, which limits the breakdown of more volatile components (benzene and other VOCs). The aquifer is low in oxygen creating an anaerobic environment, thereby slowing contaminant breakdown. Consequently, this analysis represents the composition of the least altered material since releases ended several decades earlier.

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The other source areas are closer to the surface and likely contain a lower volatile fraction because of weathering and alteration since industrial activity ended in the 1930s and 1940s. Regardless, data from sediment, soil and groundwater confirm high levels of volatiles in proximity to product source zones remain. Inspection of the summaries of soil, groundwater and sediment (Section 4) indicate the highest levels of VOCs are found in samples collected within the identified free-product source areas. (The 2000 analyses on the free-product collected from the Copper Falls aquifer shows a benzene fraction of nearly 10%.)

Benzene is a highly mobile, highly soluble compound and provides an indicator of the extent of contamination from the free-product source areas.[54] As described in Section 4, contaminants have not migrated significantly outside the filled ravine at the upper bluff area because the fine-grained low permeability Miller Creek Formation has limited the lateral migration of contaminants at the upper bluff. Groundwater flow in the ravine is to the north toward Kreher Park and benzene levels in groundwater and soil decline with distance from the product zone. The same condition is found at Kreher Park, with the highest benzene concentrations at the seep area; however, the extent of benzene includes most of Kreher Park.

Within sediments, the highest benzene levels have been measured just offshore north and west of the former WWTP. Within the Copper Falls aquifer, the highest benzene levels have been measured at MW-2A, immediately down gradient from the thickest product zones in the Copper Falls aquifer.[55] However, the extent of benzene in the Copper Falls extends to beneath Chequomegon Bay, in the vicinity of MW-24A and -25A.

Although each of the affected areas differ from one another with regard to the geologic setting, the decline in volatile concentrations is consistent with distance from the free-product source zones at each area. For the filled ravine and Kreher Park, these declines do not reach a level of non detection because of the free-product located at the base of the ravine and the free product prevalent throughout Kreher Park. In the case of the filled ravine, the free-product at the seep is present at its former opening to the lakeshore. VOC levels decline in the direction of groundwater flow north of St. Claire Street, but increase significantly at the seep just beyond the mouth of the ravine. In the case of Kreher Park, VOC levels decline radically away from the seep. However, PDB data indicate that shoreline concentrations increase. This occurs because

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[54] Published values for benzene solubility are approximately 1,750 mg/l at 25° C.

[55] MW-2A was replaced with well MW-2AR following the clay tile investigation in 2001. Since that time, MW-2AR has yielded several feet of product. Analyses have only been performed on wells when less than 0.5 feet of product thickness has been measured in site monitoring wells.

the free product within the sediments along the shoreline acts as a periodic source for dissolved contaminants within the area along the shoreline where groundwater-surface water interaction takes place. This is supported by the increased benzene concentrations towards the lakeshore, compared to other groundwater data from Kreher Park (see PDB values in Table 4-10).

Limits on the migration of volatiles have been measured in the sediments and the Copper Falls aquifer. For the sediments, concentrations for benzene and other VOCs decline to non detect levels roughly parallel to the north affected area boundary (2900N), which extends from the north end of the Ellis Avenue Marina to the north end of the Prentice Avenue boat launch. This area is not sheltered by storm and wave action that has dispersed contaminants. Vertically, the depth of contaminants has been measured at the greatest depth (10 – 12 feet) along the shoreline between the WWTP and the boat launch. However, this area is also where the wood waste thickness has been measured at its greatest depth of more than six feet.

In the Copper Falls aquifer, the confining pressures within the aquifer have potentially restricted migration of the free-product plume as well as the dissolved phase plume. The lightweight nature of the free-product acting with the confining pressures have combined to limit the greatest depth of free-product to about 70 feet as measured at monitoring well MW-13B. Similarly, it has not been measured beyond the bluff face in the down gradient horizontal direction. These same hydraulic conditions have resulted in only trace measurements of benzene (at the analytical detection limit) and other aromatics in samples from bedrock well MW-2C, and far down gradient wells MW-24A, MW-25A and MW-26A along the shoreline at the north edge of Kreher Park.[56]

SVOCs

The individual SVOCs in Table 4-1 were discussed with regard to the measured exceedances in each media in Section 4.0. This discussion on characteristics and persistence groups the LMW and HMW PAH compounds because of their similarity. A summary of these compounds follows:

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Deleted: appear to create a convergent flow pattern beneath the middle of Kreher Park. However, based on this pattern, it is evident that groundwater must flow either cross-gradient in this area or vertically through the Miller Creek. It is more likely that flow in this area is cross-gradient in either the southwest or northeast directions, as evidence is not present in Kreher Park to indicate that the Miller Creek is acting as a leaky aquitard. The current understanding of the extent of the free product in the Copper Falls is that

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[56] MW-2C, MW-024A and MW-25A yielded initial benzene measurements of 9.1, 11 and 3.3 µg/l of benzene during the initial sampling events immediately after installation; subsequent events yielded either no detections or values just above the detection limit. These initial measurements are likely an artifact of drilling through the contaminated zone.

- LMW PAHs include acenapthene, acenaphthalene, anthracene, fluorene, 2-methyl naphthalene, naphthalene, and phenanthrene; these compounds exceed soil standards at upper bluff, filled ravine and Kreher Park soils; naphthalene is the most frequently measured of the LMW group; the highest levels are found at the coal tar dump; significantly lower levels are found at the upper bluff, the seep and along the bluff pipe trace; LMW PAHs exceeding groundwater standards include anthracene, fluorene and naphthalene; naphthalene exceeds the groundwater standard across all of Kreher Park, within the entire length of the filled ravine (including one detection at MW-6), and at MW-8 and MW-10 at the upper bluff; it is found at these levels at Copper Falls wells proximate to the free product source; the LMW compounds are associated with the free product source areas located near the former MGP and across Kreher Park.
- HMW PAHs include BaA, BaP, BbF, BkF, B(g,h,i), chrysene, D(a,h), fluoranthene, and I(1,2,3) and pyrene; HMW PAHs exceed soil standards at upper bluff, filled ravine and Kreher Park soils; the relative concentrations and distribution of these compounds in soil are similar to that for the LMW PAHs; HMW PAHs exceeding groundwater standards include BaP, BbF, chrysene, fluoranthene, and pyrene; BaP exceeds the groundwater standard across all of Kreher Park, within the entire length of the ravine (including MW-6), and at upper bluff well MW-10; it is found at Copper Falls wells proximate to the free product source; the HMW PAHs are associated with the free product source areas located near the former MGP and across Kreher Park (the same source materials as the LMW PAHs).

- 1-methyl naphthalene exceeds the soil standard in filled ravine and Kreher Park samples; the highest levels are found at the coal tar dump and along the bluff trace; significantly lower values are found in the filled ravine; as with the other PAHs, this compound is associated with free product but the Kreher Park data show it may not be exclusive to MGP wastes;

- PCP exceeds the groundwater standard in one sample (MW-4); its origin is unknown.

- Dibenzofuran exceeds the soil standard at Kreher Park at the coal tar dump and along the bluff pipe trace; it exceeds the standard in one sample from the filled ravine (GP-122); the highest level at Kreher Park is several times greater than the GP-122 level; as with the other SVOCs and PAHs, this compound may be associated with fill especially at Kreher Park; the distribution indicates it is not likely associated with the waste tars (dibenzofuran is a combustion by-product found in grate ash, fly ash, and soot); dibenzofuran exceeds

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the sediment standard south of 2400N both east and west of the POTW, and within the same lobe north of the POTW similar to the distribution of other sediment contaminants; the contaminants in sediment are likely derived from the same sources as those found at Kreher Park, but at significantly lower levels.

- Phenol exceeds the groundwater standard in nine samples proximate to the free product source in the Copper Falls Aquifer, and one sample from MW-4 in the filled ravine; it is found at lower concentrations in a few samples from wells in the filled ravine and Kreher Park, but the predominant number of detections are from Copper Falls wells; this compound is similar to cyanide in that it is a typical component of coal gasification waste, but not carbureted water gas operations; it is associated with the free product source.

- Pyridine exceeds the groundwater standard in three samples from Copper Falls wells (MW-4A, -4B and -13A) and two samples from filled ravine wells (MW-3 and TW-13); it is associated with the free product.

- Total PAHs exceed the sediment standard at a distribution similar to benzene and xylene, (south of 2400N and north of the WWTP to approximately 3000N between 1800E and 2000E); sources of total PAHs in sediment are from free product observed during sampling; the levels of PAHs in sediment are significantly lower than those found at Kreher Park.

The source for SVOCs and PAHs in the filled ravine is recognized as the former MGP. The free product source areas associated with the MGP, which include the filled ravine and the seep area, but especially the material in the Copper Falls aquifer, represent tars similar to those released during plant operations. All these materials have an absolute limit of the total mass of PAHs, which as shown in the GP-122 sample is about 20,000,000 µg/kg. The dramatically higher concentration of PAHs at TP-133 (136,000,000 µg/kg) indicates a different composition from MGP waste tars and/or weathering, decantation or the addition of spilled products from the adjacent tank car siding..

Spills of high PAH-laden feedstocks from rail car off-loading at this area for MGP and other industrial activities may be potential additional contaminant sources. The likely destination for

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these feedstocks was the MGP and/or Schroeder Lumber.[57] As described earlier, there is no historical record other than fuel oil as the feedstock for the former carbureted water gas facility. These spills would necessarily have been large and much of this material not recovered. Observations made during the test pit investigation identified the coal tar dump and material from inside the pipe at the bluff as the only areas at Kreher Park where free product was observed above the wood waste layer. Samples of this material from the dump area and the bluff pipe yielded the elevated PAH values. Samples from the former MGP site yielded significantly lower PAH values. Rail car spills may have dispersed across the coal tar dump and encroached the pipe, conveying contaminants along the bluff face. However, the data indicates this material is not derived exclusively from the waste tars found at the former MGP site but are most likely the result of spills of feed products..

Many subsurface soil and NAPL samples within the Kreher Park Area contained tar in various states of weathering. Lightly weathered tars have high levels of naphthalene and other volatile aromatic compounds (Figure 6a). Environmental weathering preferentially removes these more labile substances primarily by evaporation, dissolution, biodegradation, and other processes. Moderately weathered tars are left with lower levels of 2-ring PAHs and abundant 3-ring PAHs (Figure 6b). Heavily weathered patterns exhibit lower levels of 2- and 3-ring PAHs compared to 4-ring PAHs (Figure 6c). These high resolution hydrocarbon fingerprints identified commingling with non-tar derived materials such as diesel and heavy range petroleum (Figure 6c). The variable presence of petroleum among tar contaminated samples indicated that the petroleum and tar were independently released. Mixtures of tar and petroleum were observed towards the middle of the former Coal Tar Dump while samples around the boundary of the Coal Tar Dump contained primarily tar.

5.2 Potential Routes of Migration/Contaminant Transport Processes

Contamination in the form of tar was encountered at Kreher Park during investigations for the proposed expansion of the former WWTP in 1989. At that time the WDNR informally referred to the property as the "creosote site". This terminology was based on general local knowledge that former lagoons holding tars (or "creosote" as it was referred) existed at Kreher Park. The former MGP was then identified as a potential source in 1995. Record drawings of the WWTP's construction were recovered from the City of Ashland's archives in 1997. These identified the existence of the area labeled by City engineers as the former "coal tar dump" south of the present location of the WWTP, and a buried 2-inch diameter pipe within the former ravine

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[57] MGP feed stock and later propane off-loading at the area of the seep following closure of the MGP in 1947 is documented. This propane was conveyed via underground pipe networks to storage tanks in the area of the NSPW storage building.

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labeled "2-inch tar to former dump."[58] These same drawings identified a 12-inch culvert leading from the north end of the former dump beneath Pulp Hoist Road (now Marina Drive) to an open ditch, which led west to the bay inlet immediately south of the WWTP.

The MGP is considered the primary source of contaminants at the Site. However, other sources, such as historic industrial activities, waste disposal, and rail car off loading likely caused additional contamination measured at Kreher Park and the bay sediments. Additionally, historic filling and construction projects associated with WWTP construction and expansion also caused additional contaminant distribution and dispersion.

Filled Ravine

The former MGP began operation on or about 1885, and continued until 1947. The gas plant, now incorporated as the east lobe of the NSPW service center building, was serviced by four gas holders in use at varying times during its lifespan. Additionally, buried fuel oil tanks and a tar well occupied space south of St. Claire Street in the vicinity of the NSPW service center. When the MGP began, records indicate the ravine was open, and that a bridge for St. Claire Street spanned its width. However, by 1909 it was filled to its mouth. Figure 1-3 shows the layout of the historic MGP features and the outline of the former ravine.

During its operation, the plant released tars in the area of these appurtenances. Before the ravine was backfilled in 1909, released tars likely migrated through the open ravine to the Kreher Park area directly to the lake. Kreher Park was at the time less extensive and contained less fill. Later, after filling advanced past the mouth of the ravine and the clay tile pipe/open sewer network was installed, this tar easily penetrated the wood waste placed on top of the tar and potentially migrated to the above open sediments.

Information on the configuration of the Park at the time of the early MGP operation includes historic Sanborn maps and lithographs. The 1890 map indicates that the shoreline extends northwest from the railroad east of Prentice to the end of a tramway roughly coincident with the intersection of the current Marina Drive, turns west to the edge of a second tramway for about 300 feet, then turns southwest where it intersects the railroad west of 2nd Avenue East. The 1901 map shows filling to the present extent of Ellis Avenue to the west, and the open sewer. In 1902,

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[58] NSPW performed a series of investigations in the storage yard north of St. Claire Street in 1998, which identified a two-inch diameter steel pipe similar in description to that identified on the record drawings. Forensic analyses on a section of this pipe indicated it to be of an early 20th c. vintage, but that it had no residual hydrocarbon.

the City enacted an ordinance in forbidding the release of MGP wastes directly to Chequamegon Bay. The ordinance required that MGP discharges must utilize an underground conveyance system. The clay tile was likely installed at this time.

Tars continued to be released to the lake through a tile that was placed in the ravine before the ravine was filled. This tar migrated to the base of the ravine, and in the area of the alley where geologic conditions allowed (possibly via excavation in the early years of operation at the former MGP), to the Copper Falls aquifer. As discussed in Section 4.1, the extent of this tar has been well defined (see Figure 4-1). After the MGP ceased operations in 1947, additional free-product releases ended. Investigations prior to 2001, identified tar at the base of the ravine. The 2001 investigation exposed the clay tile at the base of the ravine and the source of the seep discharge. Subsequent to the 2001 excavations which removed much of the tile, free product began to appear in MW-2R beginning in June 2002 (see Section 4.1 and Figure 4-1).

The primary contaminant transport mechanism when active releases occurred (prior to the cessation of industrial activity), was through direct discharge into the ravine (prior to placement of the clay tile) and later through the clay tile buried at the base of the ravine. The findings regarding the extent of free product along with the historical background indicate that the buried clay tile was likely installed in response to the 1902 ordinance. It also was likely part of the same network identified during the Kreher Park test pit investigation performed for the 2005 RI. The property on which the tile was constructed (the buried ravine) was not owned by NSPW's predecessor, although there is no record beyond the sewer ordinance that details its possible construction or ownership.

Knowledge of this conveyance system was lost years after the ravine was backfilled. The ongoing release of free-product at the seep area in the decades following filling of the ravine likely occurred from breeches in the conveyance system due to disrepair. Visible sheens and discharges observed at the seep in recent years were not continuous, but noted primarily following rainfall events. Such observations are commonly associated with neglected subdrain systems. These releases were eliminated following the remedial actions taken at the seep area and the installation of extraction well EW-4 during 2002.

Kreher Park

The extent of free product at Kreher Park was discussed in section 4.1.2. As described there and in the groundwater discussion in section 4.3.2, the highest contaminant levels in groundwater are

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found in close proximity to these source areas. These include the seep area (where the buried clay tile previously discharged) and since June 2003 the TW-11 area. During the test pit investigation performed during the 2005 RI, free product sheens were observed when the contaminated wood waste layer was exposed in several test pits. However, contaminant levels in historic groundwater samples from areas near sheens were less than those where measureable free-product was located, such as at MW-7R (the maximum benzene concentration measured in groundwater at Kreher Park in a sample not collected in the proximity of the seep was 4,280 µg/l from GP-6, a Geoprobe boring advanced near the former open sewer; the maximum benzene level at MW-7R was measured at 36,000 µg/l).

