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Appendix K

Groundwater-Surface Water Interaction

Introduction

This Groundwater-Surface Water Interaction (GSI) and Human Health/Ecological Screening Assessment (Appendix K to the *Corrective Measures Proposal*) addresses requests from the United States Environmental Protection Agency (U.S. EPA) and Ohio Environmental Protection Agency (Ohio EPA) in correspondence from May 2010 through March 2011 to Motors Liquidation Company and Revitalizing Auto Communities Environmental Response Trust (RACER Trust) for the Moraine Facilities. This assessment provides information on:

- GSI for surface water reaches downgradient of the Site.
- Waste load allocation (WLA) calculations for discharge of pollutants to receiving surface water reaches downgradient of the Site for the site-specific list of volatile organic compounds (VOCs).
- Comparison of WLA calculated values to current groundwater concentrations of site-specific VOCs.
- Human health and ecological screening assessment to include recreational fishing.
- Evaluation of potential sediment exposures.

GSI for Surface Water Reaches

The GSI includes information on the reaches of the Great Miami River and Holes Creek downgradient of the Site (Figure K-1) and updated risk assessment for surface water. The GSI was used for development of the revised conceptual site model (CSM; Section 2.7 of the *Corrective Measures Proposal*) and the updated Human Health Risk Assessment (Appendix G to the *Corrective Measures Proposal*). The text below contains excerpts from the *Corrective Measures Proposal* to provide the CSM focused on GSI and the risk assessment summary for surface water exposure.

> *DN-13 Transducer Study in March and April 2007 – 2012 Corrective Measures Proposal in Appendix C - Attachment C-2*
>
> As part of the supplemental groundwater investigation, a detailed water level study was completed for pumping well DN-13 for the refinement of the understanding of groundwater flow downgradient of the Site and documentation of responses to specific stresses on the aquifer. The transducer study findings confirmed that the Great Miami River adjacent to and downgradient of the Site, is

primarily a losing river. During low river stages, portions of this section of the River can become a gaining reach. There appears to be some degree of hydraulic separation between the River and the upper aquifer groundwater such that groundwater can flow under the River even in situations when the River level is above or below the upper aquifer groundwater level.

Groundwater Flow Model Update – 2008 Corrective Measures Proposal in Appendix D (ARCADIS, Inc. 2008)

Characterization of the Site-wide hydrogeology was refined and the three-dimensional groundwater flow model was revised to incorporate additional data from the supplemental investigations to refine the understanding of river stage elevations and riverbed conductance values for the Great Miami River and Holes Creek. Recharge to the study area is primarily from flow within the aquifers that includes direct infiltration of precipitation and recharge from perennial streams. The perennial Great Miami River flows generally from north to south through the groundwater model study area and locally as a source and sink for groundwater. The perennial Holes Creek, located south of the Site, flows generally southeast to northwest and is a minor source of groundwater recharge.

The interaction between surface water and groundwater is an important relationship and an in depth evaluation was conducted as part of updating the model. Therefore, great efforts were made to accurately represent this relationship during model re-calibration. River cells were used to simulate the exchange of water between the river and the groundwater system along the reaches of the Great Miami River and Holes Creek. River cells allow for the specification of a river stage and a conductance term, which regulates the amount of groundwater discharge from, or recharge to, the river. The gradients and river stage elevations were assigned using data collected from monitored surface water gaging stations and supplemented by data from the United States Geological Survey (USGS) Quadrangle map and digital elevation model (DEM) in areas where no measured stage elevations were available. The locations of the gaging stations and their corresponding elevation stages are shown in Figure 6 of Appendix D in the 2008 *Corrective Measures Proposal* (data measured in September 2006), which are representative of the long-term average river stage elevations. These gaging station elevations, combined with USGS Quadrangle maps and DEM data, were used to estimate the riverbed elevations in the model domain. River conductance is a term used to represent the collective effects of river dimensions within a model cell and the hydraulic conductivity of riverbed and bank materials. The conductance values for the river cells were estimated and adjusted based on the previous groundwater modeling efforts, literature values, and model re-calibration (i.e., water level matching). Conductance values for the Great Miami River range from 20 to 500 square feet per day ($ft.^2$/day) and the conductance value for Holes Creek is 500 $ft.^2$/day.

Results of Updated Risk Assessment – Surface Water Exposure

A supplemental human health risk analysis was performed in support of the 2008 *Corrective Measures Proposal* (Appendix G; ENVIRON 2008). As presented in Appendix G, this supplemental risk assessment evaluated potential exposure to surface water in the Great Miami River given the potential for constituents to be transported to the River via groundwater in the upper aquifer. The maximum predicted surface water exposure concentration is well below drinking water criteria, which represent a conservative screening criteria for assessing exposure to surface water (i.e., exposures are more likely to be from nondrinking water exposures, such as water contact while swimming). Therefore, current and reasonably expected future exposure to surface water in the River is not expected to be significant.

