GM Sustainable Workplaces
VEC East, 5th Floor
30400 Van Dyke
Warren, MI 48093

February 19, 2021

Mr. Peter Ramanauskas
U.S. EPA Region 5
77 West Jackson Blvd.
Chicago, Illinois 60604-3590

Dear Mr. Ramanauskas:

Re: Final Submittal of the RCRA Facility Investigation (RFI) Report Addendum
GM BCO – Bedford Facility,
ID 006036099, Docket No. RCRA 05 2017 0011
Bedford, Indiana

Please find enclosed the final Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report Addendum for the General Motors (GM) Bedford Casting Operations Facility at 105 GM Drive in Bedford, Indiana (U.S. EPA ID No. IND 006036099), submitted in accordance with the Conditions of the Administrative Order on Consent (AOC) dated August 4, 2014 (AOC Docket No. RCRA-05-2014-0011). This RFI Addendum supplements the RFI Report with information obtained during the installation of the Pilot Perimeter Groundwater Collection Trench, conduct of soil sampling in the 'Unsampled Areas' and the investigation at AOI-8 West. This final document includes revisions set forth in the agreed upon response to the U.S. EPA comments on the draft addendum, submitted on October 26, 2020, and January 19, 2021. In addition, it includes minor revisions for consistency and clarification that were emailed to you on January 28, 2021, and February 4, 2021.

Upon approval of this RFI Report Addendum by U.S. EPA, GM will initiate the development of a Corrective Measures Proposal (CMP) that will include any appropriate final corrective measures at AOIs 1, 8, 9, 11, perimeter groundwater and ongoing interim measures as well as site wide deed restrictions. A proposed long-term operation, monitoring and maintenance plan will also be included with the CMP.

If you have any questions regarding the RFI Report Addendum, please do not hesitate to contact me at 313-506-9465.

Sincerely,

Edward Peterson

Ed Peterson
Project Manager, Eco-Restorers
GM Sustainable Workplaces

cc: See Attached Distribution List

GM Bedford Electronic Distribution List

Peter Ramanauskas	U.S EPA, Region 5
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Resource Conservation and Recovery Act Facility Investigation (RFI) Report Addendum

General Motors LLC
Bedford Casting Operations
Bedford, Indiana

U.S. EPA ID NO. IND 006036099

GHD | 455 Phillip Street Waterloo Ontario N2L 3X2 Canada | 013968 | Report No 433 | February 19, 2020

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List of Acronyms and Terms

Agreement	GMC RCRA Corrective Action Agreement
AOC	GM Administrative Order on Consent
AOI	Area of Interest
AST	Above-ground Storage Tank
ATEL	Aqua Tech Environmental Laboratories
bgs	below ground surface
CA	Corrective Action
CCR	Current Conditions Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CM	Corrective Measure
CMP	Corrective Measures Proposal
cm	centimeter
cm/s	centimeters per second
CRA	Conestoga-Rovers & Associates, Inc. On July 1, 2015, CRA changed its name to GHD. CRA/GHD was retained by both GMC and GM to conduct and/or oversee the RFI-related activities.
CSM	Conceptual Site Model
CV	Coefficient of Variation
DNAPL	Dense Non-Aqueous Phase Liquid
Downstream Parcels	The Downstream Parcels include Parcels 13 (RACER), 15, 20 (RACER), 21, 23 (RACER), 24, 25, 27 (RACER), 28 (RACER), 29, 30, 36, 37, 38 (RACER), 39 (RACER), 40, 72, 76 (RACER), 78 (RACER), 81, and 216 (east of Bailey Scales Road).
EDD	electronic data deliverable
East Plant Area	Portion of the Facility located East of GM Drive
Facility	Property owned by GM and constituting GM's Casting Operations (formerly known either as Powertrain or Castings, Engines, and Transmissions or Global Propulsion Systems) in Bedford, Indiana

List of Acronyms and Terms

ft	feet
ft bgs	feet below ground surface
GC/MS	Gas Chromatograph/Mass Spectrometry
GM	General Motors LLC
GMC	General Motors Corporation (renamed Motors Liquidation Company on July 9, 2009)
gpm	gallons per minute
GPR	ground penetrating radar
Groundwater Trench	Perimeter Groundwater Trench Collection System for the East Plant Area
≥50 mg/kg PCBs	greater than or equal to 50 mg/kg PCBs
HASP	Health and Safety Plan
HDPE	high-density polyethylene
HHRA	Human Health Risk Assessment
HI	hazard index
HSA	hollow-stem auger
HSCM	Hydrogeologic Site Conceptual Model
ICP	Inductively Coupled Plasma
ID	identification number
IDEM	Indiana Department of Environmental Management
IM	Interim Measure
ISM	Incremental Sampling Methodology
kg	kilograms
<50 mg/kg PCBs	less than 50 mg/kg PCBs
mg/kg	milligrams per kilogram
ml	milliliters
MMP	Monitoring and Maintenance Plan
NAPL	Non-Aqueous Phase Liquid
NFA	No Further Action
NFG	National Functional Guidelines
NPDES	National Pollutant Discharge Elimination System
OMM	Operation, Maintenance, and Monitoring
OMMP	Operation, Maintenance, and Monitoring Plan

List of Acronyms and Terms

PCBs	polychlorinated biphenyls
PDF	portable document format
Pilot Trench	Pilot Perimeter Groundwater Collection System Study
PPE	Personal Protective Equipment
ppm	parts per million
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RACER Trust	Revitalizing Automotive Communities Environmental Response Trust
RA	Risk Assessment
RA Work Plans	Work Plans for the Upstream Parcels RA, Parcel 22 RA, and Downstream Parcels RA
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RFI Addendum	RCRA Facility Investigation Report Addendum
RME	reasonable maximum exposures
RSLs	Regional Screening Levels
SOP	Standard Operating Procedures
SSC	Site Source Control
SL	Screening Level
STL	Severn Trent Laboratories
Tributary 3	a tributary to Bailey's Branch in the north section of the East Plant Area
TSCA	Toxic Substances Control Act
UCL	upper confidence limit
µg/L	micrograms per liter
µg/m3	micrograms per cubic meter
µm	micrometer
Upstream Parcels	The Upstream Parcels include Parcels 3, 4, 5 (RACER), 6, 7 (RACER), 8 (RACER), 10 (RACER), 11 (RACER), 12 (RACER), 205, 215, 216 (west of Bailey Scales Road), 401, and the area north of the AOI 4.
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
UST	Underground Storage Tank
Vault	East Plant Area TSCA Permitted Vault

List of Acronyms and Terms

VOC	Volatile Organic Compound
West Plant Area	Portion of the Facility located west of GM Drive
IWTP	GM Casting Operations Bedford Facility Industrial Water Treatment Plant
WTP	On-Facility Site Source Control and Stormwater Treatment Facility

1. Introduction

1.1 Purpose

GHD (formerly Conestoga-Rovers & Associates, Inc. (CRA))[1] has prepared this Resource Conservation and Recovery Act (RCRA) Facility Investigation Report Addendum (RFI Addendum) on behalf of General Motors LLC (GM) for GM's Casting Operations (formerly referred to as either Powertrain Division or Castings, Engines, and Transmissions or Global Propulsion Systems) of the Bedford Facility (Facility) located in Bedford, Lawrence County, Indiana, in accordance with the RCRA Administrative Order on Consent (AOC) (effective August 4, 2014) by and between United States Environmental Protection Agency (U.S. EPA) and GM for the Facility (Docket No. RCRA 005-2014-0011)[2].

This RFI Addendum is supplemental to the RFI Report (GHD, March 2020) to describe the procedures, methods, and results of the field investigations or Corrective Measures (CMs) completed at the Facility after those that are described in the RFI Report (i.e., the collection of soil sampling at the 'Unsampled Areas', an investigation at AOI-8 West, and the installation of the Pilot Perimeter Groundwater Collection Trench. The information in this RFI Addendum includes comparison of the data with generic risk-based screening criteria to identify where a potentially significant release of hazardous waste or hazardous constituents has occurred. Where a potentially significant release is identified, the nature and extent of hazardous constituents in the environmental media characterized are discussed. A summary of the site-specific Risk Assessment (RA) results that were evaluated as part of each investigative is also included in this RFI Addendum to provide a basis for determining whether the presence of these hazardous constituents poses an unacceptable risk that would warrant additional CMs.

This RFI Addendum presents RFI information from June 2015 to present.

1.2 Report Organization

This report is organized as follows:

Section 1.0	This Section provides an introduction to the report and presents the purpose of the RFI Addendum.
Section 2.0	This Section presents a summary of the environmental setting; including a discussion of the site setting, surface water hydrology, and regional and local geologic and hydrogeologic conditions.

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[1] On 2 July 2014, GHD and Conestoga-Rovers & Associates merged. On July 1, 2015, CRA changed its name to GHD. Where work was conducted prior to July 1, 2015, CRA is identified as the entity performing the work. GHD is the current entity providing consulting services for this project.

[2] General Motors LLC (GM) refers to the company formed on July 10, 2009, as a result of the 363 Asset Sale pursuant to the bankruptcy of General Motors Corporation. Any reference in this RFI Report to historical documents or to the property or work prior to July 10, 2009, refers to the work performed by General Motors Corporation which includes work on properties owned by RACER Trust, third parties and/or GM.

Section 3.0	This Section presents and overview of the supplemental investigations, including incremental sampling and AOI 8 West Investigation, as well a summary of IM activities associated with the Pilot Trench Groundwater Collection system.
Section 4.0	This Section provides a description of the data validation and assessment process and the Quality Assurance/Quality Control (QA/QC) procedures that were implemented during the investigative sampling.
Section 5.0	This Section presents the results of the supplemental investigations.
Section 6.0	This Section presents the results of risk evaluation for the areas investigated.
Section 7.0	This Section provides the summary and conclusions regarding the information presented in this RFI Report to support a Corrective Measures Proposal (CMP).
Section 8.0	This Section lists the references used in compiling this RFI Report.

2. Environmental Setting

The Facility is located on the northeast side of the City of Bedford at 105 GM Drive, Bedford, Shawswick Township, Lawrence County, Indiana 47421. The Facility contains approximately 1,080,000 square feet of floor space and is located on 152 acres of land on either side of GM Drive and extends north along Bailey Scales Road (excluding several parcels recently purchased by GM -– referred to as owned residential properties) and currently employs approximately 600 to 700 people. The Facility location and Facility plan are presented on Figures 2.1 and 2.2, respectively.

Information on Land Use, Climate, Public Water Supply, Regional and Local Surface Water Hydrology, and Regional Geology and Hydrogeology can be found in the RFI Report (GHD, March 2020). The following presents conditions related to the Facility geology and hydrogeology, and the Conceptual Hydrogeologic Site Model for the presence and movement of contaminants in a karst area.

2.1 Conceptual Hydrogeologic Site Model

The following presents the current Conceptual Hydrogeologic Site Model. Full details regarding the regional and local geology, and hydrogeology can be found in the RFI Report (GHD, March 2020).

2.1.1 Physical Setting

The Facility is in the Mitchell Plateau physiographic province, a carbonate karst plateau dissected by a few major stream systems. The term karst describes a terrane underlain by soluble rocks, where openings in the rocks are widened through dissolution, creating unique networks of preferential groundwater flow and, frequently, features including caves, sinkholes, and springs. The main Facility structures are situated on a flat hilltop in the West Plant Area (Inset 1). The land surface comprising the East Plant Area generally slopes to the east and is underlain by a veneer of recently placed fill materials situated on limestone bedrock. The bedrock surface is incised by two narrow, roughly east-west trending valleys that convey groundwater eastward to Bailey's Branch creek. The Pilot Trench is constructed across the northernmost of these two bedrock valleys.

2.1.2 Geologic Conditions

This section provides an overview of relevant geologic conditions at and around the Facility. Details regarding geologic conditions are contained in the RCRA Facility Investigation (RFI) Report (GHD, March 2020).