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The high permeability wood waste material and the flat horizontal gradient result in little defined groundwater movement. Although contamination is widespread across the area between Prentice and Ellis Avenues, there is little dissolved contaminant plume development, other than in and adjacent to the free-product source areas. Contaminant migration at the Park area from these free product areas continued, but it is dominated more by diffusion then advection and dispersion.

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As stated earlier, the 2005 test pit investigation identified a former clay pipe trending between the seep area and the former open sewer. One test pit exposed a pipe lateral connected to this pipe about 150 feet west of the former seep discharge. Exposure of the contents of this pipe during the test pit investigation confirmed it was filled with soil and free-product. It is possible that until this pipe network was no longer functional, free-product was conveyed to the open sewer. However, photo documentation and historical information confirms the open sewer was filled by the early 1940s.

Deleted: This is evidence that this pipe (and the clay tile) were part of a larger sewer network installed by the City in the early years of the MGP and the sawmill activities at Kreher Park.

This same test pit investigation identified other pipe sections. Two other pipe residuals were found in the area of the former coal tar dump. One pipe consisted of a six-inch steel section that was likely installed as part of the 1952 WWTP construction (TP-117). The second was a clay pipe section that was short and could not be traced for any extended length (TP-118). Elevation measurements of the clay pipe in place indicate it was not likely connected to the clay pipe parallel to the bluff face, or to the clay tile in the ravine. Consequently, there is insufficient data or historical evidence to propose a function for this pipe. A fourth pipe section was found west of the former WWTP. This was the residual of a corrugated metal culvert, and aligns with the former open ditch identified on the record drawings from the original construction of the WWTP (see Figure 5-1). This is a likely remnant of a culvert that replaced this ditch sometime after the WWTP's original construction in 1952. This section was buried at the time the WWTP was expanded in the early 1970's.

This information indicates the abandoned clay pipe network appears to have provided a possible transport mechanism for free-product released at the MGP to have reached Chequamegon Bay via discharge from the former open sewer. These data further indicate that the potential discharge of free-product from the MGP via the open sewer was terminated long before the MGP ceased operations.

The coal tar dump area also requires evaluation. Free-product (DNAPL) is limited to the seep, which is south of the coal tar dump area (and a small area around monitoring well TW-11 north of the WWTP). Possibilities for the origin of this material are: (i) the MGP installed a free-product conveyance system to this area; (ii) product accumulated there following Schroeder Lumber's abandonment of Kreher Park via the seep discharge; and/or (iii) spills during rail car off loading resulted in free product accumulation. Significant liquid free-product is no longer present at the dump area although a layer of solidified tar was encountered; contaminant levels in groundwater approximate other areas of Kreher Park. It is possible this area drained (decanted liquids) via the ditch and culvert both shown on the Greeley and Hanson drawings and as encountered during the 2005 RI test pit investigation was utilized. However, as stated earlier, soil data from the coal tar dump area yield PAH levels on average an order of magnitude higher than any samples directly associated with the MGP. Additionally, rail sidings near this area appear on historical maps..

Deleted: Another possibility supporting eye witness testimony is that the coal tar dump is the residual of a wood treatment facility operated by Schroeder.

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Sediments

The distribution of contaminants in sediments is fairly uniform from the marina to the boat launch. This does not resemble a point source discharge, which would be expected to form a fan shape of contaminant concentrations decreasing with distance from the discharge point. Although the protected nature of the inlet may result in a greater contaminant distribution over time because of wave action, the wood waste layer has acted as a buffer protecting sediments with the highest contaminant levels from disturbance. The inlet probably has not only prevented the contaminant mass from dispersion and dilution to the greater extents of the bay, but it has helped maintain the wood waste layer as well.

The observations made during sampling as well as the analytical data indicate the presence of extensive zones of free-product parallel to the shoreline. As described in Section 4.1, this area extends along most of the shoreline and is covered by wood waste up to six feet deep. This large volume of free product in sediments, and its absence at Kreher Park is noteworthy for

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purposes of the conceptual site model. It is also likely that this free product is affecting near shore groundwater quality during storm events that increase wave heights and drive surface water (and suspended sediment) south into the groundwater zone. This is shown by the first appearance of free-product in TW-11 in 2003, located north of the WWTP and adjacent to the shoreline. Prior to that time, only low levels of contaminants were measured in samples from this well. Similarly, diffusion bag data gathered during the 2005 RI show decreasing levels of benzene and other VOCs with distance from the shoreline for the west line of bag samples. These conditions are likely the result of contaminant migration from the bay.[59]

The discharge into the ravine prior to placement of the clay pipe, the former open sewer and the associated abandoned clay pipe/sewer network appear to have provided a vehicle to transport free-product and other contaminants to the inlet. However, the contaminant levels and distribution pattern in the sediments may have resulted from the removal and disposal of residual tars remaining in the coal tar dump area to the bay. This would have been accomplished by draining the area (via the open ditch/culvert) and direct discharge by filling of materials. The 1950s WWTP construction project likely disrupted the coal tar dump and seep area since construction of the new sewer pipe network crossed this area. This activity also explains the distribution of contaminants in sediment. The highest levels of benzene and other VOCs in sediment are not found near the mouth of the open sewer, but west and north of the WWTP (2400N-1700E, 2300N-1700E, 2500N-1800E)). The contaminant distribution in sediment also confirms (shown on Figures 4-213 through 4-216) that these materials were measured at several stations within the wood waste. Although these areas are not extensive, these conditions are the result of potential contaminant discharge contemporaneous with and/or after placement of the wood waste.

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Copper Falls Aquifer

The Copper Falls aquifer is the best defined of the four areas of concern. The extent of free-product in the aquifer was described in Section 4.1.4, and the extent of the associated dissolved phase contaminant plume was described in Section 4.3.3. The likely route of transport for the free-product is via downward migration in the area of the alley where potential sources were located. These included two of the MGP's former gas holders and former USTs (see Figure 1-3). It is at this location where the geologic conditions permit this migration. Physical data from boring logs and monitoring wells indicate the Miller Creek Formation in this area is less plastic

[59] During construction of the WWTP, the City of Ashland installed a clay core barrier wall to prevent groundwater from infiltrating subsurface structures. Monitoring well TW-11 is located north of this installed clay barrier.

(very low plasticity indices from soil samples), and downward vertical gradients are present in this area. North of this area the formation becomes more plastic, and the vertical gradients in the Copper Falls aquifer reverse, indicating upward flow beneath the aquitard. These gradients further increase in magnitude with increasing depth as well as distance toward the north and artesian conditions occur at Kreher Park. Northerly horizontal gradients exist from the MGP Site to beneath about the middle of Kreher Park. The gradient direction in the upper Copper Falls is southerly from the middle of Kreher Park to the shoreline. This results in an apparent convergent flow condition. As previously described, the thickening of the aquitard beyond the bluff face in the direction of the lake causes a potential stagnation zone, or "basin effect" with regard to groundwater flow in the upper Copper Falls between the alley and the lakeshore, potentially restricting further movement of the contaminant mass. Cross-sections B-B' and C-C' on Figures 3-3 and 3-4**,** graphically display the free-product and dissolved phase plumes, as well as flow lines and equipotential lines (lines of equal pressure) highlighting the convergent conditions. Water quality information indicates that both the free product and dissolved phase plumes are potentially restricted because of the flow conditions in the upper Copper Falls. Although future contaminant movement could occur if pressure conditions in the aquifer are altered (e.g., pumping or severe drought).

The deep groundwater in the Copper Falls aquifer likely continues to flow to the north discharging to the bay beyond the potentially confining conditions caused by the Miller Creek aquitard. As deeper monitoring wells have not been installed at the shoreline, it is unknown whether contaminants are migrating within the deep Copper Falls groundwater beneath Chequamegon Bay.

The aquifer characteristics have been shown to be affected by the pumping action from the active free-product removal system. The water level in one piezometers (MW-13B) screened near the extraction wells indicate approximately a 10 foot decline since pumping began in 2000. Although this represents a maximum based on the highest water levels measured during pre-pumping conditions (1999), increased pumping could potentially reduce the upward gradients further and mobilize the free-product and dissolved phase plumes. Figure 3-7 **is** the same cross section as that shown on Figure 3-3**,** but displaying these 1999 flow conditions.

5.3 Contaminant Distribution and Trends

The extent of free-product in the separate areas of concern was described in Section 4.1. This material is the primary source of dissolved phase compounds in groundwater in the ravine,

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The deep groundwater in the Copper Falls aquifer likely continues to flow to north discharging to the bay beyond the confining conditions caused by the Miller Creek aquitard. Although flow information beyond deep monitoring wells at the study area have not been installed, w

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Kreher Park and the Copper Falls aquifers. As described earlier, sheens were observed in test pits when the wood waste layer was encountered at several locations, primarily in the coal tar dump and solid waste areas. Although high levels of volatiles in groundwater (i.e., benzene) compared to samples collected in the proximity of measurable free-product were not found at these areas, it is believed these sheens represent the diffusion of contaminants impregnated into the wood waste. The significantly higher levels of insoluble PAHs in soil samples from the Kreher Park area, compared to similar samples collected from the ravine, corroborate these observations.

No continuing releases of free-product within the source area have occurred since the latest active industrial operations ceased in 1947 with the closing of the MGP. For the Copper Falls aquifer, the slow removal of free-product from the aquifer by the removal system continues to reduce the contaminant mass in the aquifer.[61] Similarly, potential contaminant migration in the filled ravine has been mitigated by extraction well EW-4.

The cessation of industrial activity at Kreher Park with the closure of the WWTP in the early 1990's has prevented further releases of contaminants to the sediments. The contaminated sediments are dispersed during storm action. These investigations have identified that high levels of contaminants in the sediments impact the near shoreline conditions at the Park, as demonstrated by the appearance of free-product in TW-11 nine years after it was installed.[62] Similarly, the diffusion bag data identifies a similar effect as described earlier. Despite these localized observations, the history of contaminant monitoring at the lakefront indicates contaminant conditions within the Kreher Park area are not diminishing.

The historic monitoring record has provided a large database of various media. Graphs of the information previously discussed were developed from historic database. Figures 5-2 and 5-3 are examples of the soil PAH concentration data versus depth comparing the datasets between the filled ravine and the coal tar dump areas, respectively. The highest levels from the coal tar dump dataset range between 50,000 and 150,000 mg/kg (50,000,000 and 150,000,000 µg/kg) collected from depths of about 3 -5 feet, at the top of the contaminated wood waste layer. The highest levels from the ravine dataset range between 5,000 and 20,000 mg/kg, collected from a larger depth range between five and 20 feet. This not only shows the variability in the fill materials between the two locations because of the depth variation, but also shows the disparity in total PAHs between these locations.

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[61] More than 8,300 gallons of free-product have been removed since 2000.

[62] The highest level of benzene measured in a sample from TW-11 prior to 2003 was 50 µg/l, collected during a 1997 event.

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The database has been used to develop graphs showing contaminant trends in groundwater. Figure 4-140A shows the time concentration data for benzene at monitoring well MW-1(NET), screened on the north side of the coal tar dump area. The benzene data has remained fairly static between 2,000 and 4,000 µg/l. This indicates the steady state conditions with respect to contaminant concentrations in groundwater at Kreher Park, confirming the earlier discussion regarding contaminant levels beyond areas where free product has been measured. Similar groundwater data trends can be seen on Figure 5-4 for wells MW-2A(NET) and MW-2B(NET), screened as a nested well in the upper and lower Copper Falls aquifer. MW-2B(NET), the shallower of the two, shows elevated but constant levels at the interface between the overlying Miller Creek aquitard and the Copper Falls. MW-2A(NET), the deeper well, shows the lower contaminant levels typical of deeper wells in the aquifer as shown on Figure 3-3.[63] These values are also constant over time. These monitoring wells are located in the potential stagnation zone which is likely the reason for the static contaminant concentrations through time.[64]

A final groundwater example is shown for the MW-9 well nest, which monitors the deepest extent of the dissolved phase plume in the Copper Falls aquifer beneath the NSPW service center. Figure 4-169A shows benzene concentrations with time at MW-9B, MW-9A and MW-9C. MW-9A, the first deep well installed in 1996 at a depth of 135 feet, initially yielded low levels of benzene, but then high levels were measured in 1999, followed by successive low, high then low levels through 2002. Levels since that time have been low. MW-9B, installed in 1999 at a depth of 110 feet, also initially yielded low levels, followed by successive high, then low and then again high levels through 2002; levels then fluctuated successively high, low, high then low through 2005. However, the trend at this well has been progressively lower through this monitoring period. It is believed these fluctuations are directly influenced by the extraction system. The early fluctuations likely correspond to perturbations in contaminant levels between 2000 and 2002 when the free product removal system was frequently out of service.

Deleted: This well intersects the leading edge of the dissolved phase plume north of the free product mass. The leading edge is north of MW-2B(NET) as shown on cross-section B-B'(Figure 3-3). This indicates that the dissolved phase plume is not migrating further north steady state at this location, and not migrating.

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[63] Table 4-2 indicates the latest water level (November 2005) at MW-2A(NET) is 612.90 feet; the water levels at MW-24A, -25A and -26A, located to the north and along the shoreline are 616.21 ft, 616.45 ft and 617.61 ft respectively; these wells are screened at the base of the Miller Creek Formation at approximately the same elevation as -2A(NET); flow of the plume further to the north is potentially restricted by the thickening aquitard and the increasing confining conditions.

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[64] The two readings in 2001 and 2002 that show steep declines at MW-2B(NET) and corresponding increases at MW-2A(NET) resulted from an inversion of the data between these wells during sampling at those events. The historic data will not be reversed because the likely measurement error cannot be proven at 100% reliance; however, the data trends before and after this event are obvious.

Contaminant Fate and Transport

The MW-9 well nest is located 90 feet down gradient from the MW-15 nest. It is located on the down gradient edge of the former gas holders. MW-15 is located on the southern edge. The vertical gradients at MW-15 in the Copper Falls aquifer are downward. At MW-9 they are upward. The MW-13 well nest, where the greatest thickness of free-product has been measured, is located 75 feet down gradient from the MW-9 well nest. The vertical gradients at MW-13 are also upward. The VOC levels at the -13C and -13D indicate the screens are below the dissolved phase portion of the plume. However the data from MW-9A, -9B and -9C, at approximately the same elevations as -13C and -13D, indicate these screens are within the dissolved phase portion of the plume. MW-15B, below the free product mass but screened at an elevation approximately 50 feet above MW-9B, is at the lower edge of the dissolved phase plume.

Based on historic records and the extent of free product measured at the former MGP, the area between MW-15 and MW-9 represents the release area to the Copper Falls aquifer. Although free product has not been measured at the MW-9 well nest, the cross section (Figure 3-2) indicates the screens in the deep wells at this nest are below the free product mass. It is unknown how thick the mass is above the screen levels. It may be thicker than depicted. The original deep well (MW-9A) and MW-9B were installed with drilling mud. The deep well (-9C) was installed to 160 feet; using double-casing techniques (double cased to 100 feet) to prevent the downward migration of contamination while drilling. The early data fluctuations at MW-9A and MW-9B are believed to be conditions caused by the drilling and installation techniques used for these wells. The VOC measurements in these deep wells (and the lack of measurable free product), confirm the "halo" effect due to the proximity of the free product mass in the presence of the upward gradients. Considering the age of the release and these geologic conditions, further downward migration is not occurring for either free product or dissolved phase contaminants at the MW-9 nest. Free product removal since 2000, however, indicates an improvement in groundwater quality.

The Copper Falls Aquifer has been monitored in the area of the free product plume for nearly 10 years. This monitoring has provided measurements of flow and contaminant conditions that have been accurately replicated. The artesian conditions at Kreher Park are present because the Miller Creek Formation thickens and the elevation of the base of the unit declines toward and beyond the shoreline. This has created a convergent flow condition at MW-2B(NET). Although upward discharge to the water table aquifer likely occurs, the volume is extremely small because of the low permeability of the aquitard. Additionally, no mounding condition at MW-2NET (the water table well at this nest) has been measured.