Waste Load Allocation Calculation

The updated groundwater model presented in the 2008 *Corrective Measures Proposal* was used to evaluate groundwater flux from groundwater to surface water reaches (Great Miami River and Holes Creek) (Figure K-1). The groundwater flux is a parameter that is required for the waste load allocation calculation as described below. The surface water reaches depicted in Figure K-1 were determined from the current groundwater plume distribution as presented Appendix J of the 2012 *Corrective Measures Proposal*. The areas used are 1,960,614 square feet (ft.) for the Great Miami River and 204,045 square ft. for Holes Creek (Figure K-1). The model results indicate that groundwater does not discharge to these surface water reaches and these reaches are losing to the upper aquifer. This is likely due to the regional groundwater withdrawal within the model domain (i.e., Appleton Paper – Table 1 of 2012 *Corrective Measures Proposal*). Therefore, in order to obtain groundwater flux values to perform the waste load allocation calculation, simulations in the model were run for four different pumping scenario conditions:

- Pumping Scenario 1: Current Conditions – Regional Pumping and Site Pumping On
- Pumping Scenario 2: Hypothetical Condition – Regional Pumping On and Site Pumping Off
- Pumping Scenario 3: Hypothetical Condition – Regional Pumping Off and Site Pumping On
- Pumping Scenario 4: Hypothetical Condition – Regional Pumping and Site Pumping Off

Regional pumping withdrawal (2011) was 10.5 million gallons per day (MGD) as presented in the 2012 *Corrective Measures Proposal* (Table 1) and Site pumping (DN-13 and TW-2) withdrawal (2011) was estimated at 1 MGD.

The results indicated that if regional pumping is active (Pumping Scenarios 1 and 2), groundwater does not recharge to the Great Miami River and Holes Creek (Table K-1). The reaches as shown in Figure K-1 are losing reaches. However, under hypothetical conditions (Pumping Scenarios 3 and 4), the Great Miami River is a gaining reach when regional pumping is off; whereas Holes Creek is still a losing reach. In order to complete the WLA for these two reaches, the most conservative (highest groundwater flux) value was used (Pumping Scenario 4). These values are 0.17 cubic ft. per second (cfs) for the Great Miami River and 0 cfs for Holes Creek.

The WLA was calculated following Ohio EPA Rule OAC 3745-2-05 titled Calculating Waste Load Allocations with the following formula:

$$WLA = \frac{WQC\left(Q_{eff} + Q_{up}\right) - Q_{up}(WQ_{up})}{Q_{eff}}$$

Where:
$WLA = waste\ load\ allocation\ (micrograms\ per\ liter\ [\mu g/L])$
$WQC = water\ quality\ criterion\ (\mu g/L)$
$Q_{eff} = effluent\ flow\ (cfs)$
$Q_{up} = percent\ of\ the\ stream\ design\ flow\ (cfs)$
$WQ_{up} = background\ water\ quality\ (\mu g/L)$

The water quality criteria (WQC) are values from Ohio Surface Water Criteria (aquatic life and human health) from OAC 3745-1 (Ohio EPA 2009); U.S. EPA maximum contaminant levels (MCLs), and U.S. EPA Region 5 Ecological Screening Levels (ESLs) (U.S. EPA 2003). The effluent flow (Q_{eff}) are groundwater flux values obtained from the groundwater model simulations (Pumping Scenario 4) presented above. From correspondence with Laura Marshall of the Ohio EPA, percent stream flow design (Q_{up}) for chronic aquatic life (7Q10) was provided for the Great Miami River (339.9 cfs) and Holes Creek (0.89 cfs). The background water quality (WQ_{up}) was assumed to be 0 cfs.

The calculations presented in Table K-1 indicate that resulting WLA values are sizeable due to the minimal groundwater to surface water flux of less than 1 cfs for the Great Miami River. Values were not obtained for Holes Creek due to 0 cfs flux. A comparison of the calculated WLAs to actual groundwater quality data is presented in the following section.

Human Health and Ecological Screening Assessment

As described above, WLAs were calculated using WQC including Ohio surface water criteria (i.e., criteria for aquatic life outside mixing zone average [OMZA] and human health drinking and non-drinking sources from OAC 3745-1), U.S. EPA Region 5 ESLs, and U.S. EPA MCLs. The derivation of these WQC is discussed below.