2.1.2.1 Geologic Materials

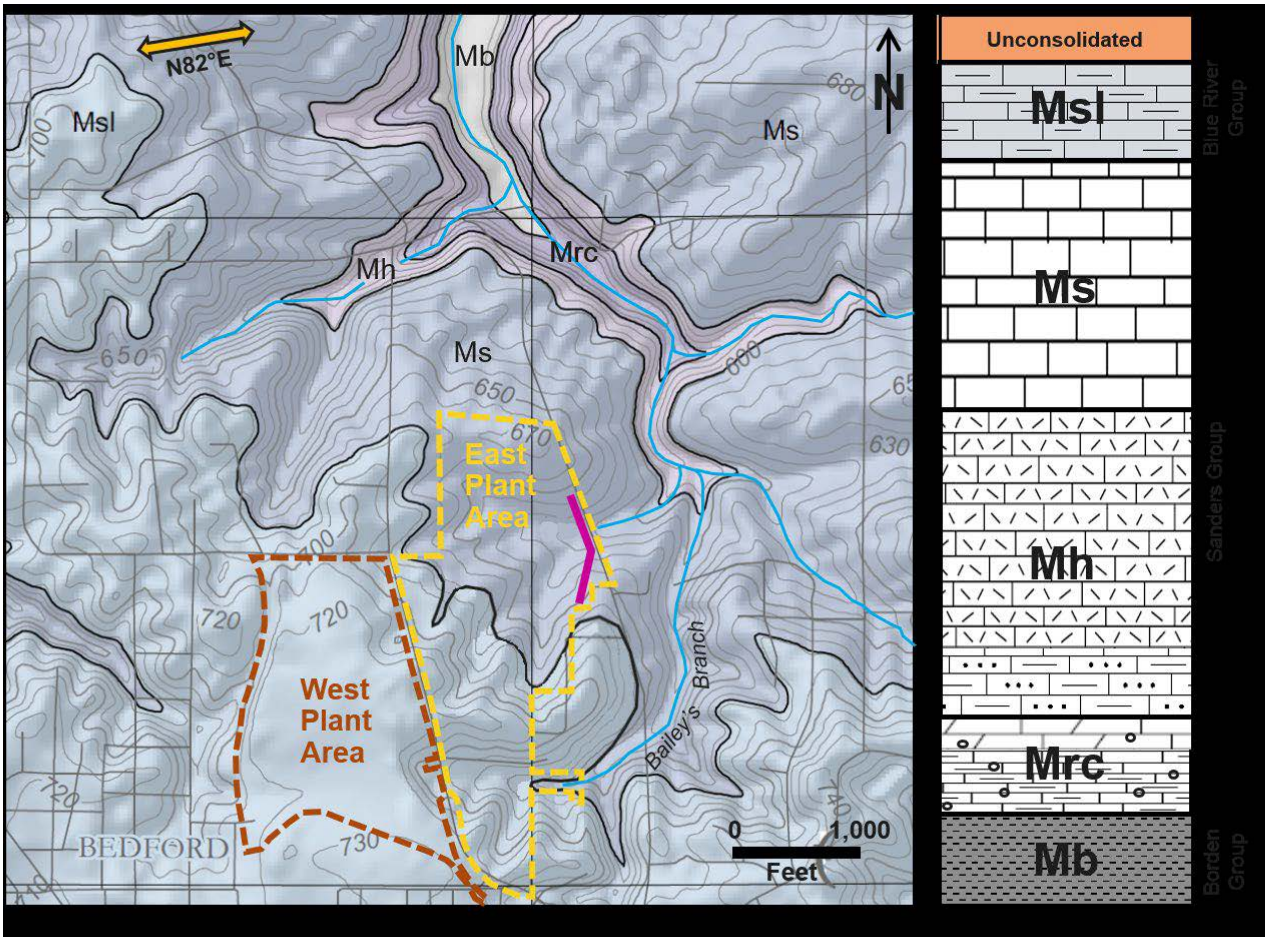
The geology of the site and surroundings consists of a thin veneer of unconsolidated clay-rich and finer grained material overlying bedrock comprised of several Mississippian geologic formations (Inset 1).

2.1.2.2 Unconsolidated Material

Unconsolidated, native materials overlying the bedrock at the Facility are relatively thin and consist chiefly of loess (silt deposited by wind) underlain by residuum. Residuum is mineral material that accumulated in place as the carbonate bedrock dissolved and disintegrated (chemically weathered). The residuum at the facility is described as predominantly clay with traces of silt and gravel, clayey sand, and silty sand. Fill materials placed at the Facility consist of gravel with varying amounts of finer-grained material. Debris such as wood, plastic, brick, and metal are occasionally encountered in the fill.

2.1.2.3 Bedrock Description

In descending order (youngest to oldest), these are the St. Louis Limestone (Msl) of the Blue River Group, the Salem Limestone (Ms), the Harrodsburg Limestone (Mh), the Ramp Creek Formation (Mrc) of the Sanders Group, and the Edwardsville Formation of the Borden Group (Mb). The bedrock geologic map prepared by Thompson et al. (2008) does not differentiate between the three formations that comprise the Borden Group. All three are denoted by the symbol "Mb".



Inset 1. (Left) Bedrock geology map with topographic contours (after Thompson et al., 2008, with adjustments based on site-specific data); **(Right)** generalized stratigraphic column showing unit relationships. The thickness of the Blue River and Sanders Group Formations shown are relative to the approximate average thickness of formations penetrated at the site. Unit abbreviations explained in text. Yellow arrow denotes strike of regionally dominant joint set (Powell, 1976 [Plate 1]). Pilot trench shown in magenta.

St. Louis Limestone

The St. Louis Limestone in Indiana is divided into two parts based on lithology: the upper St. Louis and the lower St. Louis. Only the lower St. Louis is present at the Facility. The lower St. Louis consists mostly of thin-bedded, generally micritic, limestone with thin beds of calcareous shale and silty dolostone (Carr, 1986). The average matrix (i.e., primary) porosity of samples tested from rock cores collected at the Facility was 8.6 percent. The St. Louis Limestone thins from the southwest to northeast across the Facility, with an average thickness of approximately 21 feet (GHD, March 2020). This formation grades into and conformably overlies the Salem Limestone.

Salem Limestone

The Salem Limestone comprises the youngest unit of the Sanders Group. The most widely known rock type of the Salem Limestone is cross-bedded calcarenite that is medium to coarse grained, porous, and fairly well sorted which occurs in exceptionally thick beds. The individual grains consist of microfossils and fossil fragments cemented with calcite. Other rock types comprising the formation include biocalcirudites, very fine grained argillaceous dolostone, and dense argillaceous limestone (Pinsak, 1957). The average thickness of the Salem Limestone beneath the Facility, where overlain by the St. Louis Limestone, is approximately 61 feet. In the northeast portion of the Facility, where the St. Louis Limestone has been eroded away, the Salem Limestone thins due to weathering. The base of the Salem Limestone grades into and conformably overlies the Harrodsburg Limestone. The average matrix porosity of samples tested from rock cores collected at the Facility was 9 percent.

Harrodsburg Limestone

The Harrodsburg Limestone has been divided in the literature into an upper and a lower unit. The upper unit at the Facility consists of bioclastic calcarenite and calcirudite with beds of variable thickness. Occasional shale laminae and small vugs were also present (GHD, March 2020). The average matrix porosity of samples tested from rock cores of the upper unit collected at the Facility was 5.4 percent. The thickness of the upper unit beneath the Facility averaged 51 feet. The lower Harrodsburg Limestone consists predominantly of fine-grained limestone with beds of variable thickness and contains interbedded shale laminae and thicker shale beds. Small vugs occur throughout the lower unit, with small siliceous geodes present near its base. The average thickness of the lower unit is approximately 26 feet. The matrix porosity of the lower unit was not measured.

Ramp Creek Formation

The Ramp Creek Formation beneath the Facility consists of very fine- to medium-grained, evenly bedded, dolomitic limestone with occasional shale seams. Vugs and geodes are numerous throughout the formation. The average thickness of the formation beneath the Facility is approximately 20 feet. The matrix porosity of the unit averaged 26 percent.

Edwardsville Formation

Only a few feet of the Edwardsville Formation were penetrated by borings at the Facility and consisted of relatively soft calcareous shale. The top of this formation was observed to contain a thin layer of glauconitic shale with small crystals of pyrite, which is consistent with information provided by Nicoll and Rexroad (1975). In addition to shale, Stockdale (1931) reports that the Edwardsville Formation also contains beds of siltstone and fine-grained sandstone, and that the formation thickness ranges from 40 to 200 feet in Indiana.

Bedrock Structure

Regionally, all the bedrock formations dip gradually toward the southwest at about 30 to 250 feet per mile (Powell, 1976). Mapping performed as part of the RFI indicates that the dip of the strata locally is on the order of 40 to 100 feet per mile. Local dip angle and direction can vary significantly from the regional trend (Perry and Smith, 1958) due to local folding of strata. The type, orientation, and frequency of fractures are important factors governing karst development and the movement of groundwater through the bedrock. Fractures represent a form of secondary porosity of the rock. Fractures present in the bedrock are divided into two types: bedding-plane fractures and joints. As their name implies, bedding-plane fractures occur along bedding planes. Because the bedding plane fractures are nearly horizontal, they are the type of fractures most-commonly intercepted by vertical borings. While bedding-plane fractures were identified in all the bedrock formations penetrated, their frequency tended to decrease with depth. Also, because bedding planes are less common in the Salem Limestone, bedding-plane fractures in this formation were also less common than in the other limestone formations. For the purposes of this CSM, joints are defined as rock fractures that are not aligned along bedding. Powell (1976) conducted an extensive study of jointing of Mississippian rocks in southwest Indiana and their implications in terms of karst formation and groundwater movement. He determined that the jointing was common in rocks in the region, including the Blue River and Sanders Groups. The joint system in the area consists of two sets of near-vertical joints, denoted "master" and "cross". The joints in the master-joint set normally transect more than one bed of rock vertically, are longer than cross joints, and have a preferred orientation that, in the region, is roughly east-west. Cross-joints commonly terminate at master joints, to which they are nearly normal (intercept at right angles) and generally transect only one bed. Powell (1976) notes that the spacing of master joints in the Salem Limestone ranges from 10 to 50 feet.

2.1.3 Karst

Karst refers to geologic terrain that is comprised of and underlain by soluble bedrock. Such terrains often have diagnostic landforms like sinkholes and hydrologic features such as sinking streams and springs. A karst aquifer is comprised of bedrock whose permeability has been enhanced by dissolution processes. A karst aquifer can be present even if there are no karst landforms nearby. Regionally, karst has been shown to form in all four of the limestone formations that underlie the Facility (the St. Louis, Salem, Harrodsburg, and Ramp Creek). Although it is calcite-rich, thick-bedded, and possesses the requisite secondary porosity, the Salem Limestone appears less susceptible to karstification than does the St. Louis Limestone (Thornbury 1969). Karst aquifers represent triple-porosity systems comprised of primary (matrix), secondary (fracture), and tertiary (solution or "conduit") porosity. The uppermost several feet of the bedrock, termed the epikarst, are highly weathered and contain cavities and solution widened fractures. Due to dissolution, the epikarst is more porous than the underlying bedrock, which contains fewer solution features and becomes increasingly more competent (less porous) with depth. Worthington, et al. (2000) examined the storage and movement of groundwater in four well-studied karst aquifers. They found that, in all cases, more than 90 percent of the groundwater in the aquifers was stored in the matrix porosity and more than 90 percent of the flow through the aquifers occurred in the conduit porosity, with fractures playing an intermediate role. Hydraulic-head and groundwater-quality data from wells screened across conduit porosity, therefore, are most important in assessing the movement of contaminants dissolved in, or adsorbed to particulates moving with, groundwater in the bedrock. Solution-widened pathways in karst aquifers enlarge and become integrated over time forming networks of conduits that typically have apertures in the millimeter to centimeter range (Worthington and Ford 2009). These networks converge in the downgradient direction, focusing groundwater flow, and discharging at springs.

2.2 Groundwater Recharge and Movement

The bedrock aquifer is recharged by infiltration of precipitation. Two types of infiltration occur at the Site – diffuse and concentrated. Diffuse recharge consists of relatively slow, uniform seepage of precipitation through the residuum. Concentrated recharge occurs rapidly in discrete areas, such as at sinkholes and areas where the bedrock is at or near the land surface. Concentrated recharge is subject to little or no filtration before entering the bedrock flow system. Evidence that a component of site recharge is concentrated is provided by historical water-level data. This data shows that the water levels in some monitoring wells respond rapidly to storm events whereas in other wells they do not. The rapid response indicates concentrated recharge that is delivered rapidly to solution-widened fractures. In general, wells that respond rapidly are better connected hydraulically to the active flow system, while wells with muted responses (or no response) are poorly connected.

The cover system at the Site affects recharge in the vicinity by essentially eliminating recharge within its footprint. Evidence of this is also provided by historical water-level data. Examination of these data show that rapid responses to precipitation events occur at greater magnitude from wells outside the cover system. Conversely, wells screened beneath the cover system tend to show relatively muted responses to storm events. Figure 4.17 of the Pilot Trench Performance Monitoring Plan (GHD, April 2019), included as Appendix A.2, shows a graph of the transducer data that have been collected at the Facility, where these conditions can be observed.

Groundwater moves, on a macro scale, from areas of relatively higher to lowest pore pressure. On this macro scale water flows principally within regions of the karstic rock where the voids are larger and more densely inter-connected, thus allowing easy communication (i.e., low pressure gradient) between them. On a micro scale, groundwater in the matrix porosity, or in closed or poorly interconnected fractures, drains more slowly toward nearby inter-connected fractures and/or conduits and requires much higher pore pressure gradients to achieve such movement. In practice, groundwater within these interconnected fractures and conduits drains relatively rapidly through the bedrock and discharges to the ground surface or to surface water bodies at seeps and springs.

In the East Plant Area groundwater flow is also influenced by two bedrock valleys, one to the northern and the other towards the southern end where Bailey's Branch begins. These generally east-west bedrock valleys are preferentially more karstic and thus act to consolidate the shallow bedrock groundwater flow in the East Plant Area, directing it from areas immediately north and south of the valleys and then and eastward along the axis of the individual bedrock valleys. The Pilot Trench exploits the intrinsic control of groundwater flow by the bedrock topography, which includes the northeasterly trending bedrock valley that consolidates the shallow bedrock groundwater flow, as well as surface water flow, along the topographic and bedrock valley axes. The Pilot Trench transects and is oriented roughly perpendicular to this bedrock valley.

Thus, the Pilot Trench may have a practical horizontal collection zone that exceeds the mere length of the trench by producing an inward flow path upgradient of the trench location. However, the imperfect knowledge of the bedrock permeability structure in such karst aquifers renders validation of these local groundwater flow directions using only potentiometric maps less certain than in non-karst settings. Nevertheless, supported by other available data (e.g., previous dye tracer testing results, observed geology) and professional experience with karst aquifers, it is reasonable to infer that, prior to trench installation, shallow groundwater in the northern portion of the East Plant Area indeed discharged to springs along Tributary 3 and/or Bailey's Branch, but is now be expected to be captured by the Pilot Trench. To better characterize groundwater movement in karst aquifers, dye tracer studies are often used to supplement hydraulic data collected from monitoring wells and therefore provide better overall confidence in the characterization of groundwater flow.