Deleted: and is likely to force water to flow either to the northeast or southwest and parallel to the shoreline, or vertically through the Miller Creek which would act as a leaky aquitard. Most plausible is that flow in the Copper Falls is cross-gradient in the area beneath Kreher Park with ultimate Although discharge of the aquifer likely occurs somewhere in Chequamegon Bay. These flow conditions dictate that the free product and dissolved plumes are likely still migrating through the Copper Falls aquifer., the contaminant plume associated with the free product is not migrating because it is restricted at the stagnation zone immediately down gradient from the release.

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6.0 CONCEPTUAL SITE MODEL

This section develops a conceptual site model (CSM) for the Site with regard to historical perspective regarding current contaminant disposition. This overview builds upon the previous information discussed to construct this model. The information presented is based on the historical record gathered from maps, physical and forensic analyses, eyewitness accounts and other documents. It is intended to provide a comprehensive interpretation of contaminant sources and present conditions based on previously developed as well as the latest data developed during the 2005 RI.

6.1 Historical Setting

The MGP was constructed on the east flank of the former ravine in the mid 1880s. Contemporaneously, lumber operations at the lakefront were active with the Pope, Barber and Sutherland mills. The land on which these mills operated was reclaimed lakebed constructed from logs and other wood materials rafted from the Apostle islands and the Arrowhead Region of northern Minnesota. By 1901 the ravine was filled with locally available materials to the level of St. Claire Street, although it was still open to the north. Filling continued at that time at the lakefront; much of the western portion of present day Kreher Park was filled and the open sewer was present. The John Schroeder Lumber Company had begun its operations by this date. During this time the sewer network linking the open sewer to the clay tile in the ravine was installed. This timeframe corresponds to the 1902 City of Ashland ordinance forbidding the direct discharge to Chequamegon Bay of manufactured gas plant wastes except via an underground conveyance. Eight years later, by 1909, much of the ravine had been filled, although the bluff face was several feet south of its current location. Later records from 1923 show an expansion of the gas plant with the addition of gas holders and tanks, and expansion of the sawmill and appurtenances at the Schroeder facility. By 1946, Schroeder's facilities remained, but active operations had ceased in the late 1930s. The open sewer was still visible, and the MGP reached its maximum output. By 1951, some of the MGP facilities remained (one holder), although it was no longer operating. A large horizontal tank (propane) was present on the MGP plant site.[65] At the lakefront, the area of the open sewer had been filled, and the Schroeder facilities had been removed. The shoreline had been altered/filled in the area of the former sawmill, and the coal tar dump area was shown on historical maps.

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[65] This tank and another smaller tank were serviced by underground lines which extended to a railcar loading manifold located at the seep area. These operated during the late 1940s through the 1960s.

The WWTP was constructed in the early 1950s and began operation in 1953, and was expanded in 1973. During this time, the shoreline east of the WWTP was altered, and additional filling occurred to extend the Prentice Avenue boat launch. The NSPW service center was constructed in the late 1960s. The Ellis Avenue marina was later constructed in 1986. When investigation for a second expansion of the WWTP found contamination in the area of the former coal tar dump in 1989, the project was abandoned. The City later moved operations for the WWTP to another location southeast of the City in 1992.

6.2 Contaminant Sources and Disposition

During the life of the MGP, releases of free-product to the environment occurred. . Records indicate that a small quantity of this tar material was utilized for fuel or sold, but much was inadvertently lost. The likely routes for discharge of tar is direct discharge of tar into the filled ravine prior to installation of the 12-inch clay tile, and continuing releases to the clay tile pipe network/open sewer when it was functional. It is possible that some of the tar material was entrained in plant wastewater that was discharged to a sewer (e.g., the clay tile). Other tars and free product generated as co-product in the gas manufacturing process (such as at holders or releases from fuel tanks) discharged directly to the environment. This material migrated to the base of the ravine, following complete backfilling of the ravine early in the life of the MGP. Other material migrated to the Copper Falls aquifer. Wastewater and other incidental free product discharged to the sewer were conveyed via the clay pipe network to the open sewer and then to the bay inlet.

In 1900, Schroeder Lumber began operation at the lakefront. It performed active sawmilling and other lumber operations for more than three decades. The County acquired the lakefront property in 1941; the City then acquired the property from the County in 1942.

Additionally, other industrial sources (such as rail car offloading of feedstocks and raw materials for MGP and other industrial activities) may have caused or contributed to high levels of PAH-rich contaminants at the Lakefront.

In 1947, continued releases of free-product from the MGP were eliminated with cessation of its operations. However, remnants of free-product in the ravine continued to migrate via the clay tile to the seep area, discharging to the surface during high flow (storms, etc.) conditions. Since this time, free-product and the associated groundwater plume in the Copper Falls aquifer continued to migrate north. However, data from these investigations confirm that a potential stagnation or convergence zone in the Copper Falls aquifer in the area of MW-2B(NET) has

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Deleted: During that time, Schroeder likely treated lumber at the site as verified by eyewitness testimony, forensic analyses[66], and the PAH data previously discussed in this report. Inventory remained on site and sales/shipment continued until 1939.

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The eyewitnesses indicated the wood treatment structure was in the general area depicted on maps as a "coal tar dump." When Schroeder ceased operations, it is likely residuals of this material remained. Following the City's acquisition of the property, a landfill was established in the area of the open sewer. This activity eliminated the functioning of the pipe network that discharged to the open sewer. Consequently, continued discharges to the network were then released to the environment at breeches at low points in the system. One of these breeches later became the seep.

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potentially restricted further movement of the plume to the north (since 2000), the free product removal system has removed a fraction (more than 8,300 gallons of product) of the free product and dissolved plume mass).

In 1952, the City of Ashland began construction of the WWTP. During the construction, the remnants of the industrial wastes including historic waste from the MGP at the Lakefront were likely discharged to the bay to allow for installation of the new sewer network. The clay core wall was installed to prevent groundwater infiltration into basement areas, and the pipe/sewer distribution network to the new WWTP was constructed. The latter further damaged the earlier pipe network connected to the former open sewer. The distribution of contaminants in sediments along the shoreline was significantly affected by this activity. Other construction actions that occurred after this time that may have further affected contaminant disposition include the WWTP expansion in 1973, and the marina construction in 1986. Since operations at the WWTP were relocated in 1992, no significant contaminant contribution action has occurred.

The residual contamination remaining in the ravine continued to discharge to Kreher Park via the buried tile and fill material. Surface breakthrough was observed following rainfall events. The tile investigation in 2001 crushed and removed much of the tile. The seep remediation in 2001 removed much of the surface contamination at the seep, replaced it with clean fill, and installed EW-4 to capture residual contamination migrating through the seep into the mouth of the ravine. This pathway has been subsequently removed and further migration through the ravine controlled.

The residual contamination at Kreher Park continues to migrate to the lake sediments from the primary free product (DNAPL and LNAPL) source areas. The contaminants in the fill appear to be in dynamic equilibrium with the sediments. Free product sources in sediments near the shoreline appear to impact near shore upland areas, as shown by historical monitoring of product levels near the north side of the WWTP (TW-11) and shoreline water quality (PDB) data. These conditions are also demonstrated by vertical gradient measurements between piezometers screened at the base of the fill and water table wells at the shoreline.

6.3 Summary

The above mentioned CSM corresponds with the historical findings and data developed since investigations began at the Site.[67] The zones of free product in the filled ravine and Copper Falls

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aquifers as well as at the seep occurred through the transport mechanisms described above. Contaminant loading to sediments potentially occurred from the day the MGP began operation initially through direct discharge in ravine and later through clay tile, bluff pipe and open sewer networks. Following filling and abandonment of the sewer system this pathway was eliminated. However, the contaminant loading in the sediments continued through groundwater/NAPL discharge into the lake. Later discharge of residual contamination at Kreher Park by the City via culverts and construction activities occurred prior to and after WWTP construction. The distribution of contaminants in sediments are only explained as multiple discharge points, however, the primary source for the sediment contamination is likely the former MGP. Additionally, the high levels of PAHs in soil at Kreher Park compared to the upper bluff confirm the presence of a source at the Lakefront not exclusively caused by MGP waste tars. These other potential sources include rail car off loading of fuel feedstocks and raw materials to support industrial activity.

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7.0 BASELINE HUMAN HEALTH RISK ASSESSMENT

7.1 Introduction

Human health risk assessment has been defined as "the characterization of the potential adverse health effects of human exposures to environmental hazards" (NRC,1983). In this assessment, the extent to which a group of people has been or may be exposed to a certain chemical is evaluated, and the extent of exposure is then considered in relation to the kind and degree of hazard posed by the chemical, thereby permitting an estimate to be made of the present or potential health risk to the group of people involved. NSPW completed a draft HHRA, and the draft HHRA report was submitted to USEPA on April 30, 2006. The draft HHRA report has been revised based on review comments provided on August 25, 2006 and October 27, 2006. A copy of the revised report is included as Appendix H. Section 7.0 is s summary of that report.

A comprehensive HHRA consists of the following five steps.

1. *Hazard identification* – The hazard identification involves a review of the available Site sampling data to identify chemicals of potential concern (COPCs) and define exposure areas. The goal is to focus the risk assessment on those chemicals that contribute significantly to the total risks posed by a site. The hazard identification for this Site involved the following steps:

    - Identifying the exposure areas at the Site and determining the physical characteristics of the site that influence risk assessment decisions.
    - Reviewing the analytical dataset to be used to measure risk.
    - Developing a CSM to serve as the focus of the HHRA by defining the potential source areas, receptors, chemical transport mechanisms, and receptors of concern.

Section 7.2 provides a summary of the hazard identification for the Site. A detailed presentation of the hazard identification is presented in Sections 1 and 3 of the HHRA included in Appendix H of this report.

2. *Exposure assessment* – Exposure assessment involves describing the nature of the population exposed to a chemical and the magnitude and duration of their exposure. The evaluation could concern past or current exposures, or exposures anticipated in the future. The exposure assessment provides the information required to complete the

quantification of chemical intake. For this HHRA, an evaluation of land use and the Site characteristics were used to evaluate the potential means by which receptors might come in contact with chemicals in impacted media.

Section 7.3 provides a summary of the exposure assessment. A detailed presentation of this step is included in Section 3 of the HHRA included in Appendix H.

3. *Dose-response assessment* – Dose-response assessment, or toxicity assessment, is the quantitative evaluation of the potential of developing adverse health effects as a result of exposure to a chemical and selection of toxicity values to be used in the HHRA. This step in the HHRA process involves reviewing available toxicological information to identify toxicity benchmarks necessary for developing a quantitative dose-response assessment.

Additional information regarding the toxicity assessment is provided in Section 7.4 and Section 4 of the HHRA included in Appendix H.

4. *Risk characterization* – Risk characterization generally involves the integration of the data and analysis of the first three components of the risk assessment process (hazard identification, dose-response assessment, and exposure assessment) to determine the likelihood that humans may experience any of the various forms of toxicity associated with a chemical. A framework to define the significance of the risk is developed, and all of the assumptions, uncertainties, and scientific justification of the preceding three steps are presented.

Section 7.5 provides a summary of the risk characterization. A detailed presentation of this step is described in Section 5 of the HHRA included in Appendix H.

5. *Uncertainty analysis* – The HHRA is not a fully probabilistic estimate of risk. Rather, it is a conditional estimate given a considerable number of assumptions about exposure and toxicity. Therefore, estimates of potential carcinogenic risk and noncarcinogenic health effects have numerous associated uncertainties. The primary areas of uncertainty and limitations are qualitatively discussed in Section 7.6. A detailed presentation of this step is described in Section 6 of the HHRA included in Appendix H.

7.2 Hazard Identification

7.2.1 Exposure Areas

The Site includes the following potential exposure areas:

- NSPW's property (a former manufactured gas plant [MGP]), and potentially the areas beneath residences located on the upper bluff,
- Potentially the areas including a school, a playground, and a church (also located on the upper bluff);
- Soils along the flat terrace adjacent to the Chequamegon Bay shoreline including Kreher Park (filled lakebed areas north of the bluff face);
- Other areas of the filled former lakebed not within the Kreher Park boundary including a former City WWTP and buildings, grassed areas, and boat storage; and
- Impacted sediment in the lake adjacent to the filled lakebed area north of Kreher Park.

Based on current data, the impacted area of Kreher Park consists of a flat terrace adjacent to the Chequamegon Bay shoreline. At the present time, the park area is predominantly grass covered. A gravel overflow parking area for the marina occupies the west end of the Kreher Park property, while a miniature golf facility formerly occupied the east end of the Site. The former City of Ashland WWTP and associated structures front the bay inlet on the north side of the Kreher Park property. The impacted area of Kreher Park (excluding the affected sediments area) occupies approximately 13 acres and is bounded by Prentice Avenue and a jetty extension of Prentice Avenue to the east, the Canadian National railroad to the south, the Ellis Avenue and the marina extension of Ellis Avenue to the west and Chequamegon Bay to the north.

The offshore area with impacted sediments is located in an inlet created by the Prentice Avenue jetty and marina extensions previously described. For the most part, impacted sediments are confined in the inlet bounded by the northern edge of the line between the Prentice Avenue jetty and the marina extension. Data collected to date indicate that impacted sediment levels decline beyond this boundary. The affected sediments consist of lake bottom sand and silts, and are overlain by a layer of wood chips and larger wood waste fragments (slab wood, logs), likely originating from former lumbering operations. The wood waste layer varies in thickness from zero to seven feet, with an average thickness of nine inches. Based on current data, the entire area of impacted sediments encompasses approximately ten acres.

7.2.2.1 Population and Land Use

The Site is located in Ashland County, Wisconsin. Ashland County has a population of 16,866 and covers a land area of 1,047 square miles. The City of Ashland (population 8,620 based on the 2000 Census) is the largest city in Ashland County, as well as the county seat. The Bad River Indian Reservation, an area of 200 square miles, is located entirely within Ashland County and has a population of 1,538. According to census estimates, the population of Ashland County and the City of Ashland have changed little since 1990. Ashland County grew by 3.3 percent between 1990 and 1999 (16,307 to 16,866). The City of Ashland dropped in population by 0.8 percent (8,695 to 8,620). This is consistent with the limited population growth in the region over the last 20 years.

Residents are served by the city's municipal water supply, which is provided from Chequamegon Bay surface water. The surface water intake is located approximately 1,900 feet offshore at Longitude 90º 50' 29" E and Latitude 46º 36' 25" N. The intake is located in approximately 23 feet of water and is approximately one mile northeast of the Site. The area is located in the Lake Superior Lowland Physiographic Province characterized by flat to undulating topography underlain by red glacial clay (Miller Creek Formation). Uplands lie to the south of Ashland and are characterized by rolling hilly topography and underlain by sand and gravel soils (Copper Falls Formation). Elevations in the Ashland area range from 601 feet MSL datum (Lake Superior surface elevation) to approximately 700 feet MSL. Regional slope is generally to the north.

Tourism in the Ashland area is a year-round enterprise. The area is a recreation destination during the spring and summer fishing seasons. The area is a draw during the fall for hunting for both small and large game. Winter sports, especially snowmobiling and skiing, are also popular.

7.2.2.2 Groundwater Use

Groundwater is present in both a shallow aquifer and a confined deep aquifer. Currently the shallow groundwater is not used as a potable water source. There are two artesian wells in the Site vicinity—one located near Prentice Avenue on the eastern boundary of the Site and the other located near the marina on the western boundary. Both wells draw water from the Copper Falls aquifer, which is a deep aquifer separated from the shallow groundwater by the Miller Creek Formation (URS, 2005; ATSDR, 2003). The City of Ashland temporarily closed these wells for public use in August 2004. The City of Ashland will determine when the wells will be reopened pending the outcome of the RI/FS. To date water from these wells have met all federal and state

safe drinking water standards. Water from these artesian wells is considered safe to drink as Site-related chemicals have not been detected in these wells at levels of concern (ATSDR, 2003).

Shallow groundwater at the Site is not a drinking water source for the City of Ashland. Drinking water at the Site and the remainder of the City is provided by the City of Ashland as described above. The water intake is outside the known extent of Site-related surface water impact. Therefore, there are no known receptors to shallow groundwater beneath the Site.