Ohio Surface Water Criteria

The Ohio WQC for aquatic life are derived from laboratory studies on the sensitivity of biological organisms (e.g., fish, benthic macroinvertebrates, zooplankton) to specific chemicals and are considered to be protective of long-term exposure of aquatic organisms. The Ohio WQC for human health drinking and non-drinking sources are derived from laboratory studies on the sensitivity of mammals (e.g., mice, rats) to specific chemicals. Ohio WQC for drinking water are considered to be protective of people exposed to chemicals via drinking water and fish consumption. Ohio WQC for non-drinking water (i.e., recreational use) are considered to be protective of people exposed to chemicals via fish consumption. Both aquatic life OMZA and human health non-drinking WQC are applicable to all surface waters. Human health drinking WQC are only applicable to designated use waters as defined in OAC 3745-1. The designations for the Great Miami River are:

Designated Uses (1)	Great Miami River	Holes Creek
Aquatic Life	EWH	WWH
Water Supply	PWS/AWS/IWS	AWS/IWS
Recreation	PCR	PCR

Notes:

(1) According to OAC 3745-1-07 (Water Use Designations and Statewide Criteria) and 37451-21 (Great Miami River drainage basin).

(2) Definitions:
   a. EWH = exceptional warmwater habitat
   b. WWH = warmwater habitat
   c. PWS = public water supply
   d. AWS = agricultural water supply
   e. IWS = industrial water supply
   f. PCR = primary contact recreation

Aquatic life OMZA and human health drinking and non-drinking WQC were used to develop WLAs for the Great Miami River (Table K-1).

U.S. EPA Region 5 RCRA Ecological Screening Levels

U.S. EPA Region 5 ESLs represent protective ecological benchmarks that are intended to function as screening levels. ESLs for water were used to develop WLAs for the Great Miami River (Table K-1). Surface water ESLs are considered to be protective of aquatic and terrestrial biota, and were derived based on the following hierarchy: (1) federal criteria, (2) state criteria, (3) Great Lakes Water Quality Initiative Tier II values, (4) interim criteria, and (5) receptor-specific values (U.S. EPA 1999).

U.S. EPA Maximum Contaminant Levels

U.S. EPA MCLs represent enforceable human health standards that apply to public water systems. MCLs are not risk-based, but rather are based on technical feasibility and treatment cost. MCLs are set as close as possible to Maximum Contaminant Level Goals (MCLGs), which are risk-based and represent concentrations below which there is no known or expected risk to human health. MCLs were used to develop WLAs for the Great Miami River (Table K-1).

Comparison of Groundwater Data to WLAs

Site-specific VOC groundwater data from groundwater monitoring wells adjacent to the Great Miami River were compared to the calculated WLAs for these water bodies. Holes Creek was not compared due to 0 cfs flux. The groundwater monitoring wells that were selected represent the upper portion of the upper aquifer for both the upgradient and downgradient sides of the Great Miami River (Figure K-1). Table K-2 presents the analytical data available for these groundwater wells. As shown in Table K-2, constituent concentrations were below associated WLAs for both the Great Miami River. Because the WQC that form the basis for these WLAs represent benchmarks that are protective of human health and ecological resources, it is concluded that even under a conservative scenario (i.e., Pumping Scenario 4), groundwater VOC concentrations in monitoring wells adjacent to the Great Miami River would not result in unacceptable surface water concentrations in these water bodies (i.e., surface water concentrations would not be expected to pose a risk to human health or the environment).

Evaluation of Fish Consumption Pathway

As shown in Table K-2, VOCs were generally not detected in groundwater or were detected below MCLs, with the exception of tetrachloroethene (PCE) and trichloroethene (TCE). The highest concentrations of PCE and TCE were detected in well GM-52, which is adjacent to the Great Miami River.

For humans to be exposed to chemicals via the fish consumption pathway, such chemicals would need to have the ability to accumulate in fish tissue via ambient exposures (e.g., sediment, surface water) or aquatic food chain exposures (e.g., ingestion of lower trophic species). VOCs are generally not considered to be bioaccumulative based on environmental fate and transport properties. PCE is considered to have a low bioconcentration potential in aquatic organisms and biomagnification in the aquatic food chain is not expected because this compound is metabolized in animals (ATSDR 1997a). Likewise, biomagnification of TCE in the aquatic food chain does not appear to be important based on available data (ATSDR 1997b). The octanol-water partition coefficient (K_{ow}) is often used to predict a chemical's ability to bioaccumulate and generally a higher K_{ow} value indicates a higher propensity for bioaccumulation (U.S. EPA 2003). The log K_{ow} values for PCE and TCE are 3.40 and 2.42, respectively (ATSDR 1997a; 1997b), which are relatively low and supports the low potential for these VOCs to bioaccumulate.