This conception of groundwater flow at the Facility described above was and is being verified. In the East Plant Area, as described in the RFI Report (Section 4.4.2, GHD, March 2020), these interconnected conduits are preferentially located in the upper portion of the karstic rock. This vertical fracture/void density gradient tends to result in a strong shallow horizontal groundwater flow component in the East Plant Area. In the northern portion of the East Plant Area, where the Pilot Trench is located, potentiometric mapping of groundwater in the shallow bedrock via monitoring wells, along with previous dye tracer testing results, suggests that prior to trench installation groundwater flowed to the east, with little vertical flow, and discharged to springs located along the historical and current Tributary 3. The Pilot Trench is part of a perimeter groundwater collection trench system to be installed through the karst bedrock and designed to collect the shallow, PCB-impacted groundwater beneath the East Plant Area, thereby intercepting potential shallow groundwater migration from the Facility. The inherent capture and removal of groundwater by the constructed Pilot Trench, located along a portion of the hydraulically downgradient Facility boundary associated with a bedrock valley drainage feature, is intended to accentuate the existing hydraulic gradients to define the hydraulic capture performance of the completed installation.

Comparison of groundwater elevation data from wells screened shallow (i.e., in the St. Louis or upper Salem Limestones) with those screened deeper (i.e., in the Harrodsburg Limestone or Ramp Creek Formation) demonstrates that a strong downward gradient exists. If all the limestone formations above the Edwardsville Formation represented one well-integrated karst aquifer, such a large vertical gradient would not exist. This observation is evidence that an interval of more competent rock exists at depth beneath the East Plant Area that retards downward movement of groundwater. A complete description of the lines of evidence approach is found in Section 4.11 of the Pilot Trench Performance Monitoring Plan.

2.3 Contaminant Transport

Prior to the RCRA Corrective Action (CA) activities, the East Plant Area was used for the disposal of wastes, including PCB impacted soil and debris. In the northern portion of this area extensive soil sampling was conducted to assess the nature of this fill material and elsewhere in the East Plant Area. The East Plant Area Interim Measure resulted in the removal and on-site containment of PCB material ≥50 mg/kg in the landfill vault, and the placement of additional < 50 mg/kg floodplain soil and sediment as grading material prior to installation of a multi-component cover system. To date, PCBs have only been detected in one sample of groundwater collected in the Pilot Trench as a qualified result, indicating that PCBs have not been migrating appreciably in the groundwater collected by the trench. Table 2.1 presents the data from the Pilot Trench collection system. Furthermore, fill soil in the East Plant Area of the Facility have lower levels of PCBs, typically much less than 50 mg/kg. Observations at other sites indicate that such levels typically do not lead to appreciable levels of dissolved PCBs in groundwater because PCBs have very low water solubility and a high affinity to adhere to soil particles. While groundwater in certain areas upgradient of the Pilot Trench, including that issuing from select former seeps and springs, has been shown to contain PCBs (GHD, 2020) in either the total or dissolved fraction, careful consideration of these detections is prudent. The interpretation of PCB detections in groundwater samples as a primary line of evidence of ongoing PCB mobility is insufficient because of these previously stated properties (i.e., low solubility and high affinity for adherence). Positive detections of PCBs in groundwater could be remnant artifacts of historical migration that had adsorbed onto soil particles but now is inadvertently introduced into the groundwater sample collection process or such particles may become intermittently mobile in the conduit network of karstic terrain.

Site Source Control (SSC) systems installed in the northern portion of the East Plant Area prior to the Pilot Trench installation collect and separately route this groundwater for treatment. Similarly, the SSC system installed in the southern portion of the East Plant Area (below Outfall 002) collects and routes impacted groundwater in this area for treatment. As noted in the previous section, springs represent discharge points for conduit networks. These springs result from natural conduit networks that are convergent and drain nearly all the local groundwater moving through the bedrock. Groundwater in the primary porosity and non-weathered fractures moves slowly toward, and discharges into, the conduit networks. The presence of springs upgradient of the Pilot Trench and below Outfall 002 indicates that local conduit networks exist in these areas and are collecting and transporting impacted groundwater to the SSC systems.

If a deeper conduit network in the bedrock exists, and impacted groundwater has reached such a network, the impacted groundwater would migrate through the network and would be expected to discharge to one-or-more springs located along Tributary 3 downstream of the pilot trench or along Bailey's Branch.

PCB concentrations in groundwater migrating through fractures toward conduit networks will be significantly attenuated by matrix diffusion, as noted by Dr. Kueper in Appendix J.2 of the RFI Report (GHD, March 2020). Additionally, due to the converging nature of karst conduit networks, contaminant concentrations in groundwater flowing through such networks are commonly reduced with distance downgradient, as tributary conduits containing clean groundwater join the flow system. Seepage of clean groundwater into the network from the rock matrix and unweathered fractures would also play a role in reducing concentrations (i.e., through dilution).

Based on the above discussion, and the length of time since the release of the contaminants, it is likely that the maximum extent of groundwater impacts due to sources in the East Plant Area has been attained, that is, the distribution and migration of contaminants in this area is at quasi-steady state. Under this condition, contaminant concentrations will gradually decline over time. Short term fluctuations in contaminant concentrations detected in samples collected from monitoring wells and springs can be expected. Storm events of a certain magnitude may create ephemeral, turbulent-flow conditions. Such "threshold" storms may temporarily mobilize stored contaminants, potentially including contaminants adsorbed to aquifer sediments. If this transport mechanism occurs at the site, it has arguably been occurring periodically since the contaminants were released decades ago and can be characterized by implementing an appropriate storm-event based sampling program. This condition would be more accentuated for locations outside of the cover system and may not be applicable to those locations under the cover system. Storm-based sampling was conducted during the seeps and springs monitoring program, as described in the Site Source Control Work Plan (CRA, November 6, 2003). The purpose of the sampling was to determine if there was evidence of significant, episodic PCB transport from groundwater flow during precipitation events relative to transport during dry weather. This work consisted of sampling each seep and spring location identified along Bailey’s Branch and tributaries thereto for a total of 8 times (4 samples under high flow conditions and 4 samples under low flow conditions), in the first year. At each location one low flow and one high flow sample was collected each quarter (approximately) in the first year. Low flow conditions were defined as a minimum of 7 calendar days without precipitation prior to the sampling event. High flow conditions were defined as a minimum of 2 inches of rain in a 24-hour period. The result of this sampling showed no meaningful difference in PCB concentrations between the high and low-flow sampling events.

The conceptual model for karst groundwater flow described herein has several implications regarding contaminant characterization and transport:

- With distance downgradient of a source area, impacted groundwater will be increasingly confined to the conduit network. This means that a conventional "plume" of impacted water will not develop; rather, the limits of impacted water will represent the architecture of the conduit network transmitting it.
- Because the architecture of conduit networks cannot be characterized in detail solely with the use of monitoring wells, and individual monitoring wells often do not intercept the networks, more uncertainty exists regarding the details of groundwater flow and quality in the bedrock than in non-karst settings. This uncertainty can be reduced with the use of multiple investigative tools and the application of multiple lines of evidence.
- Some storm events likely result in a temporary reversal of the hydraulic gradient in the conduit network. Ewers, et al. (2012) note that in situations where such reversal of flow occurs, and contaminated groundwater is present in a major conduit, impacted groundwater can invade surrounding solution and fracture porosity during storm events. The invading water returns to the conduit when the flood is past; however, contaminants can remain outside the conduit due to various mechanisms. This would result in a "halo" of impacted groundwater and/or sediments in the solution porosity and fractures surrounding the conduit that is transmitting impacted groundwater (or had done so at some time, or many times in the past). Similarly, modeling performed by Smart (1999) implies that during flow-reversal storm events, clastic sediment will be transferred from primary conduits into the aquifer and will remain there rather than being transported back to the conduits when flow reverses after the storm peak passes. If such sediments are contaminated, those transported out of the primary conduits and into surrounding solution and fracture porosity may remain there indefinitely. If a monitoring well happens to tap into a fracture containing such sediments, they may be mobilized during sampling, resulting in a sampling artifact (that is, the detected contaminants were not moving with the groundwater but rather were mobilized by the sampling process).
- Given the extreme heterogeneity of karst aquifers, water-quality data collected from monitoring wells must be interpreted with care and sound judgement. Data from some groundwater samples may represent sample collection artifacts, the quality of groundwater that is stored in (or moving very slowly through) the aquifer or the quality of groundwater moving relatively rapidly through the aquifer. Data collected from still other wells will represent some unique combination of storage and transport components. Chemical concentrations in samples collected from some wells be affected by antecedent and current weather conditions, whereas samples from other wells will be largely unaffected by such conditions.
- Samples from springs represent the average quality of the water drained by the conduit network feeding them. Such data are useful for assessing potential exposure risks posed by the spring water as well as for detecting potential changes in aquifer conditions and contaminant-transport conditions over time.

2.4 NAPL Presence and Movement

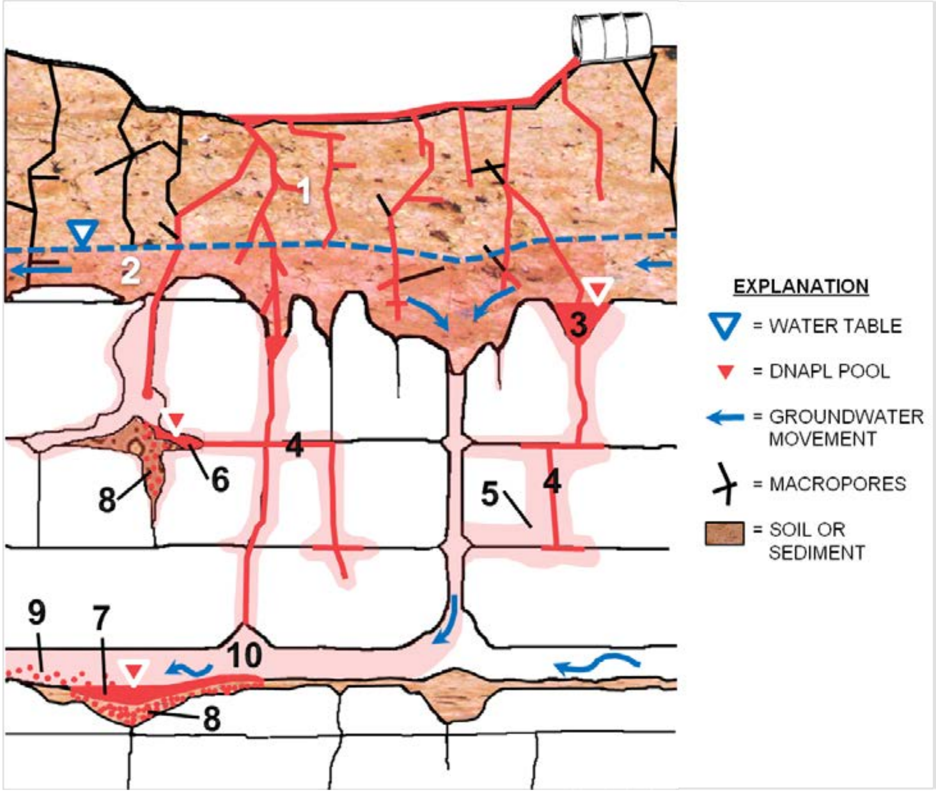
NAPL released at the Facility consisted of Pydraul hydraulic fluid, a dense nonaqueous phase liquid (DNAPL). The extent of DNAPL and the nature of its movement at the Facility is discussed in detail in RFI Report (GHD, March 24, 2020). In summary, the primary source area for DNAPL at AOI 8 is associated with Former South Lagoons #1 through #5. As described in Appendix J of the RFI Report:

> *Upon release to the subsurface, DNAPL will come to rest as both disconnected blobs and ganglia of organic liquid referred to as residual DNAPL, and in continuous distributions referred to as pooled DNAPL. Residual and pooled DNAPL can form both above and below the water table, and in both porous and fractured media. In fractured rock, the residual and pooled DNAPL is restricted to open fractures and solution enhanced features. Residual and pooled DNAPL is not expected to enter the rock matrix because of its high entry pressure*.

Residual DNAPL represents an immobile form of DNAPL in both the overburden and bedrock.

DNAPL pools will form above capillary barriers, such as silt and clay horizons in the overburden, or intervals of competent bedrock. In the limestone beneath the Facility, pooled DNAPL will form primarily in fractures and solution-enhanced features that have a horizontal to sub-horizontal orientation. Further information regarding the physics of DNAPL migration in both porous and fractured media is provided by Pankow and Cherry (1996), Poulsen and Kueper (1992), Kueper et al. (1993), Kueper and McWhorter (1991), Longino and Kueper (1999), and Reynolds and Kueper (2002).

Once released in karst terrane, there are a variety of means by which DNAPLs can be distributed and stored in karst aquifers, as depicted in Inset 2.



Inset 2. Karst model for DNAPL movement and storage (see text for explanation). Prepared by Arcadis and modified from Wolfe et al. (1997).