7.2.2.3 Current and Potential Future Land Use Patterns

The upland area (upper bluff/ravine area) is primarily used for industrial or commercial purposes.[68] Portions of the Site (e.g., the abandoned WWTP) are subject to trespassing activities. These areas, some of which are public streets, are readily accessible to the public although they are generally covered by clean fill or roadways.

The area near the lakefront is zoned conservancy district; i.e., acceptable for use as parkland. The filled lakebed portions of the Site are comprised of City parkland (Kreher Park). The area is readily accessible by the public and a majority of the Kreher Park area of the Site is mowed and maintained for public use. No physical barrier exists at the shoreline to prevent swimming or wading in the bay where the impacted sediments have been found, although warning signs are posted along the shore of the affected area. Kreher Park and the impacted sediments are surrounded by facilities that draw the public to the lakefront including city marina, public swimming beach, a boat ramp and an RV park and campground. Warning buoys also prohibit boats into the affected area.

According to the Ashland Wisconsin Waterfront Development Plan, the City has future plans for expanding the RV park, located adjacent to the lakefront portion of the Site to the east. The plan proposes that the swimming beach will be retained but the RV park will be relocated to the Clarkson Dock farther to the east. The plan proposes that the existing RV park land will be redeveloped into a parking lot and an interpretive center for the ore freighter and/or the Great Lakes Shipping and Mining Museum.

[68] Although neighboring residences and the Our Lady of the Lake school and parish grounds are designated within the Site boundary, these areas have been characterized as affected by contaminated groundwater only.

7.2.3 Data Review Protocol

The laboratory analytical data (collected during previous investigations and as part of this RI) and field data were first compiled and validated data were entered into the USEPA-specified database and tabulated for use. The data from historic sampling efforts and this RI were reviewed to:

- Evaluate the usability, including any uncertainties associated with the data; and
- Identify the nature and extent of Site-related chemicals.

The data were checked against the data quality objectives (DQOs) identified in the approved Quality Assurance Project Plan (QAPP) (URS, 2005). Details of the procedures for assessing the precision, accuracy, representativeness, completeness and comparability of field data and analytical laboratory data are described in the QAPP. Qualifications to the data usability are discussed in the quality assurance section of any reports presenting the data. Data generated under this program were considered technically sound and of sufficient quality and quantity to support the needs of the data users. Analytical data and the results of the quality assurance/quality control evaluation are provided in Appendix F of this report.

7.2.3.1 Tentatively Identified Compounds

Both the identity and reported concentrations of tentatively identified compounds (TICs) are highly uncertain. As outlined in Section 4.3.6.2.2.1.1 of the approved RI/FS Work Plan (URS, 2005), TICs were excluded from further evaluation in the baseline HHRA.

7.2.3.2 Qualified Data

Qualifiers pertaining to uncertainty in the identity or the reported concentration of an analyte were assigned to certain analytical data by the laboratories or by persons performing data validation. The following qualifiers were used for HHRA data.

QUALFIERS USED FOR THE HHRA		
QUALIFIER	**DEFINITION**	**USE OF QUALIFIED DATA IN HHRA**
U	The analyte was analyzed for, but was not detected above the reported sample quantitation limit (SQL).	If the analyte is selected as a COPC, then it is assumed to be present at one-half the SQL.
J	The analyte was positively identified; however, the associated numerical value is an estimate of the concentration of the analyte in the sample.	If the analyte is selected as a COPC, it is assumed to be present at the estimated concentration.
UJ	The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is an estimate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample.	If the analyte is selected as a COPC, then it is assumed to be present at one-half the SQL.
R	The sample results are rejected and are, therefore, unusable due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.	Data were excluded from the HHRA.

7.2.3.3 Duplicate Results

The higher measured concentrations of duplicate sample analytical results were used as the concentration term in the HHRA. If both duplicate samples are non-detect, then one-half of the lower reporting limit was adopted as the proxy sample point concentration for the purpose of calculating exposure point concentrations (EPCs).

7.2.3.4 Analytical Data Used to Evaluate Risk

Although there has been a considerable amount of data collected at the Site, not all data collected were considered relevant and appropriate for evaluating human health risk. In general, data used for the HHRA are summarized below.

ANALYTICAL DATA USED FOR THE HHRA					
Exposure Scenario	**Soil**	**Sediment**	**Surface Water**	**Air**	**Biota**
Residential	Surface and Subsurface Soil (0-1 foot bgs) (0-3 feet bgs) (0-10 feet bgs)	Not Evaluated	Not Evaluated	Soil Vapor	Not Evaluated
Industrial/Commercial	Surface Soil (0-1 foot bgs)	Not Evaluated	Not Evaluated	Indoor Air	Not Evaluated
Maintenance Worker	Surface Soil (0-1 foot bgs)	Not Evaluated	Not Evaluated	Not Evaluated	Not Evaluated
Construction Worker	Surface and Subsurface Soil (0-10 feet bgs)	Not Evaluated	Not Evaluated	Not Evaluated	Not Evaluated
Recreational	Surface Soil (0-1 foot bgs)	First 0 – 2 feet[a]	All available data	Not Evaluated	Not Evaluated
Subsistence Fishing	Not Evaluated	Not Evaluated	Not Evaluated	Not Evaluated	Fin Fish[b]

[a] Only those 0 – 2 feet sediment locations with four feet or less of surface water cover were used in the HHRA.

[b] Only the edible portions of the fish species evaluated were included in the HHRA.

As outlined in Section 7.2.1.3, neither shallow nor deep aquifer groundwater at the Site is used as drinking water source or by the City of Ashland. Although trespasser exposures to groundwater that has infiltrated into the basement of the WWTP building was identified as a potential exposure pathway, the lack of relevant indoor air and water data precludes a quantitative evaluation of this pathway. A detailed discussion of groundwater usage and potential receptors is provided in Section 3.1.4.3 of the HHRA included in Appendix H. Section 2.2 of the HHRA (Appendix H) provides detailed information regarding the data used for the HHRA. Figure 5 presented in Appendix H shows the sample locations for the Site.

7.2.4 Identification of Chemicals of Potential Concern

Although the presence of many chemicals may be identified in the environmental samples collected during site investigative activities, the results of an HHRA are typically driven by a few chemicals and exposure pathways. To streamline the HHRA process and focus efforts on important issues, several methods have been developed by the regulatory agencies and the scientific community for the identification of chemicals and pathways that contribute significantly to the total risks posed by a site.

For this HHRA, COPCs were selected by comparison of maximum detected concentrations to chemical- and medium-specific risk-based screening concentrations (RBSCs)

It should be noted that RBSCs that are protective of noncarcinogenic effects were adjusted by a factor of 0.1 (i.e., divided by a factor of 10) to account for possible additive effects of multiple chemicals. All RBSCs for the protection of carcinogenic effects are based on a target cancer risk of 1E-06.

For inorganics, a chemical was considered a COPC if its maximum concentration exceeded its background concentration and its RBSC. Although background levels were identified in the RI/FS Work Plan as one of the screening criteria for identifying COPCs, no chemicals were excluded from the HHRA based on background comparison due to the lack of relevant medium-specific background levels.

For organics, a chemical was considered a COPC if its maximum detected concentration exceeded its RBSC. RBSCs used for the HHRA are identified below.

	PRG				RBC	AWQC	VI
	Industrial Soil	**Residential Soil**	**Tap Water**	**Ambient Air**	**Fish Tissue**	**Surface Water Ingestion**	**Target Indoor Air Concentration**
Chemicals in Soil	×	×					
Chemicals in Indoor Air/Soil Gas							×
Chemicals in Surface Water						×	
Chemicals in Sediment		×					
Chemicals in Fish Tissue					×		

PRG – USEPA Region 9 Preliminary Remediation Goal (October 2004) (USEPA, 2004b).
RBC – USEPA Region 3 Risk-based Concentrations (October 2005) (USEPA, 2005a)
AWQC – USEPA National Recommended Water Quality Criteria (20026) for human health (water and organism) (USEPA, 2006a).
VI – Evaluating The Vapor Intrusion To Indoor Air Pathway From Groundwater and Soils (USEPA 2001b).

7.2.5 Human Health Conceptual Site Model

A CSM for the Site, presented as Figure 14 of the approved RI/FS Work Plan (URS, 2005), identifies the focus of the HHRA. The CSM integrates historical information to preliminarily define source areas, release and transport processes, points of contact with affected media, complete and incomplete exposure routes, and potentially exposed populations for current and expected future Site uses. The CSM was refined based on Site-specific information gathered during the implementation of the work plan.

7.2.5.1 Known and Suspected Sources of Chemical Impacts and Release Mechanisms

Based on information with respect to the history of the Site and the results of previous investigations, the potential primary sources of impact are likely associated with past industrial operations at the lakefront, past releases from the former MGP, releases from the construction and operation of the former WWTP, releases from filling activities at the lakefront, or a combination of these possible sources. Surface and subsurface soil and groundwater that have been impacted may act as secondary sources of impact through mechanisms such as leaching of chemicals from soil, groundwater recharge to surface water and wind and mechanical erosion of chemicals in soil.

7.2.5.2 Retention or Transport Media

The medium directly impacted by past industrial activities is soil. Dust is considered a potential transport medium, because chemicals in soil may become entrained in fugitive dust. Surface runoff is considered a transport medium, because storm events may have generated episodic overland flow and carried chemicals away from disposal or spill areas.

7.2.5.3 Transport Pathway

Release mechanisms and transport pathways were evaluated for the Site. Listed below are potential cross-media transfer mechanisms of chemicals:

- Chemicals in subsurface soil may enter groundwater through infiltration/percolation;
- Chemicals in surface soil may be transported to surface water and sediments through surface runoff;
- Chemicals in groundwater may be transported to surface water and sediments through groundwater discharge;
- Chemicals in surface soil may be transported to the atmosphere via volatilization or fugitive dust emission;
- Chemicals in soil or groundwater may be transported to the atmosphere or indoor air through volatilization;
- Chemicals in surface water and sediments may be transported to fish tissue through bioconcentration; and
- Chemicals in sediments may be released to surface water when agitated.

7.2.5.4 Receptor and Exposure Scenario

Presented below is an overview of populations of potential concern selected for further evaluation in this HHRA. Potential receptors are discussed based on medium of interest (i.e., soil, sediment, surface water, biota, and air). A detailed discussion of the receptor populations evaluated is presented in Section 3.1.4 of the HHRA included in Appendix H.

SUMMARY OF PATHWAYS EVALUATED IN HHRA						
Receptor Pathway	**Media of Interest[a]**					
	Surface Soil	**Subsurface Soil**	**Sediment**	**Surface Water**	**Indoor Air**	**Biota**
Industrial Worker Exposure Scenario:						
Inhalation of airborne COPCs	FMGP				Service Center Building	
Incidental ingestion of COPCs	FMGP					
Dermal contact with COPCs	FMGP					
Construction Worker Exposure Scenario:						
Inhalation of airborne COPCs	KP FMGP	KP FMGP				
Incidental ingestion of COPCs	KP FMGP	KP FMGP				
Dermal contact with COPCs	KP FMGP	KP FMGP				
Maintenance Worker Exposure Scenario:						
Inhalation of airborne COPCs	KP UB	KP UB				
Incidental ingestion of COPCs	KP UB	KP UB				
Dermal contact with COPCs	KP UB	KP UB				
Recreational Exposure Scenario/Children:						
Inhalation of airborne COPCs	KP					
Incidental ingestion of COPCs	KP					
Dermal contact with COPCs	KP					
Recreational Exposure Scenario/Adolescents:						
Inhalation of airborne COPCs	KP					
Incidental ingestion of COPCs	KP					
Dermal contact with COPCs	KP					
Recreational Exposure Scenario/Adults:						
Inhalation of airborne COPCs	KP					
Incidental ingestion of COPCs	KP					
Dermal contact with COPCs	KP					
Recreational Exposure Scenario/Swimmer & Wader/Adults:						
Incidental ingestion of COPCs			KP CB	KP CB		
Dermal contact with COPCs			KP CB	KP CB		
Recreational Exposure Scenario/Swimmer & Wader/Adolescents :						
Incidental ingestion of COPCs			KP CB	KP CB		
Dermal contact with COPCs			KP CB	KP CB		

SUMMARY OF PATHWAYS EVALUATED IN HHRA						
Receptor Pathway	**Media of Interest[a]**					
	Surface Soil	**Subsurface Soil**	**Sediment**	**Surface Water**	**Indoor Air**	**Biota**
Subsistence Fisher Exposure Scenario:						
Ingestion of COPCs in fish						CB
Off-site Residential Exposure Scenario:						
Inhalation of airborne COPCs	UB	UB			UB	
Incidental ingestion of COPCs	UB	UB				
Dermal contact with COPCs	UB	UB				

[a]The data set used to estimate risk for each receptor is defined as indicated below:

- FMGP – Former Manufactured Gas Plant
- KP – Kreher Park
- UB – Upper Bluff
- CB – Chequamegon Bay

7.3 Exposure Assessment

7.3.1 Quantification of Chemical Intakes

Integration of data gathered in the exposure assessment (i.e., the extent, frequency, and duration of exposure for the populations and pathways of concern) into a quantitative expression of chemical-specific intake is necessary to perform a quantitative risk characterization.

The potential for human receptors to be exposed to impacted media through relevant routes of exposure (e.g., inhalation, ingestion and dermal contact) were evaluated. Described below is the basic equation used to calculate the human intake of COPCs (USEPA, 1989):

$$I = C \times \frac{IR \times EF \times ED}{BW \times AT}$$

Where:

I = Daily intake (mg of chemical per kg of body weight per day)
C = Concentration of COPC (e.g., mg/kg in soil or fish, mg/L in water or mg/m^3 in air)
IR = Intake rate; the amount of impacted medium contacted over the exposure period (e.g., mg/day for soil and fish, L/day for water and m^3/day for air)
EF = Exposure frequency; describes how often exposure occurs (days/year).
ED = Exposure duration; describes how long exposure occurs (years).
BW = Body weight; the average body weight over the exposure period (kg)
AT = Averaging time; period over which exposure is averaged (days)

Each of the intake variables in the above equation consists of a range of values in the literature. To account for uncertainties associated with parameter values, two separate exposure scenarios were evaluated in this HHRA: a reasonable maximum exposure (RME) scenario and an average case (i.e., central tendency evaluation [CTE]). The RME represents the maximum exposure that is reasonably likely to occur while the CTE is representative of average exposure. The RME scenario was calculated using the 95 percent upper confidence limit of the arithmetic mean (95% UCLs) concentration and a combination of the mean and upper-bound exposure parameter values. The CTE scenario was calculated using the arithmetic mean concentration as the EPC and the mean exposure parameter values.

General information regarding the formulae and parameter values for pathways evaluated in this HHRA is provided in Attachment A, Tables 1 - 11 (for both the RME and CTE scenarios) in Appendix H.

7.3.2 Distribution Testing and Calculation of 95% Upper Confidence Limits

For this HHRA, distribution testing and 95% UCL calculations were attempted when the sample population was greater than five and the percentage of nondetects was 15% or less. For data sets not meeting these criteria, the maximum detected concentration was selected as the EPC. For evaluating health impacts potentially associated with exposures to lead using either the Integrated Exposure Uptake Biokinetic Model (IEUBK) for Lead (USEPA, 1994; USEPA, 2005b) or the Adult Lead Model (ALM) (USEPA, 2003a), the average concentration of lead was used as the EPC, in accordance with the USEPA guidance.

7.4 Toxicity Assessment

The toxicity assessment provides a framework for characterizing the relationship between the magnitude of exposure to a chemical and the nature and likelihood of adverse health effects that may result from such exposure. In an HHRA, chemical toxicity is typically divided into two categories: carcinogenic and noncarcinogenic effects of concern. Potential health effects are evaluated separately for these two categories, because their toxicity criteria are based on different mechanistic assumptions and associated risks are expressed in different units. Chemical intake estimates are combined with descriptors of the chemical's potential toxicity, referred to as toxicity values.

Carcinogenic risks associated with a given level of exposure to potential carcinogens are typically extrapolated based on slope factors (SFs) or unit risks. SFs are the upper 95 percent confidence limit of the slope of the dose-response curve, expressed in terms of risk per unit dose (given in $[mg/kg\text{-}day]^{-1}$). Unit risks relate the risk of cancer development with the concentration of carcinogen in the given medium, expressed as either risk per unit concentration in air (given in $[\mu g/m^3]^{-1}$] or water $[\mu g/L]^{-1}$).