Because VOC concentrations in groundwater were below the WLAs derived using Ohio human health WQC for drinking and non-drinking sources (which are based on fish consumption), and because VOCs are generally not considered to be bioaccumulative, it is concluded that based on the GSI evaluation, groundwater concentrations would not be expected to contribute to potential fish consumption risks for the Great Miami River.

Additionally, based on the demographics data for the City of Moraine, Ohio (U.S. Census Bureau 2009), it does not appear that a subsistence fishing population (e.g., Hmong) exists in the vicinity of the Site. Therefore, subsistence fishing is not expected to take place along this portion of the Great Miami River. Further, there is currently a consumption advisory for select sport fish from the Great Miami River based on mercury (statewide) and polychlorinated biphenyls (PCBs) (Ohio EPA 2010); this advisory would be expected to mitigate potential fish consumption in the area.

Evaluation of Potential Sediment Exposures

As previously indicated, groundwater does not discharge into the Great Miami River or Holes Creek under current conditions; however, under hypothetical conditions (Pumping Scenarios 3 and 4), it was simulated that groundwater does discharge to the Great Miami River. Based on the results of the WLA analysis, estimated surface water concentrations are unlikely to result in adverse ecological effects; however, it is also important to consider potential effects to benthic invertebrates from sediment exposure. To evaluate potential sediment exposure, groundwater concentrations were directly compared to surface water criteria, conservatively assuming that pore-water concentrations in the Great Miami River sediments, for example, would be equivalent to the concentrations measured in groundwater adjacent to the Great Miami River. Concentrations of all groundwater constituents were below surface water criteria with the exception of TCE and PCE at GM-52, where concentrations were slightly (i.e., less than 2 times) higher than their respective criteria. Despite this exceedance at one location, risks to benthic invertebrates are extremely unlikely. First, pore-water concentrations should be lower than those measured in groundwater adjacent to the Great Miami River given potential dilution with surface water at the sediment water interface and physical and chemical interactions in the sediment. Second, average TCE and PCE groundwater concentrations were well below the respective surface water criteria. Third, neither TCE nor PCE are considered bioaccumulative chemicals and there is no data to suggest that either of these constituents would accumulate in sediment over time. Finally, all calculations are based on a hypothetical scenario regarding groundwater discharge to the Great Miami River. Under current conditions this reach of the Great Miami River and Holes Creek is losing with no groundwater component; therefore, groundwater concentrations will not impact sediment or pore-water quality.

Summary

The Great Miami River and Holes Creek are losing reaches adjacent to the Site with groundwater flux equal to zero cfs. In order to determine WLAs for the associated surface water bodies, a hypothetical (conservative) scenario was used with no regional or Site groundwater pumping occurring. The Great Miami River reach was gaining and the Holes Creek reach continued to be losing under this hypothetical scenario. A groundwater flux for the Great Miami River was calculated to use for the WLAs.

Groundwater concentrations from monitoring wells adjacent to the Great Miami River are below associated WLAs, which are derived using both ecological and human health benchmarks (i.e., Ohio Surface Water Criteria, U.S. EPA Region 5 ESLs, and U.S. EPA MCLs). Therefore, even under a conservative scenario, Site groundwater concentrations are not expected to result in surface water or pore-water concentrations in the Great Miami River that would pose a risk to human health or the environment. Additionally, the fish consumption pathway is not expected to be of significant concern in the Great Miami River because the site-specific VOCs (primarily PCE and TCE were detected) in groundwater are not expected to bioaccumulate. Similarly, there is no data to suggest that either of these constituents would accumulate in sediment over time. Further, fish consumption in these water bodies is not expected to be a significant pathway because a subsistence fishing population likely does not exist in the City of Moraine, Ohio and the current fish consumption advisory would be expected to mitigate potential fish consumption in the area.

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Table K-1. Surface Water and Groundwater Criteria with Waste Load Allocation Calculations, RACER Trust, Moraine, Ohio.

Pumping Scenario	Regional Pumping[a]	Site Pumping[b]	Q_{eff} - Approximate Groundwater Flux into Surface Water (cfs)		Q_{up} - Stream Design Flow Annual 7Q10 (cfs)		WQ_{up} - Background Water Quality (µg/L)	
			Great Miami River	Holes Creek	Great Miami River	Holes Creek	Great Miami River	Holes Creek
1	ON	ON	0	0	339.9	0.89	0	0
2	ON	OFF	0	0				
3	OFF	ON	1.3E-01	0				
4	OFF	OFF	1.7E-01	0				