If released in sufficient quantity, DNAPL would migrate downward through macropores and higher-permeability lenses (e.g., residual chert gravel) in the residuum (identified by the number 1 on Inset 2). Over time, DNAPL could diffuse into the residuum matrix and dissolve into groundwater (2). Upon reaching the bedrock, the DNAPL would have experienced little resistance to movement through the epikarst (3). Because the shallow bedrock (including the epikarst) contains solution-enhanced features, it has a high storage capacity for DNAPL. In some areas, DNAPL may have distributed itself in the diffuse-flow zone of the aquifer – an interconnected network of relatively tight, low-transmissivity fractures (4) or in "dead-end" fractures that are isolated from flow. This DNAPL could be either pooled or residual and will diffuse into the rock matrix over time (5). DNAPL in the solution porosity of the aquifer may also become pooled in a cavity (6) or in low points of the conduit network (7). Conduits and cavities commonly have deposits of sediment in them. In such cases, the DNAPL could migrate into the sediments (8). During storm events, it is possible that groundwater flow in portions of the conduit network could become turbulent and entrain DNAPL droplets into the moving groundwater (9). Additionally, storm events could potentially move impacted sediments further down the conduit network. Most of the impacted groundwater would be drained by the conduit network (10). Downgradient of the DNAPL zone, concentrations of dissolved PCBs will be significantly attenuated by diffusion into the matrix (GHD, March 24, 2020) and through dilution as tributary conduits carrying clean groundwater are integrated into the network. Note that mechanisms 8 and 9 do not appear to be significant at the Facility. Given the high groundwater velocities associated with these mechanisms (on the order of hundreds-or-more feet per day), NAPL globules or impacted sediments would be expected to discharge from springs relatively rapidly following storm events. Since remediation of Bailey's Branch was completed, no sheens or other evidence of DNAPL or impacted-sediment discharge has been observed. Further information regarding DNAPL storage and movement in karst aquifers is provided by Wolfe et al. (1997), Loop and White (2001) and Ewers et al. (2005).

To date, DNAPL has accumulated in one overburden well (TW-3) and five bedrock wells (MW-X209Y053, MW-X227Y049, CH-5, CH-1B, and CH-2A) located within and immediately south of the Former South Lagoons. Evidence of NAPL (sheen on water return) was also observed during drilling at bedrock well MW-X227Y054, which is in the same general area as these wells, but no NAPL has ever accumulated in the well. At this well, the feature containing the NAPL was a 0.6" wide solution feature. At the remaining bedrock wells, observations made during drilling and packer testing indicated that the features most-likely producing the DNAPL were fractures. DNAPL accumulating in wells is periodically removed using several different methods and properly disposed.

2.5 Summary

The Pilot Trench is constructed across the northernmost of two bedrock valleys in the East Plant Area. Both valleys are tributaries to Baily's Branch, which drains northward near the Facility. The geology of the area surrounding the Pilot Trench consists of a relatively thin layer of unconsolidated material overlying bedrock. The unconsolidated material consists chiefly of residuum, the clay-rich, insoluble remnants of limestone bedrock that has been weathered in place, fill material or consolidated creek floodplain soil and sediment from the prior removal action. Bedrock beneath the area consists of four limestone formations deposited atop the Borden Group, a thick sequence of insoluble rocks – predominantly shales, siltstones, and fine-grained sandstones. In the region, all four limestone formations have been known to develop karst. In this process, certain pathways in the rock are enlarged by dissolution. These pathways converge downgradient, forming an enhanced drainage network in the rock, and discharge at springs. As the bedrock dissolves, crevices are enlarged and cavities are formed. While mitigated as a result of the installation of a cover system, unconsolidated material can move into these openings in the rock and can be intermittently transported through the conduit network. These networks occupy only a small percentage of the rock volume – most of the bedrock is sparsely fractured, particularly at depth, and poorly transmissive. However, because they are such efficient drains, 90 percent or more of the groundwater moving through the rock does so through the conduit network. Hydraulic head data collected from monitoring wells at the Facility exhibit a strong downward gradient across most of the East Plant Area. These data are evidence that all four limestone formations do not form a single, hydraulically well-connected aquifer.

Characterizing the movement of groundwater and contaminants in karst aquifers is made challenging by their extreme heterogeneity and anisotropy (i.e., unpredictability). Characterization approaches that work definitively in most other settings do not work as well in karst aquifers. Data collected from monitoring wells, while a necessary part of a characterization effort, must usually be supplemented with other data, including those collected from tracer studies. Multiple dye trace studies have been conducted in the East Plant Area to assess groundwater movement in the karst and several more planned as part of the Pilot Trench Performance Monitoring Plan.

Interpreting groundwater quality from individual monitoring well samples and events is also challenging in a karstic environment. Groundwater samples collected from those monitoring wells that are poorly connected to the conduit network draining the bedrock represent the quality of groundwater that is essentially stored in the aquifer or moving very slowly toward the network. Groundwater samples collected from monitoring wells that are well connected to the network represent the quality of groundwater moving through the Facility. With distance downgradient, most of the impacted groundwater is isolated in the conduit network; therefore, a conventional "plume" of impacted water does not develop.

A mode of contaminant transport that is important in some karst aquifers is the episodic movement of sediments through the rock in response to storm events. Storm events may also cause a reversal of flow – from the conduits into narrower fractures and other openings in the rock. This process can form a "halo" of contaminants outside the conduits. Because most conduits cannot be remotely sensed and mapped, they cannot be targeted for installation of monitoring wells. This reality means that the extent of contamination in karst aquifers cannot be characterized as precisely as in non-karst aquifers without employing a suite of investigative and risk management strategies.

PCB concentrations in groundwater migrating through fractures will be significantly attenuated by matrix diffusion, and the converging nature of karst conduit networks serves to reduce dissolved PCB concentrations with distance downgradient, as tributary conduits containing clean groundwater join the flow system. Samples from springs represent the average quality of the water drained by the conduit network feeding them. Such data are useful for assessing potential exposure risks posed by the spring water as well as for detecting potential changes in contaminant-transport conditions over time. Given the nature of the karst aquifer at the Facility and the length of time since the release of the contaminants, the maximum extent of groundwater impacts due to sources in the northern portion of the East Plant Area is interpreted to have been attained. Under this condition, groundwater contaminant concentrations will gradually decline over time. Figure 2.2 (Pilot Trench Performance Monitoring Plan, GHD, August 2019) presents the Conceptual Site Model for the construction of the Pilot Trench. This block diagram conceptually illustrates some of the groundwater movement and potential contaminant migration mechanisms presented above.

3. Overview of RFI Addendum Activities

Two specific studies/investigations were completed subsequent to the submittal of the RFI Report in order to evaluate non-AOI areas of uncovered Facility property and an AOI that was accessible during construction being completed by the Plant:

- Surface soil sampling was generally completed in areas not identified as areas of waste storage, use, or disposal using Incremental Sampling Methodology (ISM) in order to evaluate surface soil conditions where Facility personnel might be more likely to conduct routine maintenance activities, such as mowing and general trafficking
- Investigations were implemented after the Facility had completed upgrades to the Industrial Water Treatment Plant (IWTP) that allowed some access into the western portion of AOI 8 (west of GM Drive

The following briefly describes these two field investigation programs completed subsequent to the investigation and data presented in the RFI Report. A summary of the completed Interim Measures post RFI Report (Pilot Groundwater Collection Trench) is also provided below.

3.1 Incremental Sampling Methodology Study

Surface soil sampling was conducted throughout areas of the GM Bedford Facility that were determined to not be in an Area of Interest (AOI) (Current Conditions Report, CRA, 2001) and therefore had received limited to no sampling completed under the RFI. This sampling, described herein, was completed to identify whether these remaining Facility areas may require specific work restrictions or health and safety protocols for maintenance or construction workers in the event of future work activities or that may need additional corrective measures. The proposed soil sampling was conducted utilizing Incremental Sampling Methodology (ISM), as first described in the Unsampled Areas Soil Sampling Work Plan (CRA, Mar 2016) provided in Appendix B.1. A brief summary of the methodology is presented below.

3.1.1 Methodology

ISM is a specialized type of composite sampling with specific structure and requirements that stand apart from common compositing practices. ISM is designed to provide more precise and less biased estimates of the mean concentration of analytes in soil by addressing specific sampling inadequacies. Consequently, ISM can result in better performance in terms of decision error reduction than other sampling methodologies. A defined Decision Unit (DU) is first subdivided or gridded-off into cells or subareas based on the desired number of increments (an increment is the sample spacing) to be obtained. That is, the number of cells is equivalent to the number of increments within a DU. An increment represents a fixed position from which a portion of the sample is collected. The number of increments is determined based on expected variability of the chemical of concern and media. Because of the widely varying shapes and sizes of these areas, the number of increments will vary somewhat, depending on size and shape of the DU. Using a systematic-random design, a random position is established for a given cell, and then the same position is repeated in all of the remaining cells in the DU. The DU soil sampling locations are presented on Figure 2 to 12 in Appendix B.1.

Placement of markers (e.g., pin flags and posts) at the corners and/or edges of each DU were surveyed to assist with a visual delineation of the subareas (or cells) where increments were proposed to be collected. Individual cells were then measured and marked prior to sampling.

3.1.2 ISM Sampling Plan

Three replicate samples were proposed to be collected per DU. The Unsampled Areas Soil Sampling Work Plan (Appendix B.1) called for samples at approximately the upper 4 inches of surface soil to be collected at each increment location within a single DU. Each increment was to be treated as a separate sample that was collected and placed into a sample container (that is, all increments would be combined into one ISM sample for the initial sampling, one for the duplicate, and one for the triplicate for a total of three replicate samples per DU). Each of the three replicate samples were to be composited from soil collected at each increment by the laboratory, prior to analysis of PCBs. However, field compositing was completed in order to reduce the quantity of soil actually shipped to the laboratory.

In all, 25 DUs were identified across the Facility where sampling was either limited or not previously conducted, and the area has no cover system anticipated.

3.2 AOI 8 West (Clarifier Area) Investigation

The Facility has been used for industrial purposes since the 1890's. Historically the Clarifier Area had contained three cascading settling ponds associated with the original industrial wastewater treatment system that were removed in the 1970's when the system was upgraded. The industrial wastewater treatment system, which has been renovated and enhanced from time to time since installation, included treatment tanks, clarifier tanks, granular activated carbon tanks, an aeration basin and various other associated treatment components. Subsequently, nine clarifier tanks were constructed and were recently replaced with a new T-900 tank as part of a significant renovation of the system. This area is still currently an active portion of the industrial wastewater treatment plant.

This portion of AOI 8 and DU WP10 (Section 3.1) is surrounded by industrial property owned and operated by GM LLC. To the east is the road, beyond which are the remaining portion of AOI 8 and the East Plant Area. To the north and west are operational portions of the Bedford Facility. To the south is a narrow portion of the Bedford Facility that is not currently used for manufacturing.

In the 2001 CCR, AOI 8 was determined to be an area where sampling was not necessary or practical due to the active nature of the operations. However, as part of the RFI sampling, limited surface samples were collected in the western portion of AOI 8 to characterize potential releases to the environment. To supplement the RFI dataset an ISM soil sample plan was completed in July 2016 (Section 3.1) to characterize a portion of the clarifier area (DU WP10), as well as other unrelated areas. The ISM data were focused on identifying whether worker safety measures or additional corrective measures were necessary in areas not targeted for sampling as part of the RFI. After discussion with the U.S. EPA, additional discrete sample collection was performed in this area in 2017 to further address potential worker exposure in the surface, sub-surface soil and groundwater.

On April 25, 2017, GM submitted a work plan to investigate the western portion of AOI 8 (west of GM Drive). The contents of this work plan are presented in Appendix C.1. The purpose of the borings was to delineate PCB concentrations in soil in support of the Phase 2 IWTP demolition and modification work, as well as in support of the ISM work. Borings in the IWTP area were proposed to be advanced to a total depth of 4 feet bgs. An additional boring was to be advanced to the top of bedrock east of GM Drive. GM modified this work while in the field to take advantage of inactivity in this area, previously not accessible. In all, this work resulted in two phases of mobilization, presented to U.S EPA in a summary memorandum on January 9, 2019 (Appendix C.2).

The results of the initial borings completed in June 2017, in the IWTP (Clarifier Area) showed soil results in excess of the Industrial/Commercial site screening levels of 9.9 mg/Kg (IDEM, Mar 2019), in addition to the potential presence of NAPL within the unconsolidated material.

A second phase of investigation during August 2017 was conducted in order to determine the lateral extent of PCBs in soil and for the installation of temporary monitoring wells to assess the presence of NAPL. Thirteen soil borings and 6 temporary monitoring wells were completed during Phase 2. Analytical results indicated exceedances of the site screening levels within the soil and within collected groundwater samples. One temporary monitoring well showed the presence of NAPL, just above bedrock.

Based on the above results, GM proposed to advance permanent monitoring wells to determine the extent of NAPL. The summary memorandum describing the installation of monitoring wells, submitted to U.S EPA on Feb 21, 2020, is included as Appendix C.4. After failed attempts to advance up to 6 permanent monitoring wells, due to underground utilities and structures, which resulted in only 2 wells being installed. As part of the proposed permanent well installation, the work plan (Appendix C.2) called for NAPL evaluation and recovery testing (currently undergoing).