The approach used by the USEPA to gauge the potential non-carcinogenic effects is to identify the upper boundary of the tolerance range (threshold) for each chemical and to derive an estimate of the exposure below which adverse health effects are not expected to occur. Such an estimate calculated for the oral route of exposure is an oral reference dose (RfD), and for the inhalation route of exposure is an inhalation reference concentration (RfC). The oral RfD is typically expressed as mg chemical per kg body weight per day (mg/kg-day), and the inhalation RfC is usually expressed in terms of concentration in the air; i.e., mg chemical per m^3 of air (mg/m^3).

Pertinent toxicological and dose-response information for chemicals were selected from the following sources, in accordance with USEPA guidance (USEPA, 2003b):

- Tier 1 – Integrated Risk Information System (IRIS), available on-line (USEPA, 2006b)
- Tier 2 – USEPA's Provisional Peer-Reviewed Toxicity Values (PPRTVs)
- Tier 3 – Other toxicity values (e.g., California Environmental Protection Agency, the Agency for Toxic Substances and Disease Registry (ATSDR), and USEPA's Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997).

A detailed discussion of the methodology used to develop a toxicity assessment as part of the HHRA for the Site is presented in Section 4 of the HHRA included in Appendix H.

7.4.1 Evaluating Exposures to Lead

Because most human health effects data for lead are correlated with concentrations in the blood rather than an external dose, the traditional approach for evaluating health effects cannot be applied to lead. Lead is therefore evaluated separately from carcinogens and noncarcinogens.

The IEUBK Model (IEUBK Windows v1.0 build 261, [December 2005b]) is used to predict the risk of elevated blood lead levels in children (under age seven) that are exposed to environmental lead from many sources. The model estimates the risk that the blood lead level of a typical child,

exposed to specified media lead concentrations, will exceed a certain level of concern (10 micrograms per deciliter [µg/dL]) (USEPA, December 2005b). The target criterion for lead risk is 5% or less of child residents with an estimated blood lead level in excess of 10 µg/dL. The 10 µg/dL value is the "concern threshold" recommended by the U.S. Centers for Disease Control and Prevention (CDC) (ATSDR, July 1999).

For the potential exposure to lead in the workplace, the USEPA ALM (version 05/19/2003) is used to assess adult non-residential exposures to lead in soil and indoor dust by the most sensitive receptors (i.e., developing fetuses of female workers). The model is used to calculate target concentrations based on the probability of exceeding a blood lead level of 10 µg/dL for a fetus. Lead risks are considered unacceptable for a non-residential receptor (worker) if the fetal blood lead level for more than 5% of fetuses of adult female workers is estimated to equal or exceed the CDC concern threshold of 10 µg/dL.

Detailed information concerning both models is provided in Section 4.5 of the HHRA included in Appendix H.

7.5 Risk Characterization

In the risk characterization step, results of the toxicity and exposure assessments were integrated into quantitative and qualitative expressions of carcinogenic and noncarcinogenic risks. Carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. In accordance with guidance provided in USEPA's *Risk Assessment Guidance for Superfund (RAGS): Volume I. Part A – Human Health Evaluation Manual* (USEPA, 1989), incremental risk of an individual developing cancer can be estimated by multiplying the calculated daily intakes, that are averaged over a lifetime of exposure, by the SFs. This carcinogenic risk estimate represents an upper-bound value since the SF is often an upper 95 % confidence limit of probability of response that is extrapolated from experimental animal data using a multistage model.

The potential for noncarcinogenic effects was evaluated by comparing the calculated daily intake with an RfD derived for a similar exposure period. This ratio of exposure to toxicity is referred to as a hazard quotient (HQ). This HQ assumes there is a level of exposure below which it is unlikely even for sensitive populations to experience adverse health effects. If the HQ exceeds one, there may be concern for potential noncancer effects; however, this value should not be interpreted as a probability.

Carcinogenic and noncarcinogenic risk estimates were combined across pathways, as appropriate, to account for potential additive effects. The sum of HQs is termed a hazard index (HI). In general, USEPA recommends a target value or risk range (i.e., HI = 1 or cancer risk [CR] = 10^{-4} to 10^{-6}) as threshold values for potential human health impacts. When the HI exceeds unity, then the HQs will be segregated based on similarities in target organ effects.

The risk characterization results presented in Attachment D of the HHRA included in Appendix H were compared to these target risk levels and are presented below for all media evaluated. These levels aid in fulfilling the objectives of the baseline HHRA, which include:

- Determining whether additional response action is necessary at the Site
- Determining residual chemical levels that are adequately protective of human health
- Providing a basis for comparing potential health impacts of various remedial alternatives
- Helping support selection of the no-action remedial alternative, where appropriate.

7.5.1 Risk Characterization Results

Except for risks associated with the residential RME exposures to soil and construction workers exposure to soil, carcinogenic and noncarcinogenic risks for all other media were within acceptable ranges of 10^{-4} to 10^{-6} and 1, respectively. A detailed presentation of the carcinogenic and noncarcinogenic risk calculations are provided in Section 5 of the HHRA included in Appendix H.

Summary of RME Carcinogenic and Noncarcinogenic Risksa

Receptor	Table	Soil		Sediment		Biota		Indoor Air[b]	
		CR	HI	CR	HI	CR	HI	CR	HI
Resident (0-10 feet bgs)	20	**5×10^{-4}**	**15**	–	–	–	–		
Recreational Adult	21	3×10^{-6}	0.002	–	–	–	–	–	–
Recreational Adolescent	22	2×10^{-6}	0.003	–	–	–	–	–	–
Recreational Child	23	1×10^{-5}	0.04	–	–	–	–	–	–
Adult Swimmer	24	–	–	5×10^{-9}	2×10^{-5}	–	–	–	–
Adolescent Swimmer	25	–	–	3×10^{-9}	2×10^{-5}	–	–	–	–
Adult Wader	26	–	–	1E-05	0.002	–	–	–	–
Adolescent Wader	27	–	–	5×10^{-6}	0.002	–	–	–	–
Industrial Worker	28 & 29	6x10^{-6}	0.007	–	–	–	–	8×10^{-5}	3
Maintenance Worker	30	1×10^{-6}	0.001	–	–	–	–	–	–
Construction Worker	31	**1×10^{-4}**	**35**	–	–	–	–	–	–
Subsistence Fisher	32	–	–	–	–	**1×10^{-4}**	0.01	–	–

[a] No COPCs were identified for soil gas and surface water. Risks based on exposure to these media were not quantified.
[b]For the industrial worker, the air risks were estimated using indoor air data from sample locations NS-GSINDOOR-0405 and NS-GSINDOOR-0705.

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7.5.1.1 Summary of Residential Risk

Risks associated with exposure to surface and subsurface soil for residents are a CR of 5×10^{-4} and an HI of 15 for samples collected within the filled ravine area of the former MGP. Both the cancer and noncancer risks exceed the USEPA target risk range of 10^{-4} to 10^{-6} for cancer and an HI of 1 for noncancer endpoints, respectively. The resulting cancer risk of 5×10^{-4} is primarily attributed to benzo(a)pyrene (65 percent) and dibenzo(a,h)anthracene (10 percent). Upon review of the data, 10 sampling locations with detectable concentrations ranging from 22 to 340 mg/kg at intervals between 1 to 8 feet bgs are the main contributors to the benzo(a)pyrene cancer risk. In addition, one sample location for dibenzo(a,h)anthracene (CP110) with a reported concentration of 3.8 mg/kg (1 to 3 feet bgs) is the main contributor to the dibenzo(a,h)anthracene cancer risk.

The resulting HI of 15 is primarily attributed to naphthalene (with an HI of 11). Detailed calculations of cancer and noncancer risks are presented in Attachment D, Tables 1 – 3 in the HHRA (Appendix H).

Based on the results of the IEUBK model, the percentage of children predicted to have a blood lead concentration greater than 10 µg/dL is 0.11, which is within USEPA's target criteria of no more than 5% above the concern threshold of 10 µg/dL concentration. The results of the IEUBK are presented in Attachment D, Table 3f in the HHRA (Appendix H).

Indoor Air Pathway

Measured concentrations in soil vapor samples collected from subsurface soil within the filled ravine area of the Site did not exceed the USEPA's risk target shallow soil vapor screening concentrations at a target risk level of 10^{-5} (Table 17 of the HHRA) indicating that subsurface vapors are not migrating off-site towards the residential area at St. Claire Street and Prentice Avenue.

Residential Risk Discussion

PAHs appear to be the primary risk drivers for the residential receptor using data that included samples collected in the filled ravine area of the former MGP. The highest concentrations of PAHs, and thus the highest risks, are associated with PAHs detected at depths of 0 to 3 feet bgs. However, residents are not currently located in this area of the Site and residential areas are not likely to be established at this part of the Site in the future.

For this HHRA, it was conservatively assumed that the residential receptors would be exposed to both surface and subsurface soil (0 to 10 feet bgs). This assumption was made because new construction would involve excavation of soil for the construction of basements or foundations. Therefore, soil with high chemical concentrations would be brought to the surface resulting in a potential exposure pathway for residential receptors. This scenario represents the worst case for residential receptors, but is not likely to be the actual scenario associated with the Site. The residential neighborhoods adjacent to the Site are established neighborhoods and are expected to remain in the future. According to the Ashland Wisconsin Waterfront Development Plan, the future use of the Kreher Park portion of the Site does not include a residential scenario. Therefore, residential receptors would only be exposed to surface soil. If it is assumed that residential receptors adjacent to the Site tend gardens, then it is possible that the first three feet of soil will represent the most likely exposure point.

Re-evaluating the residential receptor using EPCs derived based on the exposure to surface soil and soil to a depth of 3 feet indicates that carcinogenic and noncarcinogenic risks within USEPA's target risk range of 10^{-4} to 10^{-6} for cancer endpoints and an HI of 1 for noncancer endpoints.

Receptor	Table	Soil	
		CR	HI
Resident (Surface Soil only)	33	1×10^{-5}	0.2
Residential (0-3 feet bgs)	34	3×10^{-4}	0.9

The resulting CR of 1×10^{-5} for exposure to surface soil only is primarily attributed to arsenic (76 percent). Upon review of the data, one sampling location (lSS19) with a reported concentration of 8.5 mg/kg is the main contributor to arsenic cancer risk. Attachment F1, Tables 1 - 5 of the HHRA provides a detailed presentation of these calculations.

Seventy eight percent of the resulting CR of 3×10^{-4} (exposure to soil between 0 and 3 feet bgs) is attributed to benzo(a)pyrene. Upon review of the data, 12 sampling locations within the filled ravine area with reported concentrations ranging from 0.19 to 220 mg/kg (at depths greater than 1 foot bgs) are the main contributors to cancer risk.. Attachment F2, Tables 6 through 10 of the HHRA provide a detailed presentation of these calculations.

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The primary residential noncarcinogenic risk driver in soil is 2-methylnaphthalene in the filled ravine area at depths of 2 to 10 feet bgs, with the 1 to 3 foot depth containing the highest concentrations of this chemical. The 2-methylnaphthalene concentration range is 0.094 to 3,300

mg/kg in this area. Because the noncancer risk for this receptor is greater than 1, noncancer risks were re-evaluated by target organ. Figures 7-1 (carcinogenic) and 7-2 (noncarcinogenic) identifies those sample locations with risks exceeding target risk levels.

7.5.1.2 Risk Summary for the Recreational Scenario

Risks were estimated for the recreational scenarios identified below:

- Recreational adults, adolescent, and children exposed to surface soil
- Recreational adult, adolescent, and child swimmers exposed to surface water
- Recreational adult, adolescent, and child waders exposed to sediment and surface water

No COPCs were selected for the surface water pathway; therefore, cancer and noncancer risks were not calculated for this medium. In general, risks associated with exposure to surface soil and sediment by recreational users were estimated to be between 1×10^{-5} and 1×10^{-6}. Risks associated with each medium and recreational receptor are discussed below.

Comment [A6]: The HHRA did not evaluate dermal contact with surface water sheens, which was requested by EPA and WDNR. Performed by WESTON in attached files and described in response to comment letter.

Risk Summary for Recreational Users Exposed to Surface Soil

Only limited metals and carcinogenic PAHs were identified as COPCs for recreational user exposure to surface soil. Cancer and noncancer risks to recreational adults and adolescents exposed to surface soil are generally a CR between 1×10^{-6} and 1×10^{-4} and less than an HI of 1. Cancer risks calculated for a recreational child exposed to surface soil are 1×10^{-4}, but less than a noncancer risk of an HI of 1. The primary risk driver for the recreational adult, adolescent and child is benzo(a)pyrene..

A summary of the risks to the recreational adult, adolescent, and child are provided in Tables 21, 22, and 23 of the HHRA (Appendix H). A detailed presentation of the risk calculations for the recreational adult, adolescent, and child are provided in Attachment D, Tables 4 to 12 in the HHRA.

Recreational Adults

Risks associated with exposure to surface soil for recreational adults are a CR of 3×10^{-6} and an HI of 0.002 for samples collected within Kreher Park. Both the cancer and noncancer risks are

within the USEPA target risk range of 10^{-4} to 10^{-6} for cancer and an HI of 1 for noncancer endpoints, respectively. Approximately 76 percent of the estimated CR of 3×10^{-6} is attributed to benzo(a)pyrene. Upon review of the data, four sampling locations (located in Kreher Park, one of which is located within the Former Coal Tar Dump, sample TP-118) with reported concentrations ranging from 7.4 to 68 mg/kg at intervals between 0 to 1 foot bgs are the main contributors to the benzo(a)pyrene cancer risk.

Detailed calculations of the risks to recreational adults is presented in Attachment D, Tables 4 to 6 in the HHRA.

Recreational Adolescents

Risks associated with exposure to surface soil for recreational adolescents are a CR of 2×10^{-6} and an HI of 0.003 for samples collected within Kreher Park. Both the cancer and noncancer risks are within the USEPA target CR of 10^{-4} to 10^{-6} for cancer and an HI of 1 for noncancer endpoints, respectively.

Approximately 76 percent of the estimated cancer risk is attributable to benzo(a)pyrene. Upon review of the data, four sampling locations (located in Kreher Park, one of which is located within the Former Coal Tar Dump, sample TP-118) with reported concentrations ranging from 7.4 to 68 mg/kg at intervals between 0 to 1 foot bgs are the main contributors to the benzo(a)pyrene cancer risk.

Detailed calculations of the risks to recreational adolescents is presented in Attachment D, Tables 7 to 9 in the HHRA.

Recreational Children

Risks associated with exposure to surface soil for recreational children are a CR of 1×10^{-5} and an HI of 0.04 for samples collected within Kreher Park. Both the cancer and noncancer risks are within the USEPA target CR range of 10^{-4} to 10^{-6} for cancer and an HI of 1 for noncancer endpoints, respectively. Approximately 74 percent of the resulting cancer risk is attributed to benzo(a)pyrene. Upon review of the data, four sampling locations (located in Kreher Park, one of which is located within the Former Coal Tar Dump, sample TP-118) with detectable concentrations ranging from 7.4 to 68 mg/kg at intervals between 0 to 1 foot bgs are the main contributors to the benzo(a)pyrene cancer risk.

Detailed calculations of the risks to recreational children is presented in Attachment D, Tables 10 through 12 in the HHRA.

Risk Summary for Recreational Swimmers Exposure to Sediment and Surface Water

Because no COPCs were identified for surface water, calculation of risk was not required for the recreational swimmer adult, adolescent, and child receptors.

Comment [A7]: Risks from dermal contact with sheens needs to be inserted here.

Adult Swimmers Exposed to Sediment

Risks associated with exposure to sediment for adult swimmers are a CR of 5×10^{-9} and an HI of 0.00002 for samples collected within Chequamegon Bay. Both the cancer and noncancer risk are below the USEPA target risk range of 10^{-4} to 10^{-6} for cancer and an HI of 1 for noncancer endpoints, respectively.

Detailed calculations of the risks to adult swimmers is presented in Attachment D, Tables 13 and 14 in the HHRA.

Adolescent Swimmers Exposed to Sediment

Risks associated with exposure to sediment for adolescent swimmers are a CR of 3×10^{-9} and an HI of 0.00002 for samples collected within Chequamegon Bay. Both the cancer and noncancer risk are below the USEPA target risk range of 10^{-4} to 10^{-6} for cancer and an HI of1 for noncancer endpoints, respectively.

Detailed calculations of the risks to adolescent swimmers are presented in Attachment D, Tables 15 and 16 in the HHRA.

Recreational Waders Exposed to Sediment and Surface Water

Because no COPCs were identified for surface water, calculation of risk was not required for the recreational waders.

Adult Waders Exposed to Sediment

Risks associated with exposure to sediment for adult waders are a CR of 1×10^{-5} and an HI of 0.002 for samples collected within Chequamegon Bay. The cancer risk is within the USEPA

target risk range of 10^{-4} to 10^{-6} for cancer and noncancer risk is less than the target HI of 1 for noncancer endpoints.

Approximately 82 percent of the resulting cancer risk is attributable to benzo(a)pyrene. Upon review of the data gathered for benzo(a)pyrene for the site, three sampling locations (220N-1600E, 2250N-1400E, 2400N-1200E) with detectable concentrations ranging from 10.5 to 26 mg/kg at intervals between 0 to 2 feet bgs are the main contributors to the benzo(a)pyrene cancer risk.

Detailed calculations of the risks to adult waders is presented in Attachment D, Tables 17 and 18 in the HHRA.

Adolescent Waders Exposed to Sediment

Risks associated with exposure to sediment for adolescent waders are a CR of 5×10^{-6} and an HI of 0.002 for samples collected within Chequamegon Bay. The cancer risk is within the USEPA target risk range of 10^{-4} to 10^{-6} for cancer and an HI of 1 for noncancer endpoints. Approximately 82 percent of the resulting cancer risk is attributable to benzo(a)pyrene. Upon review of the data, three sampling locations (220N-1600E, 2250N-1400E, and 2400N-1200E) with detectable concentrations ranging from 10.5 to 26 mg/kg at intervals between 0 to 2 feet bgs are the main contributors to the benzo(a)pyrene cancer risk.

Detailed calculations of the risks to adolescent waders is presented in Attachment D, Tables 19 to 20 of the HHRA.

7.5.1.3 Risk Summary for the Construction Scenario

PAHs appear to be the primary cancer risk drivers for the construction scenario. Of the calculated CR of 1 x 10^{-4}, approximately 71 percent is attributable to benzo(a)pyrene and 11 percent is attributable to dibenzo(a,h)anthracene. Upon review of the data, 27 sampling locations (located in both the filled ravine and Kreher Park) with detectable concentrations ranging from 205 to 3,000 mg/kg at intervals between 1 to 8 feet bgs are the main contributors to the benzo(a)pyrene cancer risk. In addition, 24 sample locations for dibenzo(a,h)anthracene (located in Kreher Park) with an detectable concentrations ranging from 28 to 250 mg/kg (2 to 8 feet bgs) are the main contributors to the dibenzo(a,h)anthracene cancer risk. Detailed calculations of the construction scenario cancer risks are provided in Attachment D, Tables 21 to 23 in the HHRA.

The resulting HI of 35 is primarily attributed to naphthalene (with an HI of 31) and 2-methylnaphthalene (with an HI of 1). Because the HI exceeds 1, the noncancer risk for this receptor was re-calculated based on target organs affected by each chemical. Table 31 of the HHRA (Appendix H) shows that target organ-specific HI is greater than 1 for respiratory and systemic target organ effects. Detailed calculation of the construction scenario noncancer risks are provided in Attachment D, Tables 21 to 23 in the HHRA.

Based on the results of the ALM, the percentage of developing fetuses predicted to have a blood lead concentration greater than 10 µg/dL is 1.5, which is within USEPA's target criteria of no more than 5% of fetuses of adult female workers above the concern threshold of 10 µg/dL. The results of the ALM are presented in Attachment D, Table 3f in the HHRA.

For this HHRA, it was assumed that the construction receptors would be exposed to both surface and subsurface soil. This assumption was made based on the definition of the construction scenario (USEPA, 2002a), which would involve the construction of residential or commercial structures at the Site. This represents the worst case scenario and is not likely to occur at the Site given both its current and future land use. Kreher Park is an established park and is expected to remain in the future. Any expansion to the recreational areas of the Site would likely be associated with activities such as the installation of landscaping, sidewalks, and parking lots all of which do not involve excavation to significant depths (USEPA, 2002a). Therefore, construction receptors would most likely be exposed to shallow soils.

A hot spot analysis was performed for the construction scenario using data collected from the following locations near the Former Coal Tar Dump. The results of this analysis are presented in Section 6.6. of the HHRA

7.5.1.4 Risk Summary for General Industrial Worker

Comment [A8]: Dermal contact with GW and inhalation of vapors in a trench was not quantified as requested by EPA and WDNR.

Cancer and noncancer risks associated with the exposure to surface soil for the general industrial worker receptor is 6×10^{-6} and 0.007. Risks for this receptor are within USEPA's target risk range for cancer (CR of 10^{-4} to 10^{-6}) and noncancer (HI = 1) endpoints.

Comment [A9]: Increase in risk because samples in the 0-2 ft interval were excluded from the 0-1 ft dataset,

Cancer and noncancer risks associated with exposure to indoor air are a CR of 8×10^{-5} and an HI of 3, respectively. The primary cancer risk drivers are trichloroethylene (44 percent) and benzene (3 percent). The resulting HI of 3 is primarily attributed to 1,2,4 trimethylbenzene (with an HI of 2).

7.5.1.5 Risk Summary for Maintenance Worker

Cancer and noncancer risks associated with the exposure to surface soil for the maintenance worker receptor is 1×10^{-6} and 0.001. Risks for this receptor are within USEPAs target risk range for cancer (CR of 10^{-4} to 10^{-6}) and noncancer (HI = 1) endpoints.

Based on the results of the ALM, the percentage of developing fetuses predicted to have a blood lead concentration greater than 10 µg/dL is 1.6, which is within USEPA's target criteria of no more than 5% of fetuses of adult female workers above the concern threshold of 10 µg/dL.

7.5.1.6 Risk Summary for Subsistence Fisherman

Risks associated with the ingestion of locally-caught fish from Chequamegon Bay is 1×10^{-4}, which is just within the USEPA target cancer risk range of 10^{-4} to 10^{-6} for cancer endpoints. Although the primary risk drivers for this scenario are the carcinogenic PAHs (benzo[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[e]pyrene, dibenzo[a,h]anthracene, and indeno[1,2,3-cd]pyrene), individual cancer risks for each detected carcinogenic PAH is between 1×10^{-5} and 1×10^{-6}. Because risks to individual receptors are within USEPA's target cancer risk range of 1×10^{-4} to 1×10^{-6}.

7.5.1.7 Central Tendency Evaluation

Quantitative measures of uncertainty involve the calculation of CTE risk estimates. The CTE calculation involves the use of 50th percentile input parameters in carcinogenic and noncarcinogenic risk estimates as opposed to upper-bound values for parameters used in the RME calculations. The 50th percentile parameters are considered representative of the general receptor population. The CTE scenario was only calculated for pathways in which RME risks exceed the target risk goals (i.e., carcinogenic risks above 10^{-4} and an HI above 1).

The results of this evaluation is summarized below. Detailed CTE calculations are provided in Attachment F (Appendix H): Tables 1 through 6 for residential receptors, Tables 7 through 9 for construction workers, Table 10 for the industrial worker and Table 11 for the subsistence fisherman.

Receptor	Table in Appendix H	Soil	
		CR	HI
Resident (0-10 foot soil depth)	35	2×10^{-4}	8
Resident (0-3 foot soil depth)	36	5×10^{-5}	0.3
Construction Worker	37	3×10^{-5}	13
Industrial Worker (indoor air)	38	2×10^{-5}	1
Subsistence Fisherman	39	3×10^{-6}	0.0003

7.5.2 Uncertainty Analysis

In any HHRA, estimates of potential carcinogenic risk and noncarcinogenic health effects have numerous associated uncertainties. The primary areas of uncertainty and limitations are qualitatively discussed. Areas of uncertainty that are discussed in the RI report include, but are not limited to the following:

- Data collection and evaluation;
- Assumptions regarding exposure scenarios;
- Applicability and assumptions of models selected to predict the fate and transport of COPCs in the environment; and
- Parameter values for estimating intake of COPCs.

Each type of uncertainty is discussed in the sections that follow.

7.5.3 Data Collection and Evaluation

7.5.3.1 Residential Scenario Evaluation

For this risk assessment it was assumed that the residential receptors would be exposed to both surface and subsurface soil (0 to 10 feet bgs). This assumption was made because new construction would involve excavation of soil for the construction of basements. Therefore, soil with high chemical concentrations would be brought to the surface resulting in a potential exposure pathway for residential receptors. This scenario represents the worst case for residential receptors, but is not likely to be the actual scenario associated with the Site. The residential neighborhoods adjacent to the Site are established neighborhoods and are expected to remain so in the future. According to the Ashland Wisconsin Waterfront Development Plan, the future use of the Kreher Park portion of the Site does not include a residential scenario. Therefore, residential receptors would only be exposed to surface soil. If it is assumed that

residential receptors adjacent to the Site tend gardens, then it is possible that the first three feet of soil will represent the most likely exposure point.

Re-evaluating the residential receptor using exposure point concentrations derived based on the exposure to surface soil or soil to a depth to three feet indicates that carcinogenic and noncarcinogenic risks are as presented below.

Receptor	Table	RME		CTE	
		CR	HI	CR	HI
Resident (0 – 10 feet soil depth)	20	5×10^{-4}	15	2×10^{-4}	8
Resident (0-1 foot soil depth)	33	1×10^{-5}	0.2	1×10^{-5}	0.2
Resident (0 – 3 foot soil depth)	34	3×10^{-4}	0.9	–	–

An examination of the analytical data used to derive the carcinogenic and noncarcinogenic risks to residents exposed to surface and subsurface soil to a depth of 3 feet shows that the risks are highest in samples collected between 1 and 3 feet bgs for the samples collected in the courtyard area of the former MGP. Locations GP110 and GP115 had the highest detections of all chemicals identified as COPCs at the 1 to 3 foot depth. An examination of the risks associated with sample location SS-24, which is located between the residence on Lakeshore Drive and the former MGP, shows that both carcinogenic and noncarcinogenic risks are 7×10^{-6} and 0.1, respectively.

7.5.3.2 Indoor Air Evaluation

Based on the data collected, the indoor air concentrations were as much as an order of magnitude higher than the air concentrations detected in ambient air or soil gas samples. This suggests that vapor intrusion may not be primary source of VOCs detected in the indoor samples. However, because of the nature of the chemicals detected in indoor air samples, ambient air, and soil gas samples, the chemicals detected are somewhat dissimilar (Table **19 in Appendix H)**. The chemicals detected in indoor air samples include chemicals that may be associated with solvents rather than chemicals that have been associated with historic activities at the site. There is the possibility that there may be other sources of VOCs within the former MGP facility buildings that may have contributed to the types of chemicals detected in indoor samples. As a conservative measure, all chemicals detected in the indoor air samples were included in the quantitative evaluation and the results of the evaluation suggest that risks to residents are within acceptable USEPA limits.

An HI of 3 was calculated for the worker exposure to indoor air pathway under the RME scenario. This risk level is likely to be an over-estimate because:

- It was estimated using the maximum detected concentrations as the concentrations at points of exposure.

- It was calculated based on the exposure parameters for the industrial/commercial workers (i.e., .an individual works at the Site for 8 hours per day, 5 days per week, 50 weeks per year for a total of 25 years). The NSPW Service Center where the indoor air samples were collected, is used as a warehouse; there is an office space inside the building, but used only on a part-time basis.

7.5.4 Exposure Assessment

7.5.4.1 Exposure Scenario Assumptions

The assumptions used to identify the exposure scenarios evaluated in the HHRA were based on USEPA guidance, Site history, current land use, and limited information concerning future use of the Site. It is assumed that the primary exposure scenario is recreational for Kreher Park. Based on this land use, other scenarios (maintenance and construction) and pathways were developed. If the City of Ashland changes its decision to expand the recreational areas in the future, the HHRA may need to be revisited to determine the risks associated with the future land use.

7.5.4.2 Fate and Transport Assumptions

Site-specific values needed for calculating volatilization factors (VFs) were unavailable. Therefore, chemical and physical parameters were selected from default values recommended in known literature sources based on the predominant soil type of silty clay. Using this approach to calculate Site-specific VFs may potentially result in an over- or under-estimate of risks if the actual Site-specific chemical and physical parameters are significantly different from default values selected based on the silty clay soil type.

For the general industrial worker and residential scenarios, it was assumed that the inhalation of fugitive dusts generated by wind erosion was of concern. To estimate risks to this pathway, a particulate emission factor (PEF) is needed to relate the chemical concentration in soil to the concentration of dust particles in the air. For this HHRA, Site-specific values for the wind erosion dispersion factor and non-erodible surface cover were used for the residential and

commercial/industrial scenarios. Because the non-erodible surface cover is based on current conditions, the risks estimated may not be representative of conditions with greater or lesser surface cover after the Site is developed for re-use.

Attachment G, Tables 1 through 14 in Appendix H present the PEF calculations for the commercial/industrial, residential, and construction scenarios. Attachment G in Appendix H also provides a detailed presentation of the default and limited Site-specific values used for the derivation of PEF values.

7.5.4.3 Receptor Exposure Parameter Values

Although there are future plans for expanding the recreational areas, specific information regarding construction and excavation activities that might occur are unknown. Therefore, risks to construction worker receptors were based on default industrial worker assumptions that may underestimate risks to this receptor population.

Additionally, little information is available concerning the maintenance work that is completed at the Site currently and none is available for future maintenance activities. The assumptions regarding the exposure frequency for maintenance workers is a based on seasonal weather patterns. The actual risks to this receptor are unknown but the estimates presented in this HHRA are conservative.

7.5.4.4 Exposure Point Concentrations

In general, exposure point concentrations were based on statistically-derived concentrations calculated using USEPA's ProUCL software. However, For indoor air, two samples were collected for the purpose of evaluating risk to potential receptors. Because a UCL could not be calculated with only two samples, the maximum concentration was used as the EPC. Use of the maximum detected concentration may potentially overestimate risk associated with exposure to indoor air. However, the true risk is unknown.

A separate evaluation was performed by characterizing risks using EPCs that were derived by excluding chemical concentrations in soil that exceeded the chemical-specific Csat. This evaluation was prepared in response to review comments on the draft HHRA report.
For the purpose of this evaluation, Csat values were calculated for chemicals that are in liquid form at the ambient soil temperature (55 degrees Fahrenheit). Chemical concentrations were compared to the Csat values and EPCs were derived by excluding concentrations that exceeded

Csat values. Cumulative risks calculated using these EPCs are presented on Tables 41 through 45 in Appendix H. Presented below is a comparison of the results of this evaluation to the risk evaluation using the entire soil dataset.

	EPCs Derived Based on the Entire Data Set		**EPCs Derived by Excluding Concentrations > Csat**	
	CR	HI	CR	HI
Residents (0-10 ft)/RME	5E-04	15	5E-04	14
Construction Worker (0-10 ft)/RME	1E-04	35	1E-04	33
Residents (0-10 ft)/CTE	2E-04	8	1E-04	4
Construction Worker (0-10 ft)/CTE	3E-05	13	2E-05	9
Residents (0-3 ft)/RME	5E-05	0.3	3E-04	0.9

As indicated by this comparison, similar risk levels were calculated using EPCs derived based on all soil data in the relevant data sets or data that excluded concentrations exceeding Csat.

7.5.5 Toxicity Assessment

7.5.5.1 Use of Unverified Values

There were several chemicals (as presented in Tables 1a and 1b of Attachment A of the HHRA included in Appendix H detected at this site for which there are only provisional toxicity values. The USEPA process for developing provisional toxicity values is inherently conservative and is not subject to the same vigorous review process as toxicity criteria that have been verified. For this HHRA, 2-methylnaphthalene is a risk driver for the ingestion pathway for both the residential and construction scenarios based on its provisional toxicity value. Because the toxicity values are based on limited animal and human data, the true risks associated with these chemicals are unknown.

7.5.5.2 Lack of Toxicity for Detected Chemicals

There were several chemicals (1-methylnaphthalene, acenaphthylene, benzo[e]pyrene, benzo[g,h,i]perylene, phenanthrene, 1,2,3-trimethylbenzene, p-isopropyltoluene) that were detected at the Site and for which there are no toxicity values. Because of the lack of information available for these chemicals, the true risk to potential receptors at the Site is

unknown. However, because these chemicals were detected in areas where primary risk drivers are located, it is likely that if any remediation based on known risk drivers will address chemicals for which there is a lack of toxicity data.

7.5.6 Hot Spot Analysis

A hot spot analysis was performed for the construction scenario using data collected in the vicinity of the Former Coal Tar Dump in Kreher Park (TP-4, TP113, TP115, TP116, TP118, and TP119). This evaluation was completed as a worse case evaluation of potential risks following exposures to elevated concentrations over a short duration when receptors are engaging in activities that may result in greater contact with soil.

The resulting cancer risk of 4E-06 is primarily attributed to benzo(a)pyrene (72%). Upon review of the data gathered for benzo(a)pyrene for the site, 8 samples with detectable concentrations ranging from 1,400 – 2,600 mg/kg between 2.5 and 5 feet bgs are the main contributors to the benzo(a)pyrene cancer risk

7.5.7 Quantifying Risks Following Dermal Exposure to PAHs

There are no published dermal SFs available for any chemicals in any USEPA database. The current USEPA guidance recommends converting oral SFs (an administered dose) using an gastrointestinal absorption factor to a dermal SF (an absorbed dose), if a chemical does not cause toxicological effects at the point of contact. However, based on literature evidence, PAHs have been shown to induce systemic toxicity and tumors at distant organs as well as point of contact. For this reason, the current default approach for extrapolating dermal SF values is not applicable to PAHs. Therefore, RAGS Part A (USEPA, 1989) and Par E (USEPA, 2004), only recommend a qualitative evaluation of the carcinogenic effects of PAHs. Although a quantitative evaluation for this pathway was completed in this HHRA, as requested by Agencies, the actual cancer risks associated with dermal exposure to PAHs are unknown.

7.6 Conclusions

The results of the HHRA indicate that only three exposure pathways result in estimated risks exceed USEPA's target risk levels: residential exposure pathways (for soil depths between 0 and 3 feet or all soil depths to 10 feet bgs), construction worker exposure pathway (for soil depths

between 0 and 10 feet and groundwater) and worker exposures to indoor air. These include estimates for the RME scenarios for potential cancer risks (a CR greater than 10^{-4}), and non-cancer risks (greater than an HI of 1). These conclusions are based on assumed exposures to soil in the filled ravine area (for residential receptors) and the filled ravine, upper bluff and Kreher Park area (for construction worker receptors), and to indoor air samples collected at NSPW Service Center. Carcinogenic risks based on CTE scenarios indicate that only the residential receptor exposure to soil (all soil depths to 10 feet bgs) are estimated to be at 1 x 10^{-4}, the upper-end of the target risk range. Noncarcinogenic risks for the residential receptor (for all soil depths to 10 feet bgs) and risks associated with the construction scenario are within acceptable levels. However, residential receptor exposure to subsurface soil is not expected, given the current and potential future land use of the Site. For this Site, residential risks associated with exposures to surface soil (0 to 1 foot bgs) are within the target risk ranges.

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Although the results of the HHRA indicate risks for the construction workers under the RME conditions exceed USEPA's target risk levels, the assumptions used to estimate risks to this receptor were conservative and assumed the worst case. Given both the current and future land use of the Site, it is unlikely that construction workers would be exposed to soil in the filled ravine and Upper Bluff. The most likely scenario for the future construction worker is exposure to soil within 0 to 4 feet bgs in Kreher Park (a typical depth for the installation of underground utility corridors), as most activities associated with the implementation of the future land use would be associated with regrading, landscaping, and road or parking lot construction. Therefore, risks to this receptor population from soil exposure are most likely overstated in this HHRA.

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An HI of 3 was calculated for the worker exposure to indoor air pathway under the RME conditions. This risk level is likely to be an over-estimate because:

- It was estimated using the maximum detected concentrations as the concentrations at points of exposure.
- It was calculated based on the exposure parameters for the industrial /commercial workers (i.e., .an individual works at the Site for 8 hours per day, 5 days per week, 50 weeks per year for a total of 25 years). The NSPW Service Center is used as a warehouse; there is an office space inside the building, but used only on a part-time basis.

Risks to recreational users (surface soil), subsistence fishers (finfish), waders and swimmers (sediments), industrial workers (surface soil), and maintenance workers (surface soil) are all

within USEPA's target risk range of 10^{-4} to 10^{-6} for lifetime cancer risk and a target HI of less than or equal to 1 for non-cancer risk.

8.0 BASELINE ECOLOGICAL RISK ASSESSMENT

NSPW completed a baseline ecological risk assessment, and the BERA report was submitted to USEPA on May 30, 2006 and a revised version was submitted on 25 January 2007. A copy of the revised report is included as Appendix I. Section 8.0 is a summary of that report.

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8.1 Introduction

The BERA was conducted to describe the likelihood, nature and severity of adverse effects to ecological receptors, both plants and animals, resulting from their exposure to contaminants at the Site under current conditions.

This BERA supports the Ashland/NSP Lakefront Superfund Site Remedial Investigation/Feasibility Study (RI/FS) being conducted under the regulatory framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601, et seq. and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CRF Part 300. It supplements two other ecological risk assessments that have been conducted for this Site. In 1998, SEH completed an Ecological Risk Assessment (ERA) of the contaminated sediments adjacent to Kreher Park (SEH 1998). A supplemental ERA was performed in 2001 (SEH 2002) during which additional sediment toxicity testing was conducted to provide information for determining clean up goals for the sediments.

The scope of work conducted as part of the RI studies for this BERA was approved by USEPA on December 7, 2004. The approved scope of work resulted from extensive discussions with various stakeholders and Natural Resource Trustees, including:

- National Oceanographic and Atmospheric Administration (NOAA),
- Wisconsin Department of Natural Resources (WDNR),
- Red Cliff Band of Lake Superior Chippewa Indians, and
- Bad River Band of Lake Superior Chippewa Indians.

This BERA was prepared following USEPA Guidance including, *Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final*. (USEPA 1997).

As part of this RI, a number of investigations were conducted whose results were used, along with historical information, to support this BERA. All of the historical and current data were used for screening for contaminants of potential concern (COPCs). Investigations conducted during this RI to support the BERA included:

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1) Surface soil samples collected in the vicinity of Kreher Park (See RI report URS 2006a);
2) Sediment samples collected as part of the supplemental sediment sampling and Sediment Quality Triad (Triad) investigations;
3) Sediment toxicity testing;
4) Benthic macroinvertebrate community studies;
5) Collection of fish tissue;
6) Surface water collection; and
7) Characterization of wetlands and terrestrial habitats.

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The details of these investigations are in the reports appended to this BERA or in reports submitted separately to USEPA.

8.2 Problem Formulation

Problem formulation is the systematic planning process that identifies the factors to be addressed in a BERA and consists of several activities. The initial activity of the BERA was to screen all data, including all historical data, relating to level of Site-related contaminants against conservative generic guidelines and benchmarks for soil, sediment and surface water quality. These benchmarks included Wisconsin's Consensus-Based Sediment Quality Guidelines (WDNR 2003), USEPA Region V's Ecological Screening Levels (ESLs) and USEPA Ecological Soil Screening Levels (ECO-SSLs) as well as other similar benchmarks.

Based upon this screening a number of contaminants of concern (COPCs) were identified as listed below.

List of COPCs by Medium Based on Maximum Detected Concentration.

Surface Water	Sediment	Soil
None	Total polycyclic aromatic hydrocarbons (PAHs)	Total PAHs
	Dibenzofuran	Benzene
	m-Cresol	Antimony
	o-Cresol	Barium
	p-Cresol	Cadmium
	1,2,4-Trimethylbenzene	Chromium
	1,3,5-Trimethylbenzene	Copper
	Benzene	Lead
	Ethylbenzene	Manganese
	Toluene	Mercury
	Total Xylenes	Selenium
	Antimony	Silver
	Barium	Thallium*
	Cadmium	Zinc
	Copper	Cyanide
	Iron	
	Lead	
	Manganese	
	Mercury	
	Nickel	
	Selenium	
	Silver	
	Thallium	
	Vanadium	
	Zinc	
	Cyanide*	

* Eliminated as a COPC based on frequency of detection (<5%)

Baseline Ecological Risk Assessment

As part of the Problem Formulation, an overall risk management goal was developed as the basis for evaluating risk at the Site:

> **Maintenance (or provision) of soil, sediment and water quality as well as food source, and habitat conditions capable of supporting a "functioning ecosystem" for the aquatic and terrestrial plant and animal populations (including individuals of protected species) inhabiting or utilizing the Ashland/NSP Lakefront Superfund Site area.**

Assessment endpoints were developed based upon this risk management goal. After development of a conceptual site model describing:

- The source of contamination;
- Release and transport mechanisms;
- Contact point and exposure media;
- Routes of entry; and
- Key receptors,

Assessment endpoints, risk questions and measurement endpoints were selected as the basis for the BERA. These are summarized in the following table

Endpoints and Risk Questions

Assessment Endpoint	Risk Question	Measurement Endpoint(s) (Exposure and Effects)
Benthic macroinvertebrate community	Are concentrations of contaminants in the sediments at the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?	• Determine the concentrations of Site-related contaminants in Site sediment. • Determine the levels of soot, coal, coke and slag, which may moderate the bioavailability of PAHs in the sediment. • Determine the levels of acid volatile sulfides (AVS) and simultaneously extractable divalent metals (SEM) in the sediment. • Compare concentrations of metals measured in Site sediment to WDNR (2003) sediment quality guidelines for threshold and probable effects. • Evaluate, quantitatively or qualitatively the bioavailability of sediment associated COPCs using SEM:AVS or Equilibrium Partitioning approach. • Compare concentrations of PAHs that accumulated in worm tissues in the bioaccumulation bioassay to the No Effects Body Residue (NEBR) that is associated with narcosis caused by PAHs and volatile organic compounds (VOCs). Use this as a model for predicting risk at the Site. • Using sediment toxicity bioassays, determine which sediments at the Site have elevated toxicity to surrogates for resident macroinvertebrate species compared to sediments in reference areas. • Determine on the basis of benthic macroinvertebrate sampling and analysis where benthic communities inhabiting sediments in water bodies in and adjacent to the Site are impaired when compared to benthic communities inhabiting reference area sediment.

Assessment Endpoint	Risk Question	Measurement Endpoint(s) (Exposure and Effects)
Fish community	Are concentrations of contaminants in sediments and surface waters at the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	• Determine the concentrations of Site-related contaminants in Site surface water. • Determine the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site. • Compare tissue levels of PAHs and estimated VOCs in wild fish caught at the Site to the NEBR. • Using sediment bioassays, determine whether areas on and adjacent to the Site have elevated toxicity compared to sediment from reference areas to surrogates for juvenile resident fish species. • Compare the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site to levels in fish from reference areas. (This assessment endpoint will be used only qualitatively as an indicator of exposure).
Omnivorous aquatic bird community	Are dietary exposure levels of Site-related contaminants sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?	• Determine the concentrations of Site-related contaminants in Site sediment. • Through food chain models for the black duck using sediment to benthic invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to toxicity reference values (TRVs) associated with adverse effects, including reproductive impairment.
Omnivorous birds	Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?	• Determine the concentrations of Site-related contaminants in Site soils. • Through food chain models for the red-winged blackbird using soil to vegetation and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Insectivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous avian community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Through food chain models for the tree swallow using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous birds	Are dietary exposure levels of Site-related	• Determine the concentrations of Site-related

Assessment Endpoint	Risk Question	Measurement Endpoint(s) (Exposure and Effects)
	contaminants sufficient to cause adverse alterations to individual ospreys or to the piscivorous avian community?	contaminants in Site sediments. • Determine the concentrations of Site-related contaminants in fish caught in and adjacent to the Site. • Through food chain models for the double-crested cormorant and the osprey using actual levels of Site-related contaminants measured in fish in and adjacent to the Site, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Omnivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the omnivorous mammal community?	• Determine the concentrations of Site-related contaminants in Site soils. • Through food chain models for the white-footed mouse using soil to plant and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Insectivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous mammal community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Through food chain models for the big brown bat using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?	• Determine the concentrations of Site-related contaminants in fish caught in the Site area. • Through food chain models using actual levels of Site-related contaminants measured in fish, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects.

Based upon these risk questions and endpoints a number of Receptors of Concern (ROCs) were selected as summarized below.

Receptors of Concern

ROC Category	ROC	Habitat
Aquatic Habitat		
Benthic macroinvertebrate community	Generic	Littoral portions of Chequamegon Bay
Fish Community	Generic	Littoral portions of Chequamegon Bay
Omnivorous birds	Black Duck	Littoral portions of Chequamegon Bay
Insectivorous birds	Tree swallow	Upland and riparian
Piscivorous birds	Double-crested cormorant Osprey (State endangered)	Littoral portions of Chequamegon Bay
Insectivorous mammals	Big brown bat	Upland and riparian
Piscivorous mammals	Mink	Upland and riparian
Terrestrial Habitat		
Omnivorous birds	Red-winged blackbird	Upland and riparian
Omnivorous mammals	White-footed mouse	Upland and riparian

8.3 Analysis

8.3.1 Effects Analysis

The Effects Analysis consisted of an evaluation of available toxicity or other effects information that could be used to relate the exposure estimates to a level of adverse effects. Stressor-response (i.e., effects) data that were used to evaluate ecological risks in this BERA were of three types: (1) literature-derived toxicity data, (2) site-specific ambient media toxicity tests (e.g. sediment toxicity tests), and (3) site-specific biological community surveys.

The focus of the majority of the effort for this BERA was on aquatic portions of the Site. For the evaluation of Site sediment, all three lines of evidence were integrated into a Sediment Quality Triad approach (Triad) (Long and Chapman 1985; Chapman et al. 1987). The Triad evaluates sediment quality by integrating spatially and temporally matched sediment chemistry, biological, and toxicological information. Benthic invertebrate community analysis and sediment toxicity testing provided site-specific information regarding potential ecological effects of exposure of ecological receptors to COPCs in the Site sediment. These additional lines of evidence supplement traditional bulk sediment chemistry data to provide a more relevant, site-specific assessment of risks.

The evaluation of bulk sediment chemistry data involved comparison of Site sediment chemistry data to effects levels published by WDNR (2003), derived from relevant studies reported in published literature, or from studies performed for this BERA. Site-specific sediment toxicity tests were conducted with aquatic receptors that are representative surrogates for those living on the Site and the results of this testing provided information on potential toxic effects that were observed in Site relevant organisms exposed to Site sediment. Site-specific surveys of benthic macroinvertebrate community also were conducted for the Site. In addition to these three lines of evidence that focus primarily on the benthic environment at the Site, surface water quality data and fish tissue data were collected from Site waters.

For upland portions of the Site, only two lines of evidence were used in this BERA. One was the comparison of bulk soil chemistry to soil quality benchmarks used as generic criteria, e.g., the soil ECO-SSLs (USEPA 2005a) or derived from relevant studies reported in published literature. The second was the comparison of doses accumulated through the food chain that terrestrial and aquatic prey-dependent wildlife (i.e., birds and mammals) may feed upon. These doses were compared to TRVs derived from the primary scientific literature.

The result of the ecological effects analysis was a range of TRVs that were compared with the dose estimates (birds and mammals) or toxicological benchmarks that were compared with estimated exposure point concentrations (EPCs) (benthic invertebrates and fish) to estimate potential risks in this Risk Characterization.

8.3.2 Exposure Analysis

In the exposure analysis, the relationship between receptors at the Site and potential stressors (chemical, biological, or physical entities that may result in adverse effects to one or more receptors or groups of receptors) were evaluated. Exposure point calculations (EPCs) used to estimate exposure were calculated as the mean and 95% upper confidence limit of the mean concentration (UCL_{95}) of the exposure medium. EPCs calculated for surface water, sediment, soil, or tissue residues were based directly upon the levels of contaminants in these media.