		WQC				
		Ohio Surface Water Criteria			Region 5 Ecological	Maximum Contaminant
		Aquatic Life	Human Health		Screening Levels	Levels
	Unit	OMZA	Drinking Water	Recreational Use	(ESLs)	(MCLs)
Volatile Organic Compound						
1,1,1-Trichloroethane	µg/L	76	200	NA	76	200
1,1-Dichloroethane	µg/L	NA	NA	NA	47	NA
1,1-Dichloroethene	µg/L	210	0.57	32	65	7
Benzene	µg/L	160	5	710	114	5
cis-1,2-Dichloroethene	µg/L	970	70	NA	970[c]	70
Ethylbenzene	µg/L	61	700	29,000	14	700
Tetrachloroethene	µg/L	53	5	89	45	5
Toluene	µg/L	62	1,000	200,000	253	1,000
trans-1,2-Dichloroethene	µg/L	970	100	140,000	970	100
Trichloroethene	µg/L	220	5	810	47	5
Vinyl chloride	µg/L	930	2	5,300	930	2
Xylene (total)	µg/L	27	10,000	NA	27	10,000
		WLA calculated for the Great Miami River				
Volatile Organic Compound						
1,1,1-Trichloroethane	µg/L	154480	406528	NA	154480	406528
1,1-Dichloroethane	µg/L	NA	NA	NA	95534	NA
1,1-Dichloroethene	µg/L	426854	1159	65044	132121	14228
Benzene	µg/L	325222	10163	1443173	231721	10163
cis-1,2-Dichloroethene	µg/L	1971659	142285	NA	1971659	142285
Ethylbenzene	µg/L	123991	1422847	58946499	28457	1422847
Tetrachloroethene	µg/L	107730	10163	180905	91469	10163
Toluene	µg/L	126024	2032638	406527576	514257	2032638
trans-1,2-Dichloroethene	µg/L	1971659	203264	284569303	1971659	203264
Trichloroethene	µg/L	447180	10163	1646437	95534	10163
Vinyl chloride	µg/L	1890353	4065	10772981	1890353	4065
Xylene (total)	µg/L	54881	20326379	NA	54881	20326379

Calculation Basis: Ohio Administrative Code Chapter 3745-2-05 (Calculating Waste Load Allocations [WLA])

$$WLA\ (\mu g/L) = \frac{WQC(Q_{eff} + Q_{up}) - Q_{up}(WQ_{up})}{Q_{eff}}$$

Where:
- WQC — water quality criterion (µg/L)
- Q_{eff} — effluent flow (cfs) - Scenario 4
- Q_{up} — percent stream flow design (7Q10 for chronic aquatic life criteria) (cfs)
- WQ_{up} — background water quality (µg/L)

Ohio EPA determined values:
- Q_{up} — annual 7Q10 for the Great Miami River as 339.9 cfs
- Q_{up} — annual 7Q10 for Holes Creek as 0.89 cfs
- WQ_{up} — background water quality = 0 µg/L

Values determined using groundwater model:
- Q_{eff} — approximate groundwater flux into surface water as estimated in groundwater model[d] simulations for four different pumping scenarios. Most conservative value used in WLA calculation presented as Pumping Scenario 4.

µg/L - Micrograms per liter.
cfs - Cubic feet per second.
NA - Not available.
OMZA - Outside mixing zone average.
MGD - Million gallons per day.
Sources:
Ohio Surface Water Criteria: Ohio River Basin Aquatic Life and Human Health Tier I Criteria and Tier II Values contained in and developed pursuant to Chapter 3745-1 of the Ohio Administrative Code, Ohio EPA, Division of Surface Water. October 20, 2009
U.S. EPA Region 5 Ecological Screening Levels, Resource Conservation and Recovery Act Corrective Action and Permit Programs. August 22, 2003
U.S. EPA Safe Drinking Water Act Maximum Contaminant Levels
Stream Flow Design (Annual) for the Great Miami River and Holes Creek was provided by the Ohio EPA Division of Surface Water

(a) - regional off-site pumping well rates (withdrawal at 11.5 MGD [2011]) from updated groundwater model (CMP - Appendix D - Table 2).
(b) - site pumping includes TW-2 and DN-13 (2011 withdrawal estimated at 0.9 MGD).
(c) - ESL was not available for cis-1,2-dichloroethene; ESL for trans-1,2-dichloroethene used as a surrogate.
(d) - ARCADIS, Inc., 2008. Corrective Measures Proposal Appendix D Groundwater Flow Model Update, General Motors Corporation, Moraine, Ohio, August 2008.

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Table K-2. Groundwater Analytical Results for Monitoring Wells Near Surface Water, RACER Trust, Moraine, Ohio.