3.3 Pilot Groundwater Collection Trench IM

One major component of the selected CA activities to be implemented for the Facility includes the construction of Groundwater Collection Trench System along the downgradient perimeter of the East Plant Area. To help evaluate the effectiveness of this CA activity and help with the design of the collection system as a whole, GM designed, installed, and operates a portion of this bedrock trench referred to as the 'Pilot Trench' prior to undertaking the design and construction of the remainder of the Groundwater Trench Collection System. A plan for a Pilot Trench, dated November 25, 2008, was previously submitted to U.S. EPA. The final plan (CRA, Feb 2016), included in Appendix A.1, presents a revised alignment for the Pilot Trench. The Pilot Trench is located on the east side of the East Plant Area near Bailey Scales Road and is approximately 800 feet (ft) long spanning the bedrock valley in the northeast corner of the East Plant Area. Full descriptions of the Pilot Trench construction can be found in the PMP (Section 3.0), and Construction Certification Report, provided in Appendix A.2 and A.3, respectively.

3.3.1 Investigation and Design

Coreholes were installed as part of RFI Addendum No. 9 and No. 12, using hollow-stem auger (HSA) drilling technique, along the perimeter where the trench could be installed. Additional geotechnical and geophysical data were collected along the proposed future alignment of the perimeter trench from coreholes completed in July through September 2012 (CH-45 to CH-58). The corehole drilling program provided information on the depth to bedrock and the depth to competent bedrock needed to support the design of the Perimeter Groundwater Trench Collection System. New corehole locations were proposed to support the proposed future trench alignment (Figure 3.1, Appendix A.1).

To provide an approximate range of hydraulic conductivity, several assumptions were used for the preliminary design of the trench, based on the corehole data collected. Actual conditions may vary once the Pilot Trench and compete trench has been installed. Hydraulic conductivity values above the competent bedrock were conservatively estimated between 6 x 10-4 centimeters per second (cm/s) and 6 x 10-5 cm/s based on testing completed at the Site. The current hydraulic gradient for the shallow groundwater is approximately 0.25 ft/ft and the area of the saturated thickness is conservatively assumed to be averaged approximately 40 ft over the 800 foot length (for the Pilot Trench). This yields flow estimates for the Pilot Trench between approximately 71 to 7 gallons per minute (gpm) (102,000 to 10,000 gallons per day (gpd)). The downgradient length of the East Plant Area perimeter is approximately 3,700 ft, thereby yielding an approximate flow of 330 gpm to a low estimate of 33 gpm, using the same assumptions for a trench along that complete alignment.

Downhole geophysical logging was conducted several locations along and near the proposed Pilot Trench alignment (Figure 3.1, Appendix A.1). Where the bedrock was more competent (usually at depth), logging was conducted on longer sections of the bedrock. A full suite of logs was also run upon completion of the borehole to total depth. COLOG, a Division of Layne-Christensen Company, of Golden, Colorado provided the equipment and engineer/operator for downhole geophysical logging. East Plant Area hydraulic conductivity testing was performed in selected overburden and bedrock monitoring wells using packers to isolate a test interval. Specific intervals were selected on the basis of inspecting both the drilling core logs and the downhole geophysical test results or adjacent holes.

The trench location and alignment were determined based on bedrock topography, the elevation of competent bedrock, and groundwater flow directions. By design, the trench runs through areas such as grikes, open fractures, solution cavities and vugs. The purpose was to collect groundwater potentially conveyed by these features, providing efficient means to drain upgradient water into the trench. The concept of the trench design was to install it to a depth where competent rock was anticipated at the base of the trench. If an "open" feature was encountered at the base of the trench, it was sealed prior to placement of the pipe and drainage media. Based on the available inspection data, an onsite geologist reviewed the existing records (in including new observations made pre- and post-cutting) to make the determination if the trench has been extended too deep, requiring additional grout to bring the base back into the competent bedrock layer, or if the base of the trench had not yet extended into the competent bedrock layer.

A physical barrier placed on the downgradient side of the Pilot Trench was included in the design consisting of a plastic (vinyl or fiber-reinforced polymer (FRP) sheet piling with hydrophilic or viton seals to create an impermeable barrier.

3.3.2 Final Installation

A specially-equipped bedrock trenching machine, Trencor 1660, was used by H.L. Chapman Pipeline Construction, Inc. (HL Chapman), a rock trenching company subcontracted by SES to perform the bedrock excavation for the Pilot Trench. Bedrock trench excavation commenced on November 2, 2015 at the north end of the Pilot Trench alignment (Station 0+00) and continued to the south. Bedrock trenching was completed on December 12, 2015. Trenching progressed at a rate of approximately 30 linear feet per day.

A physical barrier was constructed on the downside wall of the trench once the cuttings were removed. ShoreGuard Synthetic Sheet Piling (vinyl sheet piling) made by Crane Materials International was installed on the eastern (downgradient) wall of the Pilot Trench to serve as a water resistant membrane to minimize the potential for groundwater entering the trench from the west from migrating beyond the downgradient trench wall.

Grout was placed at the bottom of the trench to seal the trench floor to cement the barrier wall in place. The combination of grout placement on the trench bottom and the vinyl sheet piling barrier wall on the downgradient wall was designed to inhibit groundwater from bypassing the trench, either by flowing vertically out the bottom or horizontally through (across) the trench.

A 6-inch perforated HDPE drain pipe was placed at the bottom of the excavated trench to facilitate groundwater conveyance via gravity drainage to the Wet Well location. The drain pipe was placed at the bottom of the trench once the grout had sufficiently set. The drain pipe was installed in accordance with the manufacturer's recommendations, and without kinks or bends. The grade of the pipe was maintained continuously without mounds or sags in the pipe, as confirmed by survey.

A Wet Well chamber was installed to house four vertical 2-ft diameter HDPE sump pipes. The chamber is located at the low point within the Pilot Trench. Groundwater from the 6-inch diameter HDPE drain pipe installed at the bottom of the trench free-flows to the 4 sumps. The sumps, along with the wet well chamber, pumps and controls are referred to as WW#4. Water collected in WW#4 is transferred via buried force main to the on-Site GWTP for treatment prior to discharge at Outfall 004 under the NPDES permit (NPDES Permit No. IN0064424).

Fifteen vertical 2-inch diameter piezometers were installed at approximate 50-ft intervals along the Pilot Trench. Seven piezometers were installed north of WW#4 and 8 were installed south of WW#4). Eleven piezometers were installed within the trench, along the inside groove of the vinyl sheet piling and rested on the grout base. Four piezometers were installed along the outside of the vinyl sheet piling (east of the sheet piling, downgradient of the trench). The piezometers were secured with a U-clamp drilled into the vinyl sheet piling. Piezometers locations are presented on Figure 3.4 and on Drawing C-03 in Appendix D of the Construction Certification Report, found in Appendix A.3.

The drain pipe was covered using imported 1/4 inch diameter granular material. The gravel backfill extended to the top of bedrock. Geotextile was placed over the top of the granular backfill to keep separation between the granular backfill and the overburden soil. In areas where the trench extends beneath the Cover System, a sand component was added to the geotextile layer. For the portion of the Pilot Trench located within the limits of the Cover System, the area was restored consistent with the previously installed Cover System design.

A Pilot Trench Performance Monitoring Plan has been prepared to evaluate and monitor the groundwater collection hydraulic performance of the Pilot Trench. The plan includes surveying areas of groundwater discharge in areas around the Facility, dye trace studies, chemical and hydraulic monitoring of wells, seeps, springs and surface water.

4. Data Quality Assessment and Validation

This section provides a summary of the QA/QC procedures related to the activities summarized in Section 3. The QA/QC procedures were consistent with those discussed in the RFI Report (GHD, 2020) and were also discussed in the Work Plan associated with each activity (Appendices A.3, B.1, and C.1).

4.1 Sampling Procedures

Samples of soil, groundwater, and NAPL (both light and dense), were obtained as summarized in Section 3 of this RFI Addendum with adherence to the QA/QC procedures detailed in the following subsections.

4.2 Custody Procedures

Sample custody procedures during the RFI field sample collection, sample transfer, and laboratory analysis were adhered to as detailed in the RFI QAPP (CRA, July 2001).

4.3 Sample Analysis

Samples were analyzed in accordance with the laboratory SOPs presented in the RFI QAPP (CRA, July 2001).

4.4 Data Validation

Laboratory analytical data were provided in electronic data deliverable (EDD) format and as hardcopy final reports. Electronic data were checked against hardcopy final reports and updated with the validation qualifiers established during data validation.

Validation was performed by qualified chemists at the direction of CRA's QA Officer in accordance with validation guidelines specified in the RFI QAPP (CRA, July 2001). Data review and validation consisted of two tiers of assessment, incorporating an approach similar to "Innovative Approaches to Data Validation", U.S. EPA Region III, June 1995, as described in the RFI Report (GHD, March 2020).

Major quality control issues were not discovered during the data validation for these data; therefore, the data are considered complete and usable for decision making purposes. Example data validation summary memos are presented in Appendix R, and validated result data summaries for these data are found Appendix H of the RFI Report (GHD, March 2020).

4.5 Data Quality

The data quality achieved during the RFI was assessed in terms of precision, accuracy, representativeness, completeness, and comparability as defined in the RFI QAPP (CRA, July 2001). The QC sample collection frequencies were consistent with the RFI QAPP minimum frequencies. Equipment rinsate blanks were collected at a frequency above the required one per 20 investigative samples, or at least one daily for each type of equipment where non-dedicated or disposable sampling equipment was used. Trip blank samples were only required for aqueous matrices and were submitted at a frequency of one trip blank per cooler of samples for VOC analysis.

Overall objectives for precision, accuracy, representativeness, and completeness were achieved with less than 6 percent of the data qualified during data validation due to violation of the laboratory and/or NFG QC limits. The completeness objective of 90 percent was achieved with less than one percent of the data rejected due to QC violations. The analytical methods identified in the RFI QAPP (CRA, July 2001) as presented above were adhered to and the laboratory internal QC procedures were followed, insuring that the reported data were representative and comparable.

The RFI data can be used for quantitative purposes including assessment and design of the final corrective measures.

5. Results of Investigation

5.1 Incremental Sampling Methodology Study

Results of the ISM study were discussed previously in the summary memo to U.S EPA (GHD, Feb 2017) presented in Appendix B.2. Further clarification and discussion of the ISM results were provided in a response to comments memo to U.S EPA on June 22, 2018, and can be found in Appendix B.4 of this report.

The results of the analyses were evaluated from each DU using the U.S EPA calculator spreadsheet for the statistical analysis. Using this calculator the coefficient of variance (CV) for the 25 DUs were found to vary from "low" to "high" (GHD, June 2018).

Ten DUs were identified where the CVs were ranked as "low", there was minimal variability between the replicate results and thus greater confidence in the UCL for decision making.

For 11 DUs, the CVs were identified as "med"; therefore, the results from these DUs were identified as moderate between the replicate results. Two of these 11 DUs with moderate CVs were identified as WP10 and EP05, where PCBs were greater than the non-residential soil criterion of 10 mg/kg for PCBs. For the remaining DUs in this category, PCBs were less than 5 mg/kg and no individual replicate result was greater than 4 mg/kg.

For 4 DUs, the CVs were identified as "high", therefore represent a higher variability between the replicate results. However, this high variability is an artifact of the low concentrations in each of the individual replicate results within each DU. Within each DU the replicate results differed between a factor of 2 and 6 with the highest individual replicate results being 1.12 mg/kg of PCB in soil.

Based on these results, a Work Plan, presented in Appendix B.3, was developed for the collection of additional grab samples at DUs WP10 and EP05 (GHD, Jan 2018). The results of this investigation are described below, and in a summary memo (GHD, Jun 2019) found in Appendix B.5.

Soil analytical results from the additional soil investigation in the area of both DU WP10 (southern portion) and DU EP05 indicated PCB concentrations below the IDEM 2019 industrial/commercial screening level for direct contact of 9.4 ppm (IDEM, Mar 2019).

PCB concentrations from grab samples collected DU EP05 ranged from 0.497 mg/kg to 7 mg/kg in the discrete soil samples, whereas the PCB concentrations in the July 2016 ISM composite samples were 14, 5.6 (duplicate), and 14 mg/kg (triplicate). PCB concentrations from grab samples collected in the southern portion of DU WP10 ranged from 0.448 mg/kg to 3.1 mg/kg in the discrete soil samples, whereas the PCB concentrations from grab samples collected in the July 2016 ISM composite samples were 14.5, 5.67 (duplicate), and 6.89 mg/kg (triplicate).

The discrete soil sample results collected within EP05 and in the southern portion of WP10 did not confirm the PCB concentrations detected in the July 2016 ISM composite soil samples.

The memorandum (Appendix B.5) also evaluated the human health risks from potential exposure to these soil concentrations, which are summarized in Section 6.

5.2 AOI 8 West (Clarifier Area) Investigation

Currently in the clarifier area, there are three buildings and two active tanks associated with the wastewater treatment system. Portions of this area have different engineering controls/covers in place to support Facility operations, which also mitigate the potential for exposure or migration of any constituents in soil.