Exposure estimates for birds and mammals were calculated using food chain models. Simplified food chain models were developed to calculate average daily doses (ADDs) of COPCs that selected receptor groups experience through exposure to surface water, sediment, and surface soil at the Site. The ADD represents the dose of a chemical that a receptor may ingest if it foraged within designated exposure units. ADDs for wildlife receptors are calculated using (1) EPCs for prey and media developed for each, (2) COPC-specific bioaccumulation factors or

bioaccumulation models for dietary items, and (3) receptor-specific exposure parameters and food chain model assumptions, (e.g., diet composition, foraging area, amount of incidental soil or sediment ingested, etc.).

8.4 Risk Characterization

Risk Characterization was the final phase of the BERA. In the Risk Characterization the information from the effects and exposure analyses was used to determine a probability of adverse effects to ROCs and discuss the strengths, weaknesses, and assumptions in the BERA. Risk estimates (or Hazard Quotients) were developed for each assessment endpoint based upon comparison of site-specific media concentrations and/or estimated ingested contaminant dose estimates (the latter for wildlife) to effects levels (generic criteria, benchmarks and TRVs) for the various ROCs. Finally risk was characterized for each assessment endpoint by integrating the risk estimate with the results of other lines of evidence, if available.

The results of the risk characterization indicated that there are potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site. Two lines of evidence, bulk sediment chemistry and sediment toxicity testing, indicated that some impairment at the community level was possible.

However, the fact that hydrocarbons are sporadically released from the Site sediment during some high energy meteorological events or when disturbed by other activities indicates the potential for impact to the benthic community that may not have been fully measured by the studies conducted to support the RI. While there is no evidence that effects from these releases will lead to impairment of populations and communities of these receptors inhabiting the waters of Chequamegon Bay, it remains a source of uncertainty. It is possible that the presence of this continuing source of site related contaminants may sporadically impair the healthy functioning of the aquatic community in the Site area.

In addition, if normal lake front activities, i.e., wading, boating etc., were not presently prohibited, the disturbance of sediments and concomitant release of subsurface COPCS would increase. This potentially could lead to greater impacts than were measured during these RI/FS studies.

The BERA concluded that the potential for adverse effects to ecological receptors other than benthic macroinvertebrates was not sufficient to result in adverse alterations to populations and communities of these **(need to finish this paragraph)**

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9.0 SUMMARY AND CONCLUSIONS

9.1 Summary

9.1.1 Nature and Extent of Contamination

The predominant sources of contamination at the Site consist of discrete free-product zones within each of the four affected areas. These free-product zones are similar in character and contain a light-weight fraction containing VOCs and a heavy-weight fraction containing primarily PAHs. The principal compounds within each of these parameter groups are the VOC benzene and the PAH naphthalene. Arsenic, lead and cyanide are inorganic compounds also associated with the free product zones, predominantly at the former MGP site. Arsenic and lead are found at Kreher Park and in the affected sediments, but data indicates these metals are also found as part of the fill historically placed at Kreher Park. Cyanide is not found beyond the former seep discharge.

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The upper bluff/filled ravine has a free-product mass at the base of the ravine located south of St. Claire St. below the NSPW service center building. Part of the building includes an older section incorporating the former manufactured gas plant. The free-product is found at the base of the ravine varying in depth from 15 to 20 feet. It has been measured historically from a few inches to nearly 10 feet in thickness. A perched water table has formed within the filled ravine within four to six feet of the ground surface. This is part of the regional water table that extends across the area within the Miller Creek Formation, a low permeability silty-clay/clayey silt that forms the surficial geologic unit underlying the fills in the Ashland area. Soil and groundwater in the filled ravine are contaminated largely by contact/proximity with the free-product mass. The fill is variable consisting of cinders, debris, and other locally derived detritus.

A free-product mass is present underlying the Miller Creek Formation in the same area of the NSPW service center. This material is found within the upper reaches of the Copper Falls aquifer, a sandy, coarse grained unit. Free-product extends from depths of approximately 30 to 70 feet. The greatest thickness of free product is present directly south of St. Claire Street within the main access drive of the NSPW service center. It thins in all directions from this area. Since 2000, NSPW has maintained a free-product recovery system consisting of three extraction wells which have removed over 8,000 gallons of free-product/water emulsification (approximately 10% oil/tar and 90% water) from the aquifer.

Summary and Conclusions

Contaminated groundwater containing the principal VOC and PAH compounds are found in proximity to these free-product zones. Within the filled ravine, migration in the down gradient direction toward Kreher Park occurred through both the fill as well as a 12-inch clay tile that extended along the base of the ravine to its mouth. This discharge was eliminated in 2002 with the installation of an interception well at the mouth of the former ravine. The effluent is conveyed to the existing tar removal system for treatment prior to discharge to the sanitary sewer. North of the alley behind the service center, the Miller Creek Formation increases in plasticity creating an aquitard to the Copper Falls aquifer. Vertical gradients in the Copper Falls aquifer south of the alley are downward, indicating this is a zone of recharge. North of the alley, vertical gradients at nested wells screened in the Copper Falls aquifer indicate strong upward flow. These gradients increase in magnitude with both depth and distance toward Chequamegon Bay. Wells screened in the aquifer north of the bluff face forming the boundary between Kreher Park and the NSPW property are flowing (artesian) wells. Additionally, the aquitard thickens toward the shoreline. This creates an apparent convergent flow condition beneath the center of Kreher Park near MW-2B(NET). Flow in the upper Copper Falls aquifer in this area is potentially restricted because of the configuration of the Miller Creek Formation, which thickens to the north toward the shoreline. Upward vertical discharge through the Miller Creek occurs as shown by the artesian wells at the Park. However, the same condition indicates that the volume of discharge is low due the low permeability of the aquitard.

Free-product (DNAPL) is present at the seep area north of the mouth of the filled ravine at Kreher Park. This material is limited in extent, but is found at the base of the fill/wood waste layer which comprises the majority of the filled material at the Park. Although the free-product zone is limited, contaminated soil and groundwater conditions are widespread across the entire Park area. The contaminants are found at the interface of a relatively clean surficial soil unit two to four feet thick overlying wood waste and debris. Higher levels of PAHs are found across the entire Park area than are found at the former MGP site. The individual compounds are similar, but comparison of these data shows an order of magnitude or greater difference between the data from the two affected areas. The highest PAHs are present in soil/wood waste samples from the former coal tar dump area.

Free-product is also present in sediments in the offshore zone along the Kreher Park shoreline, mainly at the sand/wood waste interface (historic lakebed). The greatest mass of material extends between the marina and an area north of the former WWTP from 100 to 300 feet from the shore. Free-product is found at depths up to four feet below the sediment/water interface in

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this zone. A separate free product area is found at depths up to 10 feet between the former WWTP and the boat launch.

A wood waste layer varying from sawdust sized particles to timber is present across the entire affected bay inlet at depths from a few inches to more than six feet. Approximately 95 percent of the impacted sediments underlie this wood waste layer. The greatest wood waste thickness is found at the area east of the WWTP, where the former Schroeder Lumber sawmill operated. Approximately 25,000 cubic yards of this material is present in this layer. The bulk of the contaminant mass is found immediately below the wood waste layer at the sediment surface. However, some contaminants have been measured in samples collected from within the wood waste layer. Contaminated sediments are found across the entire inlet area, but contaminant concentrations decline significantly beyond a line between the north ends of the marina and the boat launch.

9.1.2 Fate and Transport

The source of the contamination at the Site was caused primarily by the MGP and other multiple industrial activities that began in the 1880's and continued until the mid 20th century. Although contaminant sources were no longer active after that time, continued filling activities further dispersed these contaminants. However, no large scale activities capable of mobilizing contaminants, or filling activities that add contaminant mass to the source areas have occurred at the Site since the closure of the WWTP in the early 1990s.

The primary source of contamination at the upper bluff/filled ravine, Kreher Park, Copper Falls aquifer and Chequamegon Bay is from the historic MGP operations. Contamination likely resulted from discharge of waste tars generated from the carburetted water gas manufacturing process. The tar material accumulated at the base of the ravine fill in the immediate area of the MGP facilities south of St. Claire Street and was dispersed throughout the inlet prior to filling in Kreher Park.

The tar has migrated into the bay and contaminated the Chequamegon Bay area. The migration of this material to the Copper Falls aquifer also occurred where the overlying Miller Creek Formation is less plastic and hydrogeologic conditions allow downward flow conditions. This area is south of the alley behind the present NSPW service center.

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Summary and Conclusions

Waste tars released during MGP operations migrated through the ravine fill and the buried clay tile to the base of the former ravine. The source of the free-product at the seep was the MGP. The tile was likely part of a sewer system installed contemporaneously during the early operation of the MGP. A 1902 City of Ashland sewer ordinance required the underground discharge of MGP wastes, and this pipe may have been installed as a result. However, the free-product mass found south of St. Claire Street indicates this material was released at least in part and not entirely captured by this pipe system. Following backfilling of the ravine, releases of free-product likely continued through the clay tile pipe. This material migrated to the downstream end of the tile, likely connected to a second tile system identified during the 2005 RI. This tile paralleled the bluff face and was traced to the location of an upstream inlet of a former open sewer identified at the west side of Kreher Park. Although actual records have not been recovered, this pipe network was likely part of a larger sewer system abandoned following cessation of industrial activities at the Park in the late 1930s, when the open sewer was filled. Once the open sewer was abandoned, free-product then discharged through breeches in the pipe network, such as at the seep.

The source of free product to the sediments likely resulted from a combination of effects. Direct discharge of wastes through the open ravine to the inlet prior to its filling is one source. Discharges of wastes from the open sewer prior to its filling and abandonment constitute another source. The wastes came primarily from the MGP, and potentially from other upland locations connected to the open sewer. Additionally, based on the distribution of free product in the sediments other discharge points in addition to the open sewer could be present. It is likely that the distribution of this material has been affected by construction and filling activities that continued following cessation of other lakefront operations.

The highest levels of VOC contaminants at the Park are found at areas corresponding to free product zones. These are comparable with levels near other free-product zones at the upper bluff/filled ravine and Copper Falls aquifers. The levels are consistent for both soil and groundwater. Because of the high mobility and high solubility of the VOCs, the high permeability/flat horizontal groundwater gradient has led to widespread VOC contamination in groundwater at Kreher Park. However, these levels are generally an order of magnitude lower than samples collected near the free-product (DNAPL) areas.

In contrast, the soil data from Kreher Park show the opposite relationship regarding PAHs, with an order of magnitude increase in PAH levels across the majority of the Park compared to the upper bluff/filled ravine. The PAHs are less mobile and less soluble compared to the VOCs,

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degrading more slowly. This chemical behavior combined with the physical characteristics in the fill material have created conditions for the PAHs to remain present and at similar levels in the fill since they were first released. The highest levels are most pronounced in the area of the former coal tar dump. Another potential source is the off-loading of fuel feedstocks for the MGP and potentially for other raw materials to support lakefront industrial activity.

Contaminants in the affected sediments likely originated from a variety of sources. One likely source may have been the open sewer when it was functional.

Deleted: The lack of corroborating data from samples from the upper bluff indicates these high levels of PAHs likely originated from a source unrelated to the MGP. Based on historic information including eyewitness testimony and these data, this source may possibly have been from wood treatment residuals remaining following Schroeder Lumber's tenure on the lakeshore.

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Deleted: Later activities that were a source of contaminants in sediments along the entire shore line included the draining of the coal tar dump and filling activities associated with the initial construction of the WWTP in 1952, subsequent filling activities when the WWTP was expanded in 1973, and when the marina was constructed in 1986.

9.1.3 Risk Assessment

HHRA

The results of the human health risk assessment (HHRA) indicate that only three exposure pathways result in estimated risk levels exceed USEPA's target risk levels: residential exposure pathways (for soil depths between 0 and 3 feet or all soil depths to 10 feet bgs), construction worker exposure pathway (for soil depths between 0 and 10 feet) and worker exposures to indoor air. These include estimates for the reasonable maximum exposure conditions for potential cancer risks (greater than 10^{-4}), and non-cancer risks (greater than a hazard index of 1). These conclusions are based on exposures to soil in the filled ravine area (for residential receptors) and the Kreher Park area (for construction worker receptors), and to indoor air samples collected at NSPW Service Center. Carcinogenic risks based on average exposure conditions indicate that only the residential receptor exposure to soil (all soil depths to 10 feet bgs) are estimated to be at 1×10^{-4}, the upper-end of the target risk range. Noncarcinogenic risks for the residential receptor (for all soil depths to 10 feet bgs) and risks associated with the construction scenario are within acceptable levels. However, residential receptor exposure to subsurface soil is not expected, given the current and potential future land use of the Site. For this Site, residential risks associated with exposures to surface soil (0 to 1 foot bgs) are within the target risk ranges.

Although the results of the HHRA indicate risks for the construction workers under the reasonable maximum exposure conditions exceed USEPA's target risk levels, the assumptions used to estimate risks to this receptor were conservative and assumed the worst case. Given both the current and future land use of the Site, it is unlikely that construction workers would be exposed to subsurface soil in Kreher Park at depths beyond 4 feet bgs (a typical depth for the installation of underground utility corridors), as most activities associated with the implementation of the future land use would be associated with re-grading, landscaping, and

road or parking lot construction. Therefore, risks to this receptor population from soil exposure are most likely overstated.

A hazard index of 3 was calculated for the worker exposure to indoor air pathway under the reasonable maximum exposure conditions. This risk level is likely to be an over-estimate because:

- It was estimated using the maximum detected concentrations as the concentrations at points of exposure.

- It was calculated based on the exposure parameters for the industrial /commercial workers (i.e., .an individual works at the Site for 8 hours per day, 5 days per week, 50 weeks per year for a total of 25 years). The NSPW Service Center is used as a warehouse; there is an office space inside the building, but used only on a part-time basis.

Risks to recreational users (surface soil), subsistence fishers (finfish), waders and swimmers (sediments), industrial workers (surface soil), and maintenance workers (surface soil) are all within USEPA's target risk range of 10^{-4} to 10^{-6} for lifetime cancer risk and a target hazard index of less than or equal to 1 for non-cancer risk.

BERA

The baseline ecological risk assessment (BERA) studied nine groups of ecological receptors. The results identified no unacceptable risks to six of these endpoints (omnivorous birds, insectivorous birds, piscivorous birds, omnivorous mammals, insectivorous mammals, and piscivorous mammals). Two of the other endpoints also yielded data that showed no unacceptable risks (fish community and omnivorous aquatic birds); however, the data also showed that contaminants in sediment are sporadically released to the aquatic environment where these receptors are potentially exposed. The final receptor group which was studied included benthic invertebrates. The results of the risk characterization indicated that there are potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site.

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9.2 Conclusions

9.2.1 Data Limitations and Recommendations for Future Work

The datasets developed since 1995 for the Site are extensive for all media of concern. These datasets are comprehensive and should be considered complete for characterization of the nature and extent of contamination. Further study during the feasibility study process is recommended in the BERA to address concerns related to ongoing impacts to benthic macroinvertebrates, omnivorous aquatic birds, and fish. However, the existing data are sufficient to assess and design the final remedial actions that will be proposed for the subject areas of concern.

9.2.2 Recommended Remedial Action Objectives

The Remedial Action Options Technical Memorandum is with this draft Final RI Report as Appendix A.

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The extent of many of the metals in the upper bluff and filled ravine above regulatory standards can not be defined because in a number of cases, each of the sample points exceeded the standard. However, a number of the metals tend to have higher concentrations within the filled ravine, which correlates with soil data and organic data discussed below. Figures 4-89 to 4-105A show the distribution of exceedances and time-concentration plots for a number of the metals.

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The lack of a continuous source of free-product since the MGP ceased operations indicates that further movement of the contaminant plumes should be minimal but is likely still occurring. The free-product mass has likely reached its a maximum measured depth near elevation 560 (msl) as shown by measurements collected at MW-13B.[1] Similarly the dissolved phase plume has also likely reached its maximum extent because of these same hydrogeologic conditions and equilibrium with respect to free product sources.

[1] The free-product mass' response to the pore pressures induced by the upward gradients is shown at MW-2AR, screened below the base of the Miller Creek Formation. This piezometer is located about 100' feet northwest of MW-13B in the NSPW storage yard. The screen is set at 45.5 feet, and the base of the Miller Creek Formation is at 33 feet. Free-product thicknesses as great as 20 feet have been measured, indicating the material has risen in the