		Adjacent to Great Miami River			
		GM-51			
	Unit	4/28/2006 Upper Aquifer	11/30/2006 Upper Aquifer	9/27/2007 Upper Aquifer	9/30/2008 Upper Aquifer
Volatile Organic Compound					
1,1,1-Trichloroethane	µg/L	0.9 J	0.76 J	0.61 J	0.6 J
1,1-Dichloroethane	µg/L	< 1 U	< 1 U	0.23 J	0.78 J
1,1-Dichloroethene	µg/L	< 1 U	< 1 U	< 1 U	< 1 U
Benzene	µg/L	< 1 U	< 1 U	< 1 U	< 1 U
cis-1,2-Dichloroethene	µg/L	0.32 J	0.26 J	1	2
Ethylbenzene	µg/L	< 1 U	< 1 U	< 1 U	< 1 U
Tetrachloroethene	µg/L	6.7	6.6	7.2	9.3
Toluene	µg/L	< 1 U	< 1 U	0.29 J	< 1 U
trans-1,2-Dichloroethene	µg/L	< 1 U	< 1 U	< 1 U	0.7 J
Trichloroethene	µg/L	4.9	5	3.9	7.7
Vinyl chloride	µg/L	< 1 U	< 1 U	< 1 U	< 1 U
Xylene (total)	µg/L	< 2 U	< 2 U	< 2 U	< 2 U

µg/L - Micrograms per Liter.
< - Constituent not detected above.
laboratory reporting limit shown.
J - Value is estimated.
U - Constituent not detected above.
laboratory reporting limit shown.

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Table K-2. Groundwater Analytical Results for Monitoring Wells Near Surface Water, RACER Trust, Moraine, Ohio.

		Adjacent to Great Miami River								
						GM-52				
		4/28/2006	11/30/2006	9/26/2007	9/30/2008	11/12/2009	1/27/2010	9/22/2010	9/29/2011	9/5/2012
	Unit	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer
Volatile Organic Compound										
1,1,1-Trichloroethane	µg/L	2	1.3 J	1.3 J	1.9 J	1.1 J	1.0 J	0.92 J	< 4.0 U	< 4.0 U
1,1-Dichloroethane	µg/L	0.94 J	0.93 J	1.5 J	3	1.1 J	1.0 J	0.94 J	1.9 J	4.1
1,1-Dichloroethene	µg/L	< 2 U	< 2 U	< 2.5 U	< 2.5 U	< 2.5 U	< 4.0 U	< 3.3 U	< 4.0 U	< 4.0 U
Benzene	µg/L	< 2 U	< 2 U	< 2.5 U	< 2.5 U	< 2.5 U	< 4.0 U	< 3.3 U	< 4.0 U	< 4.0 U
cis-1,2-Dichloroethene	µg/L	1.9 J	2.7	18	14	1.5 J	1.6 J	1.8 J	4.2	7.9
Ethylbenzene	µg/L	< 2 U	< 2 U	< 2.5 U	< 2.5 U	< 2.5 U	< 4.0 U	< 3.3 U	< 4.0 U	< 4.0 U
Tetrachloroethene	µg/L	75	67	88	88	94	94	90	73	66
Toluene	µg/L	< 2 U	< 2 U	< 2.5 U	< 2.5 U	< 2.5 U	< 4.0 U	< 3.3 U	< 4.0 U	< 4.0 U
trans-1,2-Dichloroethene	µg/L	0.67 J	0.76 J	1 J	< 2.5 U	0.83 J	0.99 J	0.74 J	< 4.0 U	< 4.0 U
Trichloroethene	µg/L	61	47	47	43	43	42	50	38	29
Vinyl chloride	µg/L	< 2 U	< 2 U	< 2.5 U	< 2.5 U	< 2.5 U	< 4.0 U	< 3.3 U	< 4.0 U	< 4.0 U
Xylene (total)	µg/L	< 4 U	< 4 U	< 5 U	< 5 U	< 5.0 U	< 8.0 U	< 6.7 U	< 8.0 U	< 8.0 U

µg/L - Micrograms per Liter.
< - Constituent not detected above.
laboratory reporting limit shown.
J - Value is estimated.
U - Constituent not detected above.
laboratory reporting limit shown.

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Table K-2. Groundwater Analytical Results for Monitoring Wells Near Surface Water, RACER Trust, Moraine, Ohio.