Detected concentrations of PCBs in soil exceed the screening criteria in certain locations in this area. These locations are also shown on Figure 1. Specifically, the following locations had detected concentrations of PCBs in the surface soil (0-2 ft bgs) that exceeded the screening criteria: AK-1, AK-2, AK-3, AK-5, AK-6, AK-8, AK-10, AK-11, AK-12, AK-13, AK-14, AK, AK-20, AK-21, AK-22, AK-23, AK-24, TW-3, and, TW-6. In addition, the following locations had detected concentrations of PCBs in the subsurface soil (>2 ft bgs) that exceeded the screening criteria: AK-1, AK-2, AK-3, AK-4, AK-5, AK-6, AK-7, AK-9, AK-11, AK-12, AK-14, AK-15, AK-16, AK-19, AK-20, AK-21, AK-22, AK-23, AK-24 and, TW-3. The potential for significant exposure via direct contact with PCBs in soil in this area are further evaluated below considering the existing controls and the potential for significant exposure risk. In groundwater, unfiltered PCB concentrations exceeded the drinking water MCLs in all the groundwater sample collected in this area. However, the monitoring wells in this area are typically of small diameter and installed in fill materials, thus are prone to excessive turbidity. In contrast, drinking water wells typically have fewer/no particulates because they are installed in native materials and are larger diameter, making it possible to more thoroughly developed to eliminate sedimentation and/or fouling of water supply lines. In addition, the MCLs are used in this evaluation as a conservative screening tool, when potential exposures to groundwater in this area would be limited to dermal contact exposures, where aqueous-phase ("filtered" or "dissolved") concentrations should be used to more appropriately evaluate such exposures, as discussed in the RFI Report. In the clarifier area all filtered groundwater results for PCB were non-detect, indicating that the unfiltered groundwater concentrations are the result of soil particulates in the groundwater sample and aqueous-phase concentrations of PCBs in groundwater do not exceed the MCLs.

Notwithstanding the existing exposure controls in this area, all groundwater and soil samples were conservatively evaluated assuming no covers exist during the initial screening (GHD, August 2019). This evaluation summary was submitted as Attachment A to a response to comments memo, submitted on August 29, 2019, in response to additional comments received from U.S EPA on February 19, 2019 with regard to the potential impacts of PCB movement in soil/groundwater. The full response to comments memo, including Attachment A, is presented in Appendix C.3.

Surface soil (0-2 ft bgs) was screened separately from sub-surface soil (>2 ft bgs, where the maximum boring depth ranged from 4 to 18 ft bgs, depending on the location, or refusal/top of bedrock).

Multiple engineering controls are currently in place to prevent potential worker exposure to soil in the Clarifier area. A Site fence prevents unauthorized access from GM Drive and existing surface cover eliminates potential direct contact exposure to soil over the majority of the area. The surface cover in this area includes: 6-12 inches of concrete around the remaining clarifier; a 12-inch asphalt cap; and, a combination of 30 inches of crushed gravel over a 60-millimeter LDPE liner. The specific engineering control(s) present at each soil sampling location in this area is summarized in Table 3 of Attachment A, found in Appendix C.3. As shown on Table 3, three locations (AK-15, AK-16 and, AK-18) do not have any surface cover. However, no detected concentrations of PCBs in the surface soil exceeded the screening criteria at these three locations. Detected concentrations of PCBs in the subsurface soil exceeded the screening criteria at AK-15 and AK-16. The potential for significant exposure to PCBs in soil in both the covered and uncovered portions of this area are presented in Section 6.

DNAPL removal at the Clarifier Area of AOI 8 is being conducted via an absorbent sock currently. Further evaluation of the potential recovery and IM of DNAPL from the TW-3 location will be completed under the Corrective Measures Proposal (CMP).

5.3 Pilot Trench Performance Monitoring Plan

The objectives of this PMP are to determine if groundwater above the competent bedrock in the northern portion of the East Plant Area preferentially flows into the northern bedrock drainage valley and to the Pilot Trench, and to present multiple lines of evidence to assess whether the Pilot Trench operates as designed in capturing contaminated groundwater present above competent bedrock, thereby preventing contaminated groundwater from migrating beyond the trench at levels which would result in an unacceptable risk to human health and the environment (GHD, August 2019).

The Pilot Trench PMP includes completion of a thermal image reconnaissance to identify seeps and springs, installation of new monitoring wells, conduct of two dye tracer tests to assess groundwater flow remote from and close to the trench, recording water levels from monitoring wells, piezometers and surface water staff gauges, further assessment of geological features, and the collection of secondary evidence through the analysis of groundwater, surface water, and spring water samples for PCBs. Details describing each of these components and the proposed schedule of completion are provided in Appendix A.2 (GHD, August 2019).

6. Risk Evaluation

6.1 Introduction

Section 3 discussed the scope of the additional investigation associated with the ISM study and the AOI 8 West area. Section 5 discussed the comparison of site characterization data that represent current conditions with conservative risk-based screening criteria to identify where a potentially significant release of hazardous constituents of the environment may have occurred. For each of these investigations the significant of reasonable maximum exposures (RME) to affected environmental medial under current and reasonably expected future land use at the Facility was evaluated in the area-specific memoranda, provided in Appendix B.5 and C.2. The evaluations in these memoranda were performed consistent with the approaches discussed in Section 9 of the RFI Report. The following subsections summarize the results of the area-specific risk evaluations.

6.2 Incremental Sampling Methodology Study

As discussed in Section 5, certain PCB concentrations in soil exceeded the generic risk-based commercial/industrial screening level for PCBs. As described in the RFI Report (GHD, March 2020) and the memorandum summarizing the ISM results (Appendix B.5), the generic risk-based screening levels are derived from exposure factors that reflect conservative assumptions about the magnitude, frequency, and duration of exposures, which in combination are intended to provide estimates of exposures that are higher than actual exposures to a large portion (90 percent to 99 percent) of the population. As such, the presence of constituent concentrations higher than these screening criteria does not mean that the media necessarily poses a significant risk; it only means that the potential to pose a significant risk should be further evaluated.

GHD calculated the cumulative cancer risk and noncancer hazard index (HI) estimates to determine whether Corrective Measures are necessary in the DUs where PCB concentrations exceeded the generic screening criteria (Appendix B.5; GHD, June 2019). Using the maximum detected concentration of PCBs in the soil samples from DUs EP05 and WP10 (i.e., 14.5 mg/kg of PCBs), the commercial/industrial direct contact cancer risk and noncancer HI estimates were $1x10^{-5}$ and 0.7, respectively. Assuming workers have exposures during the entire work day at a single DU for an entire career is conservative because the largest receptor population at the Facility consists of workers who are engaged in routine manufacturing that take place primarily indoors. During limited time outdoors, workers could be exposed to soil in uncapped areas, areas without ground cover, and in areas where ground cover may be removed, but such exposure is unlikely to be limited to a single DU.

These media-specific cumulative cancer risk and HI estimates do not exceed U.S. EPA's cancer risk limit of 10^{-4} or HI limit of 1, respectively, for determining whether corrective measures are warranted for a particular area of the Facility (61 FR 19432, May 1, 1996; U.S. EPA 1991). IDEM uses the same cumulative cancer risk and HI limits for determining whether remedial action is necessary in its State cleanup programs (IDEM 2012).

6.3 AOI 8 West (Clarifier Area) Investigation

As discussed in Section 5, certain PCB concentrations in soil exceeded the generic risk-based commercial/industrial screening level for PCBs in this area; however, multiple engineering controls are currently in place to prevent potential worker exposure to soil in the Clarifier area. This section summarizes the potential for significant exposure to PCBs in soil in both the covered and uncovered portions of this area.

The results of the screening evaluation in Section 5 identified the potential for significant direct contact exposure of workers to surface and subsurface soil at certain locations in this portion of AOI 8 in the area of the former clarifiers. However, existing engineering controls eliminate the potential for worker direct contact with PCBs in soil throughout the majority of the area. Where engineering controls do not current exist in this area, there are no detected concentrations of PCBs in surface soil that exceed the conservative generic criteria used in the screening evaluation. Therefore, there is currently no complete pathway for worker direct contact with soil in this area.

While there is no current pathway, there is a potential for future direct contact with PCBs in soil in this area if the existing surface cover is removed or if excavations are performed. Therefore, to eliminate the potential for future direct contact exposure to soil in the area, establishing long term institutional or engineering control is recommended.

7. Summary and Conclusions

7.1 Risk Evaluation

For the additional ISM and AOI 8 investigations the significant of RMEs to affected environmental medial under current and reasonably expected future land use at the Facility was evaluated in the area-specific memoranda (Appendix B.4, B.5, and C.3) and is summarized above in Section 6. The evaluations for these areas were performed consistent with the approaches discussed in Section 9 of the RFI Report to evaluate whether concentrations at an area poses a potentially significant risk under the RME based on current and reasonably expected future land use which would warrant further CMs.

For the ISM areas, certain PCB concentrations in soil exceeded the generic risk-based commercial/industrial screening level for PCBs. Where soil concentrations did not exceed the generic risk-based screening criteria, there is no indication of a potentially significant risk under reasonable maximum exposure based on current and reasonably expected future land use which would warrant further CMs.

For the ISM areas where soil concentrations exceeded the risk-based criterion, cumulative cancer risk and noncancer hazard index (HI) estimates were calculated to determine whether Corrective Measures are necessary. These media-specific cumulative cancer risk and HI estimates do not exceed U.S. EPA's cancer risk limit of 10^{-4} or HI limit of 1, respectively, for determining whether corrective measures are warranted for a particular area of the Facility (61 FR 19432, May 1, 1996; U.S. EPA 1991).

For AOI 8 the comparison to generic risk-based screening criteria identified the potential for significant direct contact exposure of workers to surface and subsurface soil at certain locations.

However, existing engineering controls eliminate the potential for worker direct contact with PCBs in soil throughout the majority of the area. Where engineering controls do not current exist in this area, there are no detected concentrations of PCBs in surface soil that exceed the conservative generic criteria used in the screening evaluation. Therefore, there is currently no complete pathway for worker direct contact with soil in this area. However, there is a potential for future direct contact with PCBs in soil in this area if the existing surface cover is removed or if excavations are performed. Therefore, to eliminate the potential for future direct contact exposure to soil in the area, establishing long term institutional or engineering control is recommended.

7.2 Corrective Measures Proposal (CMP)

GM will develop a CMP to assess any final CMs that are required at the Facility (AOIs 1, 8, 9 and 11) with the assumption that GM would operate and maintain the existing IMs and implement any supplemental IMs. The CMP will include deed restrictions on impacted property and the necessity of implementation of HASPs for construction and/or O&M work at the Facility (e.g., NAPL removal at AOI-8 West/Clarifier Area). Table 7.1 was originally presented in the RFI Report (Table 11.1, GHD, March 2020) which included the status of each AOI (RA, IM, and/or future CM). The version of the table displayed in the addendum includes what was previously presented in the original version of the table along with updated AOI conditions based on RFI activities summarized in this addendum.

7.3 Financial Assurance and Operations Maintenance and Monitoring

- The CMP will include a proposed long-term Operations Maintenance and Monitoring Plan (OMMP). The OMMP will be developed through discussions with the U.S. EPA on the need to include both groundwater and surface water locations in the monitoring program.
- The CMP will include provisions for a Financial Assurance mechanism for the operation, maintenance, and inspection of all engineering controls.
- The CMP will include a Perimeter Trench Alternatives Review.
- Additional monitoring south of AOI 1 will be included in the Long-Term Monitoring Plan of the CMP.

8. References

Carr, D.D. 1986. St. Louis Limestone, in Shaver, R.H., Ault, C.H., Burger, A.M., Carr, D.D., Droste, J.B., Eggert, D.L., Gray, H.H., Harper, Denver, Hasenmueller, N.R., Hasenmueller, W.A., Horowitz, A.S., Hutchison, H.C., Keith, B.D., Keller, S.J., Patton, J.B., Rexroad, C.B., and Wier, C.E., Compendium of Paleozoic rock-unit stratigraphy in Indiana–a revision: Indiana Geological Survey Bulletin 59, p. 125-126.

Conestoga-Rovers & Associates (CRA), May 25, 2001, Current Conditions Report, GM Powertrain Bedford Facility, Bedford, Indiana, Ref. No. 13968(1).

- July 18, 2001, Quality Assurance Project Plan Preliminary RCRA Facility Investigation Activities, GM Powertrain Bedford Plant, 105 GM Drive, Bedford, Indiana, Ref. No. 13968(3).

- November 6, 2003, Site Source Control (SSC) Work Plan, GM Powertrain Bedford Plant, Bedford, Indiana, Ref No. 13968(53).
- February 19, 2016, Pilot Perimeter Groundwater Trench Collection System Study, Revision 1, FM CET Bedford Facility, 105 GM Drive, Bedford, Indiana, Ref. No. 13968 (365).
- March 30, 2016, Unsampled Areas Soil Sampling Work Plan, Revision 3, GM CET Bedford Facility, Bedford, Indiana, Ref. No. 13968.

Ewers, R.O., K.A. White, K. Paschl, and M.B. Hanish. 2005. Shallow Groundwater and DNAPL Movement Within Slightly Dipping Limestone, Southwestern Kentucky. In: Sinkholes and the Engineering and Environmental Impacts of Karst: Proceedings of the 10th Multidisciplinary Conference on Sinkholes and the Engineering and Environmental Impacts of Karst, ed. B. F. Beck. American Society of Civil Engineers: Reston, VA.

Ewers, R.O., K.A. White, and J.F. Fuller. 2012. Contaminant plumes and psuedoplumes in karst aquifers. Carbonates and Evaporites, 27(2): 153-159.

GHD (formerly Conestoga-Rovers & Associates), February 23, 2017, Unsampled Areas Soil Sampling Work Plan Results Summary Memorandum, RCRA Facility Investigation, GM Bedford CET Facility, Bedford, Indiana, Ref. No. 13968 (807).

- April 25, 2017, Proposed Scope of Work for the Advancement of 15 Soil Borings, GM Bedford GPS Facility, Bedford, Indiana, Ref. No. 13968 (302).
- January 8, 2018, Addendum 1 Proposed Scope of Work for Additional Soil Samples, GM GPS, Bedford Facility, Bedford, Indiana, Ref. No. 13968 (306).
- June 22, 2018, Responses to Additional Comments on ISM Results, GM GPS, Bedford Facility, Bedford, Indiana, Ref. No. 13968 (313).
- January 9, 2019, Summary of Soil Boring Advancement and Temporary Monitoring Well Installation during the Clarifier Area Investigation (AOI 8) and Scope of Work for an Additional Six Monitoring Wells in the AOI 8 East and West Areas – Revision 2, GM Bedford GPS Facility, Bedford, Indiana, Ref. No. 13968 (303, Rev 2).
- June 20, 2019, Summary of Additional Soil Samples Collected in Decision Units WP10 and EP05, GM Bedford GPS Facility, Bedford, Indiana, Ref. No. 13968 (326).
- August 16, 2019, Pilot Trench Monitoring Plan (PMP), General Motors (GM) LLC Global Propulsion Systems (GPS), Bedford Facility, Bedford, Indiana, Ref. No. 13968 (404).
- August 28, 2019, Response to Additional Comments to Clarifier Area Sampling and Proposed Well Installation, GM GPS Bedford Facility, Bedford, Indiana, Ref. No. 13968 (325).
- December 24, 2019, Pilot Perimeter Groundwater Collection Trench Construction Certification Report, GM GPS, Bedford Facility, IND 006036099, Docket No. RCRA 05-2014-0011 Bedford, Indiana, Ref. No. 13968 (394).
- February 21, 2020, Summary of Monitoring Well Installation during the Clarifier Area Investigation (AOI 8), GM Bedford GPS Facility, Bedford, Indiana, Ref. No. 13968 (328).

- March 24, 2020, Final RCRA Facility Investigation Report, GM Bedford Casting Operations (BCO) Facility, 105 GM Drive, Bedford, Indiana, U.S. EPA ID No. IND 006036099, Docket No. RCRA 05 2017 0011, Ref. No. 13968 (267, Rev 1).

IDEM, March 4, 2019, 2019 Screening and Closure Level Table, Table A-6.

- July 9, 2012, Remediation Closure Guide, Office of Land Quality.

Kueper, Dr. B.H. and K.L. Davies, September 2009, Assessment and Delineation of DNAPL Source Zones at Hazardous Waste Sites, EPA Groundwater Issue, National Risk Management Research Laboratory.

Kueper, Dr. B.H., January 20, 2006. Site Conceptual Model Migration, GM Powertrain Bedford Facility, Bedford, Indiana. Technical Memorandum.Melhorn, W.N., and N.M. Smith, 1959, The Mt. Carmel Fault and Related Structural Features in SouthCentral Indiana, Indiana Department of Conservation, Geological Survey, Report of Progress No. 16.

Kueper, B.H., Redman, J.D., Starr, R.C., Reitsma, S. and Mah, M., 1993. A field experiment to study the behavior of tetrachloroethylene below the watertable: Spatial distribution of residual and pooled DNAPL. Journal of Ground Water, Vol. 31, No. 5, p. 756-766.

Kueper, B.H. and McWhorter, D.B., 1991. The behavior of dense, non-aqueous phase liquids in fractured clay and rock. Journal of Ground Water, Vol. 29, No. 5, pp. 716-728.

Longino, B.L. and Kueper, B.H., 1999. Non-wetting phase retention and mobilization in rock fractures. Water Resources Research, Vol. 35, No. 7, pp. 2085-2093.

Loop, C.M., and W.B. White. 2001. A Conceptual Model for DNAPL Transport in Karst Ground Water Basins. Ground Water 39(1): 119-27.

McLinn, E.L., and Stolzenburg, T.R. 2009. “Ebullition-Facilitated Transport of Manufactured Gas Plant Tar from Contaminated Sediment.” Environmental Toxicology and Chemistry, 28(11), 2298-2306.

Nicoll, R.S. and C.B. Rexroad. 1975. Stratigraphy and Conodont Paleontology of the Sanders Group (Mississippian) in Indiana and Adjacent Kentucky, Indiana Geological Survey Bulletin 51. 36p.

Pankow, J.F. and Cherry, J.A. (editors), 1996. Chlorinated Solvents and Other DNAPLs Groundwater. Waterloo Press, Portland, OR.

Perry, T.G., and N.M. Smith. 1958. The Meramec-Chester boundaries and associated strata in Indiana: Indiana Dept. Cons., Geol. Survey, Bull. 12, 110 p., 1 fig., 6 pls.

Pinsak, A. P. 1957. Subsurface stratigraphy of the Salem Limestone and associated formations in Indiana: Indiana Geological Survey Bulletin 11, 62 p.

Poulsen, M. and Kueper, B.H., 1992. A field experiment to study the behavior of tetrachloroethylene in unsaturated porous media. Environmental Science and Technology, Vol. 26, No. 5, pp. 889-895

Powell, R.L., 1976, Some Geomorphic and Hydrologic Implications of Jointing in Carbonate Strata of Mississippian Age in South-Central Indiana, Ph.D. thesis, Purdue University.

Reynolds, D.A. and Kueper, B.H., 2002. Numerical examination of the factors controlling DNAPL migration through a single fracture. Journal of Ground Water, Vol 40, No. 4, pp. 368-377.

Smart, C.C. 1999. Subsidiary conduit systems: A hiatus in aquifer monitoring and modeling. In, Karst Modeling Symposium, Charlottesville, VA, Proceedings: A.N. Palmer, and M.V. Palmer (eds.), Special Publication 5, Karst Waters Institute, Charlestown, WV, p. 146-57.

Stockdale, P.B. 1931. The Borden (Knobstone) rocks of southern Indiana: Indiana Dept. Conserv. Pub. 98, 380 p.

Thompson, T.A., B.D. Keith, W.A. Hasenmueller, and C.M. Estell. 2008. Preliminary bedrock geologic map of the Bartlettsville 7.5-minute quadrangle, Indiana. Indiana Geological Survey openfile study 08-02. One sheet. Scale 1:24,000

Thornbury, W.D. 1969. Principles of geomorphology, 2nd ed., New York, Wiley and Sons, 594 p.

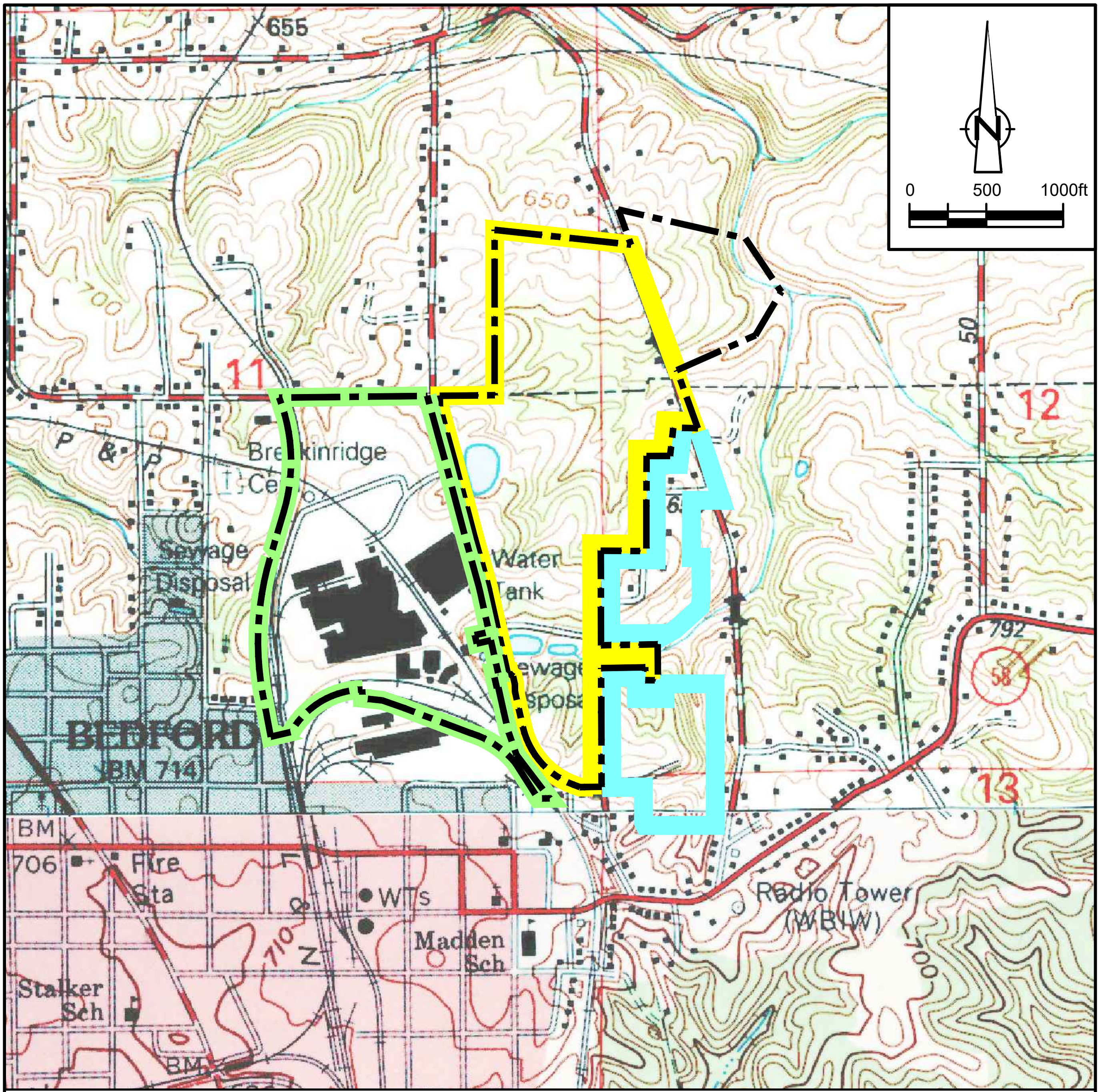
United States Environmental Protection Agency, April 22, 1991, Role of the baseline risk assessment in Superfund remedy selection decisions, Memorandum from Don R. Clay to Regional Directors, OSWER Directive 9355.030.

- June 1995, Innovative Approaches to Data Validation, EPA 903-R-95-907.

Wolfe, W.J., C.J. Haugh, A. Webbers, and T.H. Diehl. 1997. Preliminary conceptual models of the occurrence, fate, and transport of chlorinated solvents in karst regions of Tennessee. U.S. Geological Survey, Water-Resources Investigations Report 97-4097

Worthington, S.R.H., and D.C. Ford. 2009. Self-Organized Permeability in Carbonate Aquifers. Ground Water 47(3): 326-36.

Worthington, S. R. H., Ford, D. C. and Beddows, P. A. 2001. Porosity and permeability enhancement in unconfined carbonate aquifers as a result of solution. In Klimchouk, A.B., Ford, D.C., Palmer, A.N. and Dreybrodt, W. (Eds.), Speleogenesis: Evolution of Karst Aquifers. National Speleological Society, Huntsville, pp. 220-223.



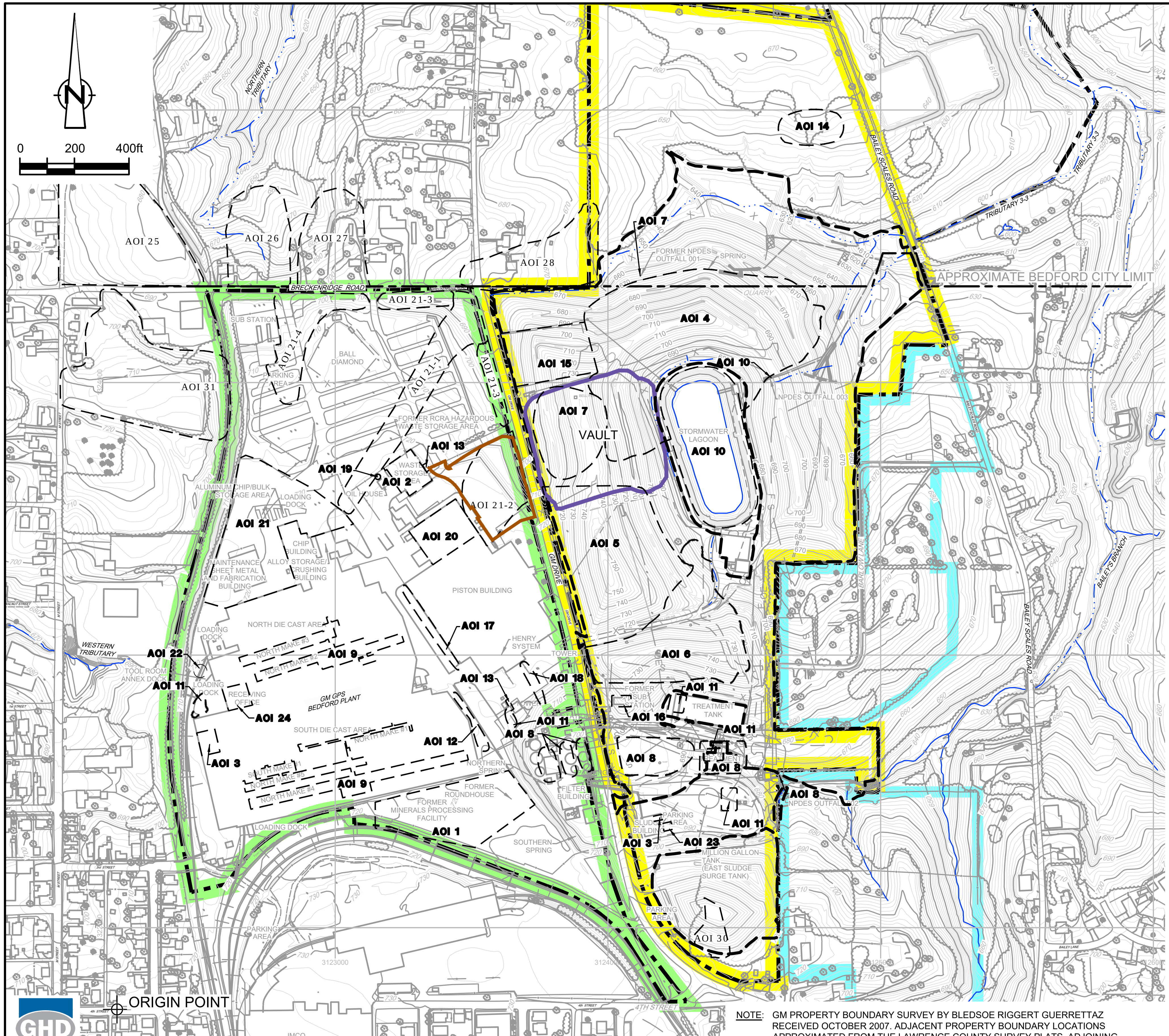
BASE SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLES;
BARTLETTSVILLE, INDIANA 1994
BEDFORD EAST, INDIANA 1978
BEDFORD WEST, INDIANA 1993
OOLITIC, INDIANA 1987
GM PROPERTY BOUNDARY SURVEY BY
BLEDSOE RIGGERT GUERRETTAZ
RECEIVED OCTOBER 2007

LEGEND

- ▬ · ▬ APPROXIMATE FACILITY BOUNDARY
- 🟦 GM LLC OWNED RESIDENTIAL PROPERTIES
- 🟨 EAST PLANT AREA BOUNDARY
- 🟩 WEST PLANT AREA BOUNDARY

figure 2.1

FACILITY LOCATION
RFI REPORT
GM GPS BEDFORD FACILITY
Bedford, Indiana



SOURCE: BASE MAP COMPLETED BY AIR-LAND SURVEYS, FLINT, MI, APRIL 2001
AND CRA SURVEYS 2002 TO 2008.

LEGEND

600	EXISTING GROUND SURFACE ELEVATION CONTOURS (feet AMSL)
▬ · ▬	APPROXIMATE FACILITY BOUNDARY
— · · · —	STREAMS
—×—×—	FENCE LINE
—+—+—	RAILROAD TRACKS
═ ═ ═	DIRT ROADS
═══	ROADS / PAVED AREAS
— — —	AOI BOUNDARY
▬	WEST PLANT COVER LIMIT
▬ ▬ ▬	EAST PLANT COVER LIMIT
🟩	WEST PLANT AREA BOUNDARY
🟨	EAST PLANT AREA BOUNDARY
▬	VAULT LIMIT
🟦	GM LLC OWNED RESIDENTIAL PROPERTIES

AOI SUMMARY

AOI ID	Description
AOI 1	Former Railroad Operations and Minerals Processing Facility
AOI 2	Waste Storage Area
AOI 3	PCB Storage Areas
AOI 4	Former North Disposal Area
AOI 5	Former East Sand Disposal Area
AOI 6	Former Sludge Disposal and Fire Training Area
AOI 7	Former North Lagoon and Outfall 001
AOI 8	Former South Lagoons and Outfall 002
AOI 9	Service Tunnels
AOI 10	Existing Stormwater Lagoon and Outfall 003
AOI 11	Aboveground Storage Tanks
AOI 12	Area Affected by the Reclaimed Hydraulic Fluid Release
AOI 13	Underground Storage Tanks
AOI 14	McBride Cows Disposal Area
AOI 15	Former Equipment Storage Area
AOI 16	Former East Electrical Substation
AOI 17	Piston Building Oil Accumulations
AOI 18	Area Affected by the Henry System Discharge
AOI 19	Area Affected by the Paint and Thinner Spill
AOI 20	Northern Portion of the Piston Building
AOI 21	Filled Ravine North of Die Cast Building
AOI 21-1	Former Drainage Valley Under Hourly Parking Lot
AOI 21-2	Former Drainage Valley Northeast of Piston and Office Buildings
AOI 21-3	Surface Water Ditches Located Along GM Drive and Breckenridge Road
AOI 21-4	Former Drainage Valley East of Electrical Sub-Station, Breckenridge Road
AOI 22	Tool Room Annex Dock Release
AOI 23	Area Affected by the 1996 Wastewater Treatment Filter Cake Release
AOI 24	Area Affected by the June 2000 Die Lube 5150 Release
AOI 25	Off-Site Suspected Fill Area - Parcel 398
AOI 26	Off-Site Suspected Fill Area - Parcels 384 & 386
AOI 27	Off-Site Suspected Fill Area - Parcels 381 & 382
AOI 28	Off-Site Suspected Fill Area - Parcel 401
AOI 30	On-Site Suspected Fill Area - Parcel 201
AOI 31	Off-Site Suspected Fill Area - Parcel 400

NOTE: GM PROPERTY BOUNDARY SURVEY BY BLEDSOE RIGGERT GUERRETTAZ RECEIVED OCTOBER 2007. ADJACENT PROPERTY BOUNDARY LOCATIONS APPROXIMATED FROM THE LAWRENCE COUNTY SURVEY PLATS. ADJOINING PROPERTY LINES MAY NOT ACCURATELY REPRESENT THE TRUE PROPERTY BOUNDARIES

figure 2.2

FACILITY PLAN
RFI REPORT
GM GPS BEDFORD FACILITY
Bedford, Indiana

GHD

N:\CA\Waterloo\Legacy\CAD\drawings\13000s\13968\13968-REPORTS\13968-00(267)\13968-00(267)GN\13968-00(267)GN-WA002.dwg Plot Date: JAN 09, 2020

TABLE 2.1.
ANALYTICAL RESULTS SUMMARY FOR WET WELL #4
GM BEDFORD BCO FACILITY
BEDFORD, IN

												General Chemistry		Field Parameters
				Aroclor-1016 (PCB-1016)	**Aroclor-1221 (PCB-1221)**	**Aroclor-1232 (PCB-1232)**	**Aroclor-1242 (PCB-1242)**	**Aroclor-1248 (PCB-1248)**	**Aroclor-1254 (PCB-1254)**	**Aroclor-1260 (PCB-1260)**	**Total PCBs**	**Oil and grease (HEM), polar**	**Total suspended solids (TSS)**	**pH, field**
				µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**s.u.**
Sample Location	**Sample Identification**	**Sample Date**	**Sample Type**											
Wet Well 4	WW-082316-GS-40459	08/23/16		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	2300 JB	--	--
Wet Well 4	GW-216-051017-MC-40919	05/10/17		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	--	--
Wet Well 4	WG-101617-MC-40977	10/16/17		0.19 U	0.19 U	0.19 U	0.26 P	0.19 U	0.19 U	0.19 U	0.26 P	--	--	--
Wet Well 4	WW-412-011018-MC-40988	01/10/18		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	1000 U	--
Wet Well 4	WW-412-041018-MC-40996	04/10/18		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	1400	--
Wet Well 4	WW-412-053118-MC-41000	05/31/18		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	830 U	--
Wet Well 4	WW-412-053118-MC-41001	05/31/18	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	830 U	--
Wet Well 4	WW-412-062718-MC-41003	06/27/18		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	1100	--
Wet Well 4	WW-412-082218-MC-41007	08/22/18		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	500 U	--
Wet Well 4	WW-412-100118-GS-41010	10/01/18		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	23000	--
Wet Well 4	WW-412-100118-GS-41011	10/01/18	Duplicate	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	21000	--
Wet Well 4	WW-412-101718-MC-41017	10/17/18		0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	ND	--	1000 U	--
Wet Well 4	GW-412-112818-GS-41020	11/28/18		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	7300	--
Wet Well 4	GW-412-122018-GS-41021	12/20/18		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	5000	--
Wet Well 4	GW-412-032519-MC-40957	03/25/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	5700	--
Wet Well 4	GW-412-042219-MC-40969	04/22/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	1500	--
Wet Well 4	WW-412-052019-MC-40982	05/20/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	1600	--
Wet Well 4	WW-412-061119-MC-40994	06/11/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	820 U	--
Wet Well 4	WW-412-072219-MC-41006	07/22/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	2500	--
Wet Well 4	WW-412-081519-MC-41019	08/15/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	7800	--
Wet Well 4	WW-412-091219-MC-41032	09/12/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	2000	--
Wet Well 4	WW-412-102419-MC-41044	10/24/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	1800	7.1
Wet Well 4	WW-412-112119-MC-41056	11/21/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	7000	7.1
Wet Well 4	WW-412-121219-MC-41069	12/12/19		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	3200	7
Wet Well 4	WW-412-011320-MC-41085	01/13/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	3300	7
Wet Well 4	WW-412-021120-MC-41103	02/11/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	2700	6.8
Wet Well 4	WW-412-031020-MC-41123	03/10/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	12000	6.6
Wet Well 4	WW-412-040820-MC-41126	04/08/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	7800	6.8
Wet Well 4	WW-412-050620-MC-41143	05/06/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	3300	6.9
Wet Well 4	WW-412-061120-MC-41162	06/11/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	1600	6.7
Wet Well 4	WW-412-071620-MC-41176	07/16/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	1600	6.9
Wet Well 4	WW-412-081720-MC-41189	08/17/20		0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	0.19 U	ND	--	2300	--

Notes:

B - Result detected in associated method blank.
J - Estimated concentration
ND ( ) - Not detected at the associated reporting limit.
P - TestAmerica:The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.
PCB - Polychlorinated biphenyl
U - Not detected at the associated reporting limit.
µg/L - micrograms per litre

Table 7.1 RCRA Corrective Action Results Summary by AOI

AOI	Description	CERCLA Removal Action[1]	RCRA IM	Exposure Risk	NFA
AOI 1	Mineral Processing	Y	N	N	Y
AOI 2	Waste Storage	Y	N	N	Y
AOI 3	PCB Storage	Y	N	N	Y
AOI 4	North Disposal	Y	Y[R,C]	N	Y
AOI 5	East Sand Disposal	Y	Y[R,C]	N	Y
AOI 6	Sludge Disposal	Y	Y[R,C]	N	Y
AOI 7	North Lagoon	Y	Y[R,V,C]	N	Y
AOI 8	South Lagoons	Y	Y[O]	Y[2]-Future	N[7]
AOI 9	Service Tunnels	Y	Y	Y[2]-Future	N[2]
AOI 10	Stormwater Pond	Y	Y	N	Y
AOI 11	ASTs	Y	Y[2]	Y[2]-Future	Y[6]
AOI 12	Hydraulic Fluid Release	Y	N	N	Y
AOI 13	USTs	Y	N	N	Y[3]
AOI 14	Cows Disposal	Y	N	N	Y
AOI 15	Equipment Storage	Y	N	N	Y
AOI 16	East Substation	Y	N	N	Y
AOI 17	Piston Building Oil	Y	N	N	Y
AOI 18	Henry System	Y	Y[R]	N	Y
AOI 19	Paint and Thinner	Y	N	N	Y
AOI 20	Northern Piston	Y	N	N	Y
AOI 21	North Ravine	Y	N	N	Y
AOI 21-1	Hourly Lot Valley	Y	Y[R]	N	Y
AOI 21-2	Office Drainage Valley	Y	Y[R,C]	N	Y
AOI 21-3	Surface Ditches	Y	Y[R]	N	Y
AOI 21-4	Electrical Sub Valley	Y	N	N	Y
AOI 22	Annex Dock Release	Y	N	N	Y
AOI 23	Filter Cake Release	Y	N	N	Y
AOI 24	Die Lube Release	Y	N	N	Y
AOIs 25-29	Off-Site Suspected Fill Areas[8]	--	--	--	--
AOI 30	Parcel 201 Fill	Y	Y[R,C]	N	Y
AOI 31	Off-Site Suspected Fill Area[8]	--	--	--	--
Off-Site	Pleasant Run	Y	N	N	Y[5]
Groundwater	-	Y	Y[T,4]	N	N[T,4,5]
Facility-Wide	-	Y	Y[T,4]	N	N[4]

[1] – Due to Source Control Systems installed for Facility-wide containment, all AOIs will not have PCB migration into the Pleasant Run and Bailey Creek area

[2] – Deed restrictions to limit excavation and movement of contaminated soil without a HASP

[3] – Subject to conditions of IDEM NFA letter

[4] – Deed restrictions to limit groundwater use, maintenance of site security, continue operation and maintenance on IM's

[5] – Longterm monitoring will be evaluated in the Corrective Measures Proposal

[6] – Subsequent to the risk assessment the 1,000,000 gallon AST was removed and the area was covered to prevent potential exposure

[7] – East of GM Drive there is a NAPL removal IM that is operating and West of GM Driver in the former clarifier area NAPL removal will be evaluated in the Corrective Measures Proposal

[8] – AOIs were included in the initial RFI list; however, subsequent to 2009 they are no longer the responsibility of GM LLC

[C] – Construction of engineered cover system to reduce infiltration and prohibit direct contact with impacted soil materials

[O] – Oil/NAPL removal

[R] – Removal of ≥50 mg/kg PCB impacted soil

[T] – Perimeter Groundwater Collection Trench (as an additional groundwater source control)

[V] – TSCA Vault construction

about
GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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