		Adjacent to Great Miami River							
		GM-65S							
		5/2/2007	1/21/2008	10/6/2008	11/12/2009	1/27/2010	9/22/2010	9/28/2011	9/5/2012
	Unit	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer
Volatile Organic Compound									
1,1,1-Trichloroethane	µg/L	0.62 J	0.58 J	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
1,1-Dichloroethane	µg/L	0.78 J	0.54 J	< 1 U	< 1.0 U	< 1.0 U	0.34 J	0.16 J	< 1.0 U
1,1-Dichloroethene	µg/L	< 1 U	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Benzene	µg/L	< 1 U	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
cis-1,2-Dichloroethene	µg/L	1.7	1.5	< 1 U	< 1.0 U	0.22 J	0.63 J	< 1.0 U	< 1.0 U
Ethylbenzene	µg/L	< 1 U	< 1 U	< 1 U	< 1.0 UJ	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Tetrachloroethene	µg/L	11	13	8.7	11	13	9.9	7.8	6.5
Toluene	µg/L	< 1 U	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
trans-1,2-Dichloroethene	µg/L	< 1 U	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Trichloroethene	µg/L	8	7.9	3.8	2.5	2.8	2.3	2.3	2.0
Vinyl chloride	µg/L	< 1 U	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Xylene (total)	µg/L	< 2 U	< 2 U	< 2 U	< 2.0 U	< 2.0 U	< 2.0 U	< 2.0 U	< 2.0 U

µg/L - Micrograms per Liter.
< - Constituent not detected above.
laboratory reporting limit shown.
J - Value is estimated.
U - Constituent not detected above.
laboratory reporting limit shown.

Table K-2. Groundwater Analytical Results for Monitoring Wells Near Surface Water, RACER Trust, Moraine, Ohio.

		Adjacent to Great Miami River						
		GM-80						
	Unit	10/23/2007 Upper Aquifer	9/22/2008 Upper Aquifer	11/12/2009 Upper Aquifer	4/9/2010 Upper Aquifer	9/21/2010 Upper Aquifer	9/28/2011 Upper Aquifer	9/5/2012 Upper Aquifer
Volatile Organic Compound								
1,1,1-Trichloroethane	µg/L	< 1 U	< 1 U	0.24 J	< 1.0 U	< 1.0 U	< 1.0 U	0.43 J
1,1-Dichloroethane	µg/L	0.38 J	0.39 J	0.55 J	< 1.0 U	0.30 J	0.47 J	1.7
1,1-Dichloroethene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Benzene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
cis-1,2-Dichloroethene	µg/L	1.5	3.6	3.2	0.85 J	1.3	2.7	8.3
Ethylbenzene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Tetrachloroethene	µg/L	0.68 J	0.93 J	1.6	1.9	2.6	4.1	5.2
Toluene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
trans-1,2-Dichloroethene	µg/L	0.21 J	0.19 J	0.25 J	< 1.0 U	< 1.0 U	0.24 J	0.30 J
Trichloroethene	µg/L	4.0	5.4	9.8	6.6	6.0	5.9	13
Vinyl chloride	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U
Xylene (total)	µg/L	< 2 U	< 2 U	< 2.0 U	< 2.0 U	< 2.0 U	< 2.0 U	< 2.0 U

µg/L - Micrograms per Liter.
< - Constituent not detected above.
laboratory reporting limit shown.
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laboratory reporting limit shown.

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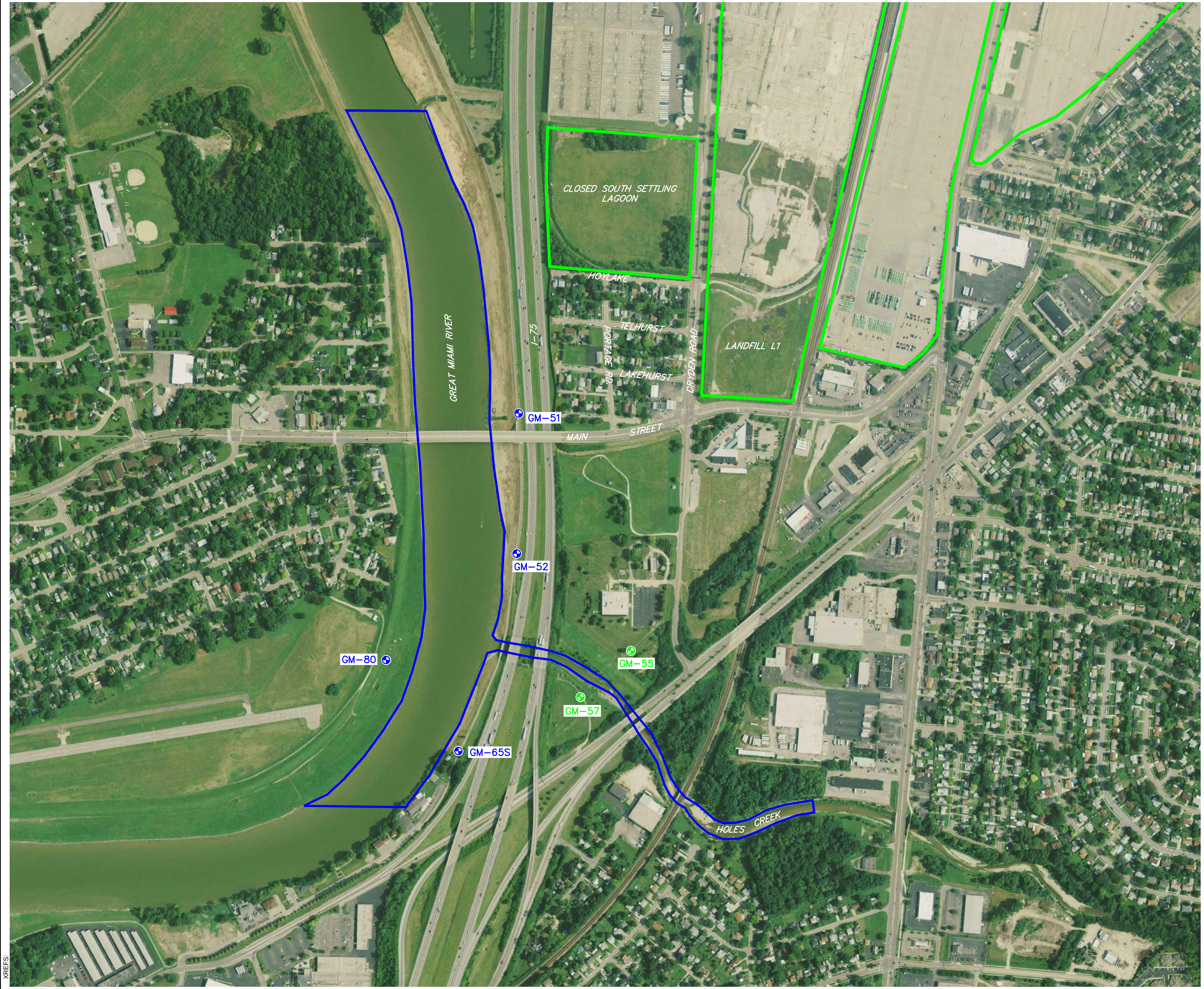
Table K-2. Groundwater Analytical Results for Monitoring Wells Near Surface Water, RACER Trust, Moraine, Ohio.

		Adjacent to Holes Creek							
		GM-55						GM-57	
		9/14/2006	10/2/2008	11/12/2009	9/22/2010	9/28/2011	9/5/2012	9/14/2006	1/21/2008
	Unit	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer	Upper Aquifer
Volatile Organic Compound									
1,1,1-Trichloroethane	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
1,1-Dichloroethane	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
1,1-Dichloroethene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
Benzene	µg/L	< 1 UJ	< 1 UJ	0.46 J	0.23 J	< 1.0 U	< 1.0 U	< 1 U	< 1 U
cis-1,2-Dichloroethene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
Ethylbenzene	µg/L	< 1 U	< 1 U	< 1.0 UJ	< 1.0 U	< 1.0 U	< 1.0 U	0.21 J	< 1 U
Tetrachloroethene	µg/L	7.4	7.2	7.7	7.2	6.1	4.6	1.9	1.9
Toluene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	0.26 J	0.48 J	< 1 U
trans-1,2-Dichloroethene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
Trichloroethene	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
Vinyl chloride	µg/L	< 1 U	< 1 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1.0 U	< 1 U	< 1 U
Xylene (total)	µg/L	< 2 U	< 2 U	< 2.0 U	< 2.0 U	< 2.0 U	< 2.0 U	< 2 U	< 2 U

µg/L - Micrograms per Liter.
< - Constituent not detected above.
laboratory reporting limit shown.
J - Value is estimated.
U - Constituent not detected above.
laboratory reporting limit shown.



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LEGEND

MONITORING WELL (UPPER AQUIFER) ADJACENT TO THE GREAT MIAMI RIVER

MONITORING WELL (UPPER AQUIFER) ADJACENT TO HOLES CREEK

SURFACE WATER REACHES USED IN GROUNDWATER TO SURFACE WATER FLUX CALCULATION

RACER TRUST
MORAINE, OHIO

OH000294.2012

MONITORING WELL LOCATIONS AND SURFACE WATER REACHES FOR GROUNDWATER TO SURFACE WATER INTERACTION SUMMARY

ARCADIS

FIGURE
K-1

CITY:(COLUMBUS) DIV/GROUP:(SER1) DB:(R. SMITH) LD:(Opt) PIC:(Opt) PM:(N. GILLOTTI) TM:(OPT) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Columbus-OH\ACT\OH000294 - RACER\294-2012-0001\EVS FIGURES\OH2942012-EVS-03.dwg LAYOUT: MW-UPPER LOCATIONS SAVED: 12/19/2012 4:21 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ACAD.CTB PLOTTED: 12/19/2012 4:21 PM BY: SMITH, BOB
XREFS: