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Revitalizing Auto Communities Environmental Response (RACER) Trust

Investigation Work Plan

Davidson Road Landfill

Burton, Michigan

September 30, 2011

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Certified Project Manager

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Task Manager

Groundwater Investigation Work Plan

Davidson Road Landfill
Burton, Michigan

Prepared for:
Revitalizing Auto Communities Environmental Response (RACER) Trust

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Date:
September 2011

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Appendices

1. Introduction

This Groundwater Investigation Work Plan (Work Plan) has been prepared by ARCADIS on behalf of the Revitalizing Auto Communities Environmental Response (RACER) Trust for the Davidson Road Landfill located in Burton, Michigan.

On June 1, 2009, General Motors Corporation (GMC) filed for Chapter 11 protection under U.S. bankruptcy code. On July 10, 2009 GMC was renamed Motors Liquidation Company (MLC) and on the same day some of the operating assets of GMC were sold to a newly formed company "General Motors Company". General Motors Company changed its name to General Motors LLC (GM LLC) on October 16, 2009. Assets not sold to GM LLC remained the property of the MLC, in its capacity as debtor-in-possession in the bankruptcy case. On March 31, 2011 the environmental remediation of the property was transferred from MLC to the RACER Trust. Ownership of the property was transferred to RACER Properties LLC, a wholly owned subsidiary of RACER Trust.

This Work Plan for the RACER Trust Davidson Road Landfill (herein referred to as the Site), has been prepared for review and approval by the Michigan Department of Environmental Quality (MDEQ).

1.1 Site Description and History

The Site comprises 56 acres of relatively flat and dry land on the southern side of Davidson Road near the intersection of Davidson Road and Donegal Street (Figure 1). The Site contains vegetation ranging from cultivated grasses to dense scrubby brush and wooded areas, as well as a former automobile test track. Gilkey Creek flows through the Site's southwest corner area. A sanitary sewer traverses the Site along the eastern property boundary. Based on field observations, a possible storm sewer was indentified near the western Site boundary. The Site is located immediately east of the Delphi Energy and Engine Management Systems, Plant 7 in Burton, Michigan.

Approximately 21 acres of the Site were used as a permitted landfill in the 1970's for disposal of construction debris, miscellaneous inert solid waste, and foundry sand from the GMC Buick Motor Division facility in Flint, Michigan. The remaining approximately 35 acres of the Site have not been used by GMC since it was acquired in the early 1960s, with the exception of the installation of an asphalt-covered test track. An aerial photograph from 1956 indicates what may have been a grass airstrip to have once been present at the Site.

The Site and vacant land to the east were historically associated with the Delphi Energy and Engine Management Systems Flint East Property, Plant 600/700 (MID 908 568 745; the Delphi Facility). In 1995 GMC initiated Resource Conservation and Recovery Act (RCRA) Voluntary Corrective Action at the Delphi Facility with the Michigan Department of Natural Resources. GMC requested at that time that the Site (a portion of the Delphi Facility) not be included in the RCRA Corrective Action program because there have been no historical records of manufacturing or related support activities being conducted on the property. A Preliminary Assessment/Visual Site Inspection was completed at the Delphi Facility in 1992 by PRC Environmental Management, Inc. for United States Environmental Protection Agency (USEPA). Inspection of the Site did not identify any Solid Waste Management Units (SWMU) or Areas of Concern (AOC).

The Delphi Facility was owned by GMC until 1999, when Delphi Automotive Systems, LLC, (Delphi) was divested from GMC. Delphi owns the Delphi Facility, while GMC retained the adjacent undeveloped 56-acres property and approximately 144 acres of undeveloped land further east. The 144 acres of undeveloped land was sold by GMC to a third party developer in 2004.

1.2 Historical Site Investigations

Site investigations were performed from 1996 through November 2007, including groundwater and soil assessment, landfill delineation (lateral extent, limited vertical extent), and ecological habitat assessment. These investigations are summarized in Sections 2 and 3 of the *Revised Site Investigation Report, 56-Acre Undeveloped Property, Adjacent to Delphi Energy and Engine Management Systems, Plant 600/700, Burton, Michigan* (ARCADIS 2008). Figures 2 through 7 of this report are included in Appendix A.

The analytical results of the soil and groundwater samples from previous investigations indicate the presence of various semi-volatile organic compounds (SVOCs) and/or inorganic constituents at concentrations that exceed MDEQ Part 201 nonresidential generic cleanup criteria for direct contact, drinking water and drinking water protection, groundwater surface water interface, and/or groundwater surface water interface protection.

1.3 Work Plan Objectives

The objective of this Work Plan is to further evaluate groundwater quality at the Site and to determine whether impacts have migrated off-Site. In addition, near-surface soil sampling is proposed within two areas of the Site where exceedances of MDEQ Part 201 nonresidential direct contact (NRDC) criteria were detected during previous investigations.

1.4 Work Plan Organization

This Work Plan is organized as follows:

Section 1 – Introduction

This section presents background information and the objectives of the Work Plan.

Section 2 – Proposed Groundwater Investigation Activities

This section describes proposed subsurface investigation.

Section 3 – Reporting

This section outlines the reporting associated with the subsurface investigation.

Section 4 – References

This section presents a list of references cited in this Work Plan.

2. Proposed Investigation Activities

The purpose of the investigation is to delineate the extent of groundwater impacts present at the Site and to determine whether impacts have migrated off-Site. In addition, site investigation activities will include near-surface soil sampling within two areas of the Site where exceedances of MDEQ Part 201 NRDC criteria were detected during previous investigations.

All work will be conducted in accordance with the Health and Safety Plan (HASP) prepared for the Site. The HASP is consistent with OSHA 29 CFR regulations and is intended to address all known hazards on the Site. All on-Site contractors will be required to review and sign the Site HASP prior to beginning Site work and are required to have 40-hour OSHA training. The HASP will remain on Site at all times during the investigation, and will be updated as new hazards become known, if any.

A utility clearance will be conducted at all proposed subsurface investigation locations. In addition, the first five feet of each boring will be hand augured to clear any potential utilities prior to drilling activities.

2.1 Monitoring Well Installation, Development and Abandonment

Two existing monitoring wells (MW-1 and MW-2) and five temporary monitoring wells (TW-1, TW-6, TW-7, TW-8, MW4-04) are present at the Site as presented on Figure 2. Five additional permanent monitoring wells will be installed to further evaluate the groundwater flow direction and the extent of impacts at the Site. Three piezometer wells will also be installed to further evaluate the groundwater flow direction. The approximate proposed locations for the groundwater monitoring wells and piezometer wells are depicted on Figure 2.

2.1.1 Monitoring and Piezometer Well Installation

The monitoring piezometer wells will be installed in accordance with local, state, and federal requirements, and will be installed using Geoprobe drilling techniques. In addition, the wells will be installed in accordance with the ARCADIS standard operating procedure (SOP) for Monitoring Well Installation located in Appendix B. Continuous sampling from the ground surface to the final boring depth shall be completed at all locations to a depth of up to 15 feet below ground surface (bgs). The borings will be screened using a photoionization detector (PID). Soil description and PID readings will be logged along with other pertinent observations including any visual evidence of contamination (e.g., staining, odor, sheen, etc.). In the event that fill material is encountered, the depth and thickness of fill material will be evaluated to determine if well installation is appropriate at the location. Observations will be recorded in a field log book. Drilling tools will be decontaminated prior to and between drilling at each well location.

Monitoring wells will generally be screened to straddle the encountered water table and will be constructed of Schedule 40, 2-inch polyvinyl chloride (PVC) with 10-foot wells screens having 0.0010-slots. The well screens will be completed with a sand pack along the entire extent of the screen extending two feet above the screen. The remaining annulus will be filled with bentonite pellets. A stick-up locking protective steel casing will also be installed at each well location (including a stick-up protective steel casing at MW4-04). The monitoring and piezometer well locations will be surveyed following installation.

2.1.2 Monitoring and Piezometer Well Development

The newly installed monitoring and piezometer wells will be allowed to sit for at least 24 hours after installation prior to development. The wells will be developed in accordance with the ARCADIS SOP for Monitoring Well Development located in Appendix B. Well development will be completed using a pumping and surging method. Surging of the well will be accomplished with a disposable polyethylene bailer, surge block, or submersible pump. The existing wells will also be redeveloped prior to sampling because these wells have not been accessed for sampling in over 4 years. After development, the wells will be allowed to sit for at least 72 hours prior to sample collection.

2.2 Sampling

2.2.1 Groundwater Sampling

Ground water samples will be collected from MW-1, MW4-04, TW-1, TW-6, TW-8, and the five newly installed monitoring wells. Prior to the beginning of groundwater sampling activities, a depth to groundwater measurement will be collected from each monitoring well and piezometer well. All groundwater samples will be collected in accordance with MDEQ’s Remediation and Redevelopment Division (RRD) Operational Memorandum No. 2 (Op Memo 2) (MDEQ, 2004a), Attachment 5 (*Collection of Samples for Comparison to Generic Criteria*), Attachment 6 (*Sampling Methods for Volatile Organic Compounds*), and Attachment 7 (*Low Level Mercury*

Sampling Specifications). Note that low level mercury samples will only be collected from monitoring well locations adjacent to Gilkey Creek. Samples will be collected using a low-flow sampling technique. Field readings of water quality parameters including; pH, specific conductivity, temperature, dissolved oxygen, oxidation-reduction potential, and turbidity will be recorded during purging to determine stabilization prior to sampling. If the turbidity prior to sampling is greater than 10 Nephelometric Turbidity Units, in addition to total metal samples filtered samples will also be obtained using a 0.45-micron disposable filter and submitted for dissolved metal analysis.

Groundwater samples will be submitted to an accredited laboratory and analyzed using the methods specified in Op Memo 2, Attachment 1 *(Target Detection Limits and Designated Analytical Methods*). Groundwater samples will be analyzed for the following parameters:

- VOCs by United States Environmental Protection Agency (USEPA) Method 8260B
- SVOCs by USEPA Method 8270C
- Select metals: aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, manganese, vanadium, and zinc by USEPA Method 6020
- Low level mercury by USEPA Method 1631 (only for wells adjacent to Gilkey Creek)

A water sample will also be collected from Gilkey Creek and submitted for analysis of calcium and magnesium by USEPA Method 6020 to calculate a hardness value using Standard Method 2340B.

The bottles will be provided by the same laboratory that will be performing the analysis according to Op Memo 2, Attachment 4 (*Sample Preservation, Sample Handling, and Holding Time Specifications*). The field personnel will be responsible for properly labeling containers and preserving samples (as appropriate). Laboratories will add preservative prior to delivery to the sampling staff when possible.

2.2.2 Near-Surface Soil Sampling

Concentrations of benzo(a)pyrene were detected above the MDEQ Part 201 NRDC at two historical sampling locations: MW4-04SO2 located south of the test track near the eastern property boundary and FA-17 located near the southeast corner of the Site. Benzo(a)pyrene was detected above the MDEQ Part 201 NRDC from 6 to 8 feet at

MW4-04SO2 and from 0 to 1 feet bgs at FA-17. The two previously sampled locations will be located by a surveyor prior to advancement of soil borings.

At MW4-04SO2, one shallow soil samples will be collected from 0 to 2 at this location to provide vertical delineation of the historic exceedance. Four additional soil borings will be completed at locations approximately 25 feet north, east, south, and west of MW4-04SO2 as shown on Figure 3. Soil samples will be advanced vertically using a Geoprobe to a depth of approximately 10 feet bgs. Soil samples will be collected from 0 to 2 feet bgs and from 6 to 8 feet bgs at each location. The collected soil samples will be submitted for analysis of polycyclic aromatic hydrocarbons (PAHs) by USEPA method 8270C.

At FA-17, one shallow soil sample will be collected from 6 to 8 feet bgs to provide vertical delineation of the historical exceedance. Eight additional soil borings will be completed at locations approximately 50 feet and 100 feet north, east, south, and west of FA-17 as shown on Figure 3. Soil samples will be advanced vertically using a Geoprobe to a depth of approximately 10 feet bgs. Soil samples will be collected from 0 to 2 feet bgs and from 6 to 8 feet bgs at each location.

The soil samples collected from FA-17 and the 0-2 foot intervals from the 50 foot step-out borings will be submitted to the laboratory for analysis of PAHs by USEPA method 8270C. The remaining soil samples will be submitted to the laboratory on HOLD for analysis pending the results of the initial samples.

Following the completion of soil sample collection activities, the borehole will be backfilled with bentonite pellets and the surrounding surface completed with top soil and seeded. The soil boring locations will also be surveyed. Drilling tools will be decontaminated prior to and between drilling at each boring location.

Quality Assurance/Quality Control Samples

Quality Assurance/Quality Control (QA/QC) samples will be collected in accordance with MDEQ's RRD Op Memo 2, Attachment 5. The QC samples will consist of field duplicates (1 per every 10 samples), matrix spike/matrix spike duplicates (MS/MSD) (1 per every 20 samples), and trip blanks (1 per every VOC sample shipping container). Field blanks will be also collected (1 per every 20 samples) for the analysis of VOCs. If low-level mercury sampling is being completed, then the field blank will also be analyzed for low flow mercury by USEPA method 1631E. Field blanks will be prepared by pouring laboratory supplied distilled water into the appropriate sample container.

Rinsate blanks (using analyte-free water supplied by the laboratory) will also be collected once a day from the drill rig cores after decontamination and analyzed for the same groundwater parameters (VOCs, SVOCs, and the total metals) and soil parameters (PAHs) for which the groundwater and soil samples are being investigated for.

2.3 Specific Capacity Testing

Specific capacity testing will be conducted at the newly installed well locations and select existing well locations to estimate the transmissivity of the saturated zone in the vicinity of these wells. The specific capacity testing will be conducted in accordance with ARCADIS SOP for Specific Capacity Testing and Data Reduction located in Appendix B.

2.4 Investigation Derived Waste Handling

Soil cuttings and water generated from the investigative activities will be placed into 55-gallon Michigan Department of Transportation (MDOT)-approved drums and properly labeled and secured. Samples will be collected from the drums for waste characterization. Upon characterization, the drums will be transported and appropriately disposed of by a licensed transport and disposal contractor.

3. Reporting

Following the completion of groundwater investigation activities, a report will be prepared to present findings of the investigation. The report will include an evaluation of groundwater and soil quality results, recommendations for additional monitoring, or sampling, or measures, as necessary, tabulated groundwater and soil sample results, figures, and laboratory analytical reports. Analytical results from the proposed soil and groundwater samples will be compared to the applicable Part 201 cleanup criteria. .

4. References

ARCADIS 2008. Revised Site Investigation Report, 56-Acre Undeveloped Property, Adjacent to Delphi Energy and Engine Management Systems, Plant 600/700, Burton, Michigan. February 11, 2008.

MDEQ Remediation and Redevelopment Division, 2004. Operational Memorandum No. 1. Part 201 Cleanup Criteria and Risk-Based Screening Levels. December 10, 2004.

MDEQ Remediation and Redevelopment Division, 2004. Operational Memorandum No. 2. Sampling and Analysis. October 22, 2004.

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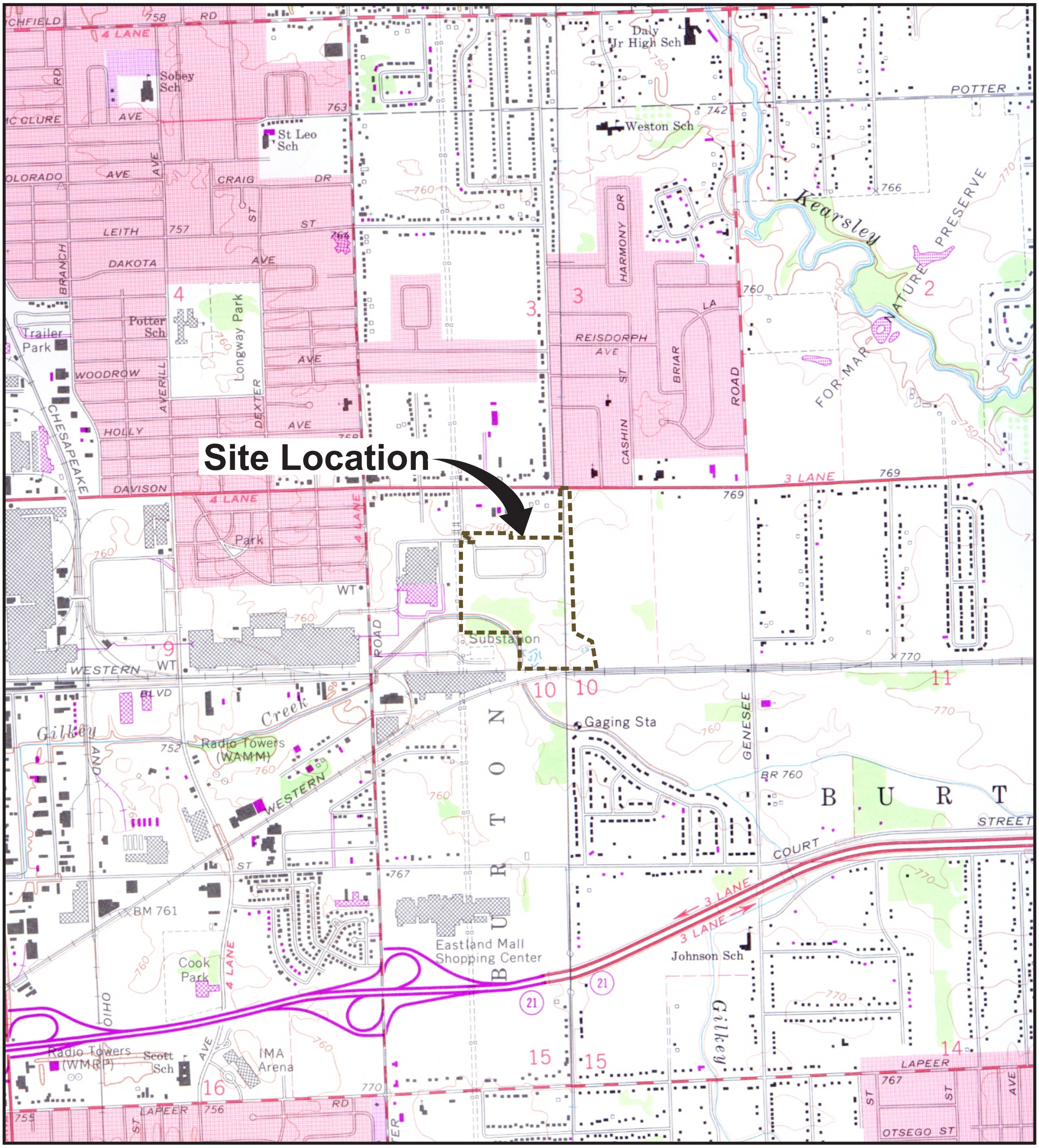
Figures



REFERENCE: Base Map Source: USGS 7.5 Min. Topo. Quads., Flint North, 1969, and Davison, Michigan, 1969, photorevised 1975.

2000' 0 2000'

Approximate Scale: 1" = 2000'

Area Enlargement

REVITALIZING AUTO COMMUNITIES
ENVIRONMENTAL RESPONSE TRUST
DAVIDSON ROAD LANDFILL
BURTON, MICHIGAN

SITE LOCATION MAP

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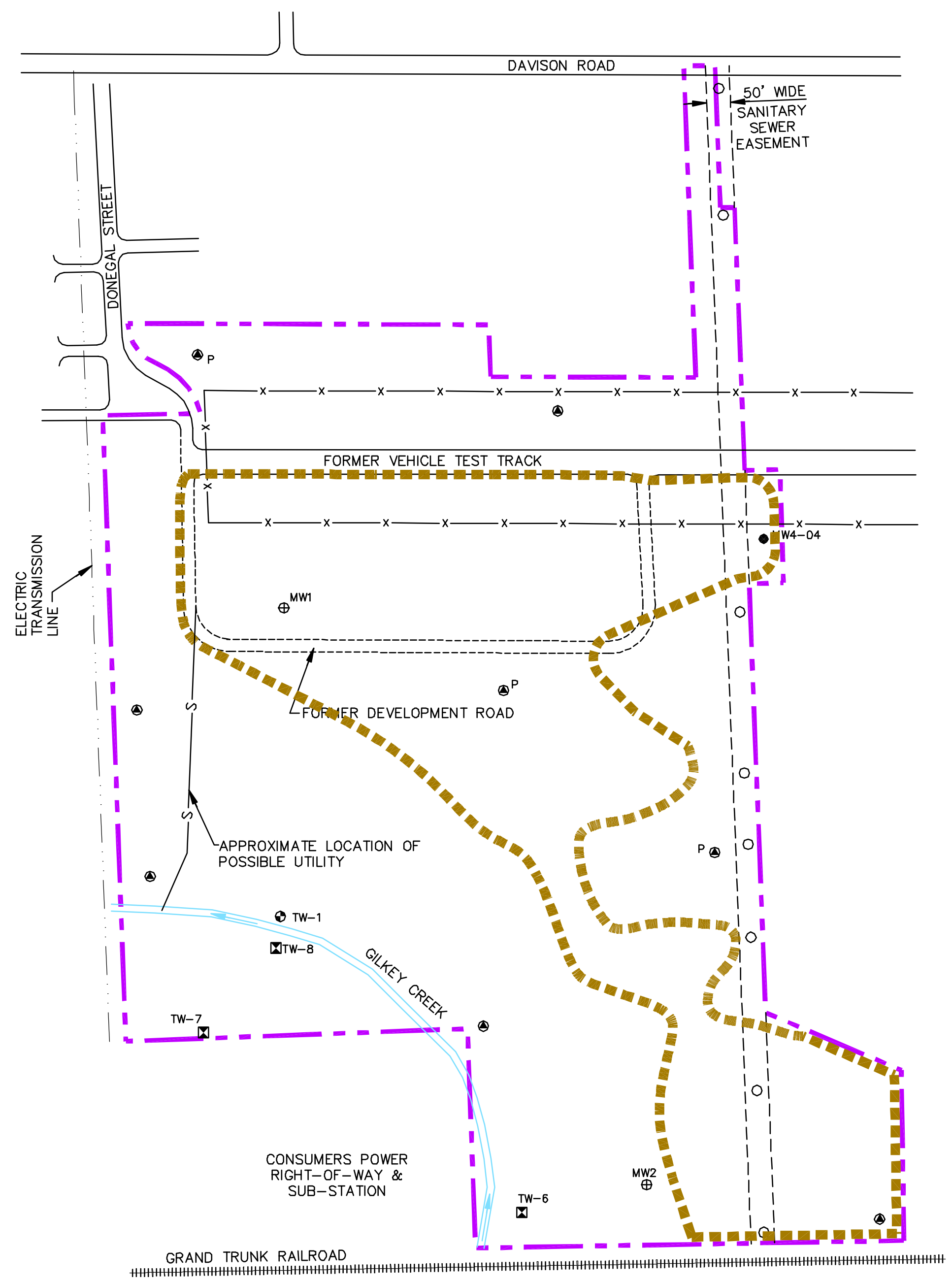
FIGURE
1

09/21/2011 SYRACUSE, NY-ENV/CAD-DJHOWES
B0064448/2011/00401/CDR/64448N01.CDR



LEGEND

- RACER PROPERTY BOUNDARY
- APPROXIMATE EXTENT OF FILL AREA
- EXISTING ROAD
- RAILROAD
- FENCE
- ELECTRIC TRANSMISSION LINE
- CREEK
- DIRECTION OF CREEK FLOW
- SANITARY SEWER MANHOLE
- SANITARY SEWER EASEMENT
- S — STORM SEWER
- MW1 HISTORICAL OBSERVATION WELL (5/96)
- TW-1 TEMPORARY MONITORING WELL (12/03)
- MW4-04 TEMPORARY MONITORING WELL (4/04)
- TW-6 TEMPORARY MONITORING WELL (8/07)
- PROPOSED GROUNDWATER MONITORING WELL
- P PROPOSED PIEZOMETER WELL

NOTES:

1. BASE MAP PROVIDED BY GENERAL MOTORS CORPORATION.

0 200' 400'
GRAPHIC SCALE

REVITALIZING AUTO COMMUNITIES ENVIRONMENTAL RESOURCES TRUST
DAVIDSON ROAD LANDFILL
BURTON, MICHIGAN

PROPOSED GROUNDWATER MONITORING WELL LOCATIONS

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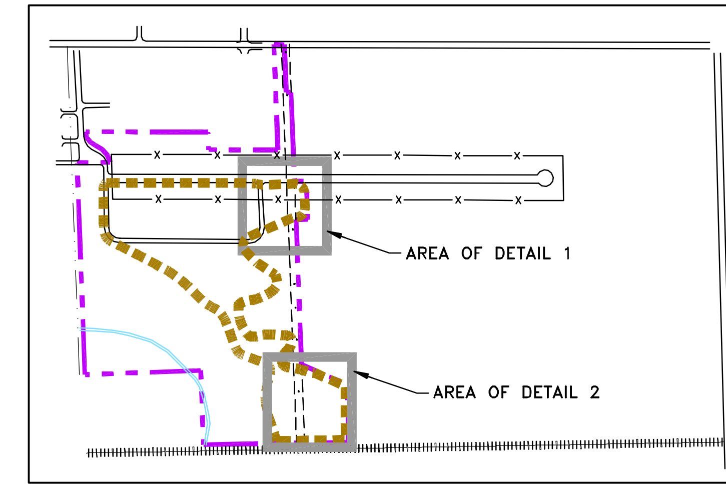
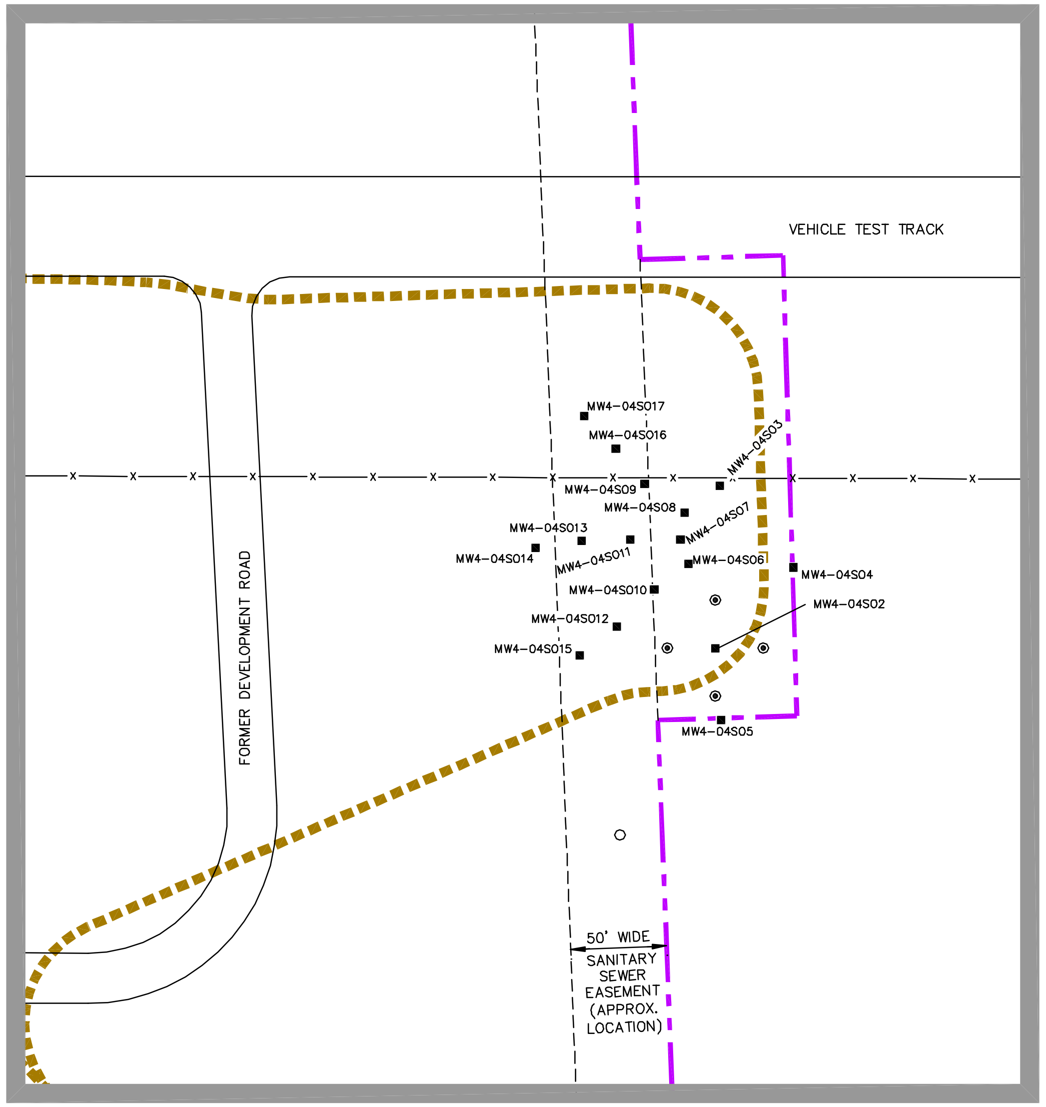
FIGURE
2



LEGEND:

- RACER PROPERTY BOUNDARY
- APPROXIMATE EXTENT OF FILL AREA
- ROAD
- FENCE
- SANITARY SEWER MANHOLE
- APPROXIMATE LOCATION OF SANITARY SEWER EASEMENT
- MW4-04S05 SOIL BORING (5/04)
- PROPOSED SOIL BORING LOCATION



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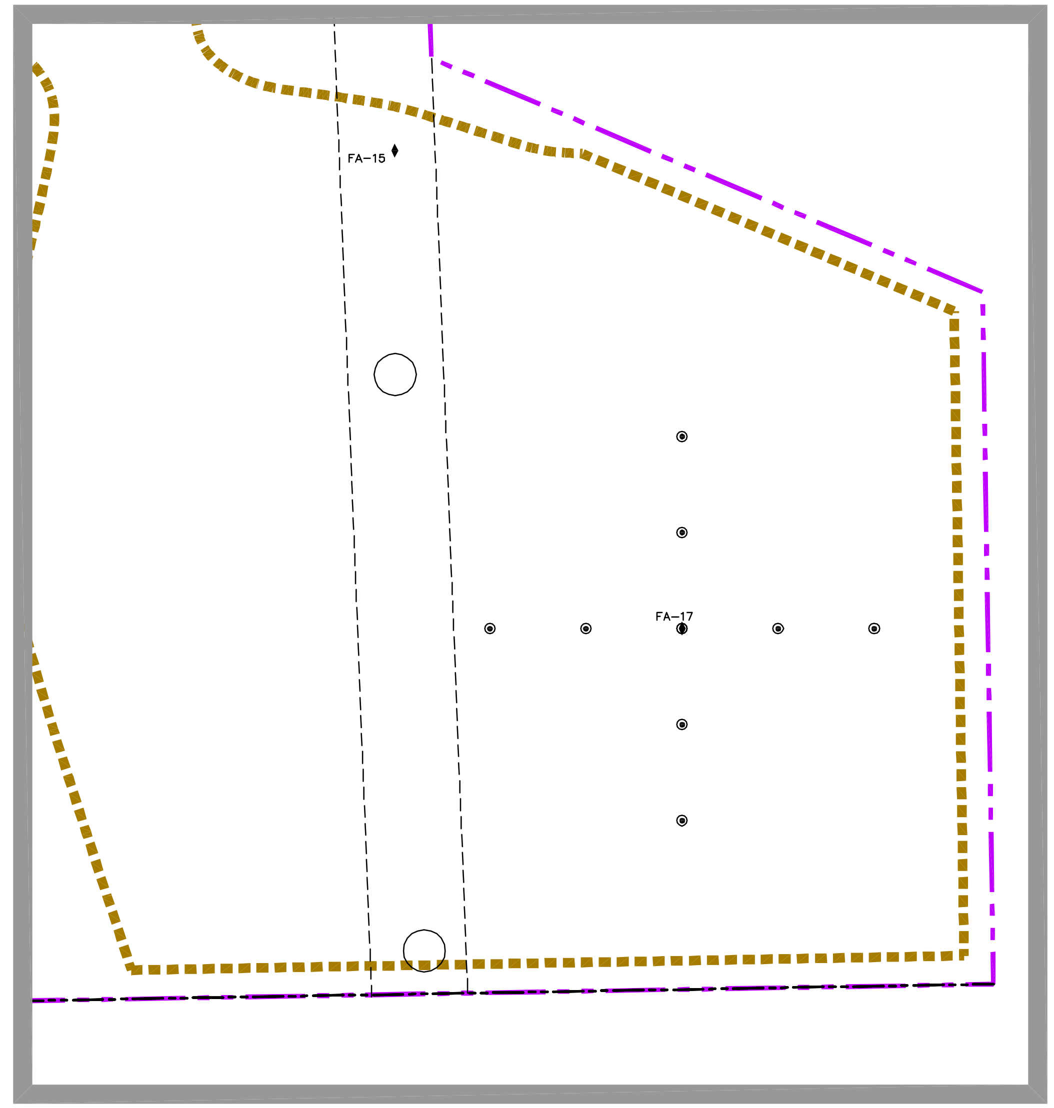

AREA 2

NOTES:

1. BASE MAP PROVIDED BY GENERAL MOTORS CORPORATION.

0 50' 100'
GRAPHIC SCALE

REVITALIZING AUTO COMMUNITIES ENVIRONMENTAL RESPONSE TRUST
DAVIDSON ROAD LANDFILL
BURTON, MICHIGAN

PROPOSED SOIL BORING LOCATIONS

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FIGURE
3

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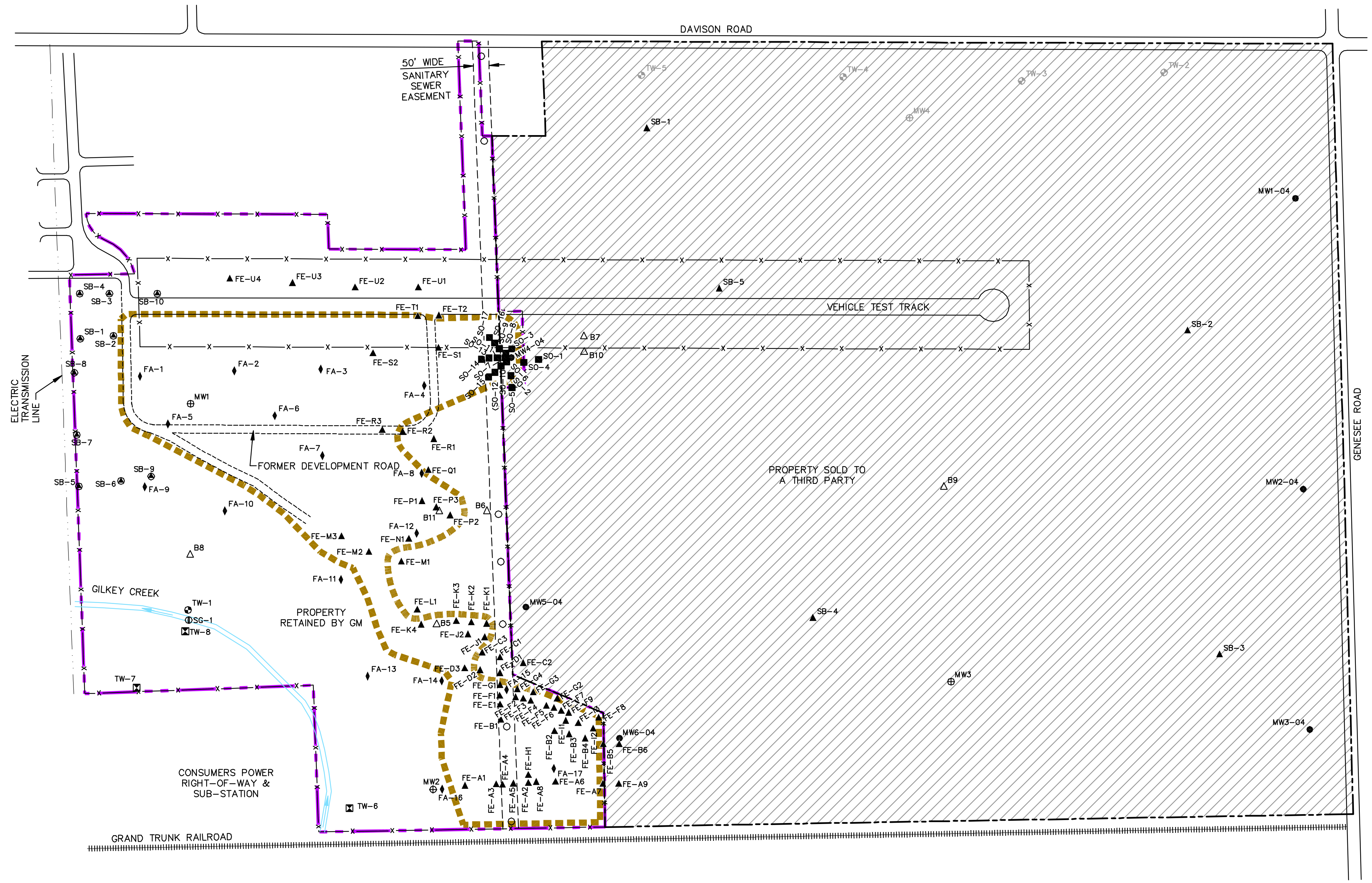
Appendix A

Historical Data Figures



LEGEND

- PROPERTY SOLD TO A THIRD PARTY
- PROPERTY RETAINED BY GM
- APPROXIMATE EXTENT OF FILL AREA
- FORMER PROPERTY BOUNDARY
- EXISTING ROAD
- RAILROAD
- FENCE
- ELECTRIC TRANSMISSION LINE
- CREEK
- DIRECTION OF CREEK FLOW
- SANITARY SEWER MANHOLE
- SANITARY SEWER EASEMENT
- MW1 HISTORICAL OBSERVATION WELL (5/96)
- MW4 ABANDONED HISTORICAL OBSERVATION WELL
- B1 HISTORICAL SOIL BORING (5/96)
- TW-1 TEMPORARY MONITORING WELL (12/03)
- TW-2 ABANDONED TEMPORARY MONITORING WELL
- SB-4 SOIL BORING (12/03)
- FA-1 SOIL BORING (3/04)
- MW4-04 TEMPORARY MONITORING WELL (4/04)
- SO-1 SOIL BORING (5/04)
- TW-6 TEMPORARY MONITORING WELL (8/07)
- STAFF GAUGE LOCATION
- SB-6 SOIL BORING (8/07)

NOTES:

1. 2003/2004/2007 SAMPLING LOCATIONS COMPLETED BY BBL WERE SURVEYED BY BMJ ENGINEERS & SURVEYORS, INC; HOWEVER, ALL LOCATIONS ILLUSTRATED ARE APPROXIMATE.
2. THE MW4-04 STEPOUT LOCATIONS (MW4-04S01 THROUGH MW4-04S017) ARE PLOTTED USING AN ABBREVIATED LOCATION NAME (SO-1 THROUGH SO-17) DUE TO SPACE LIMITATIONS.
3. BASE MAP PROVIDED BY GM.

0 200' 400'
GRAPHIC SCALE

FLINT DELPHI EAST
BURTON, MICHIGAN
BURTON 56 PROPERTY
FLINT DELPHI EAST FINAL SITE REPORT

SOIL BORING AND MONITORING WELL LOCATION MAP

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infrastructure, environment, facilities

FIGURE
2

BRI-85-PFS LAYER: ON=*, OFF=*REF*
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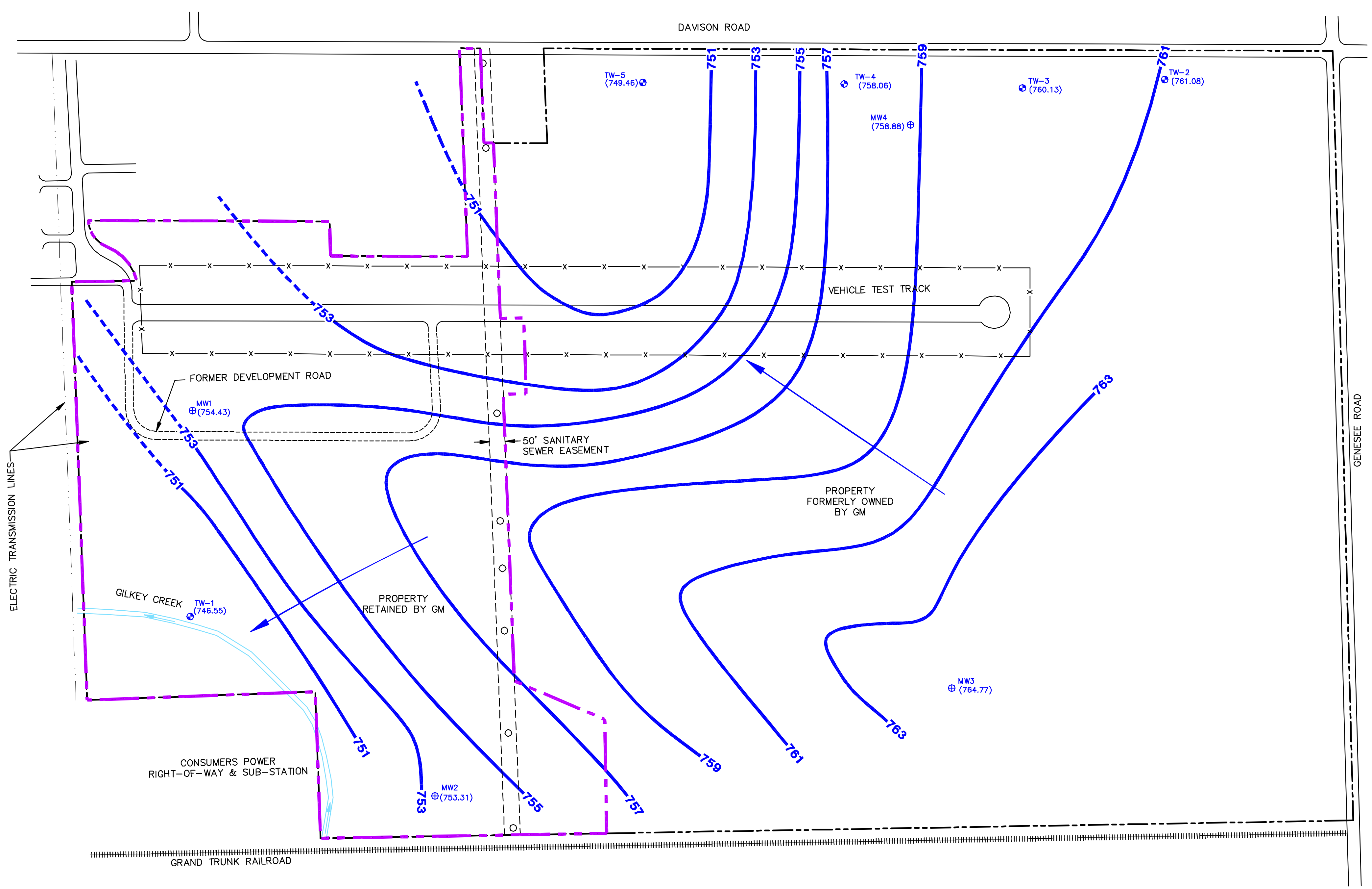


LEGEND

- FORMER PROPERTY BOUNDARY
- PROPERTY RETAINED BY GM
- FENCE
- CREEK
- DIRECTION OF CREEK FLOW
- MW1 MONITORING WELL (5/96)
- TW-5 TEMPORARY MONITORING WELL (12/03)
- (760.13) GROUNDWATER ELEVATION IN FEET (NAVD '88) (MEASUREMENTS TAKEN 1/13/04)
- 759 GROUNDWATER ELEVATION CONTOUR LINE IN FEET (2 FOOT INTERVAL) (DASHED WHERE INFERRED)
- GROUNDWATER FLOW DIRECTION

NOTE:

1. 2003/2004 SAMPLING LOCATIONS COMPLETED BY BBL WERE SURVEYED BY BMJ ENGINEERS & SURVEYORS, INC; HOWEVER, ALL LOCATIONS ILLUSTRATED ARE APPROXIMATE.
2. BASE MAP PROVIDED BY GM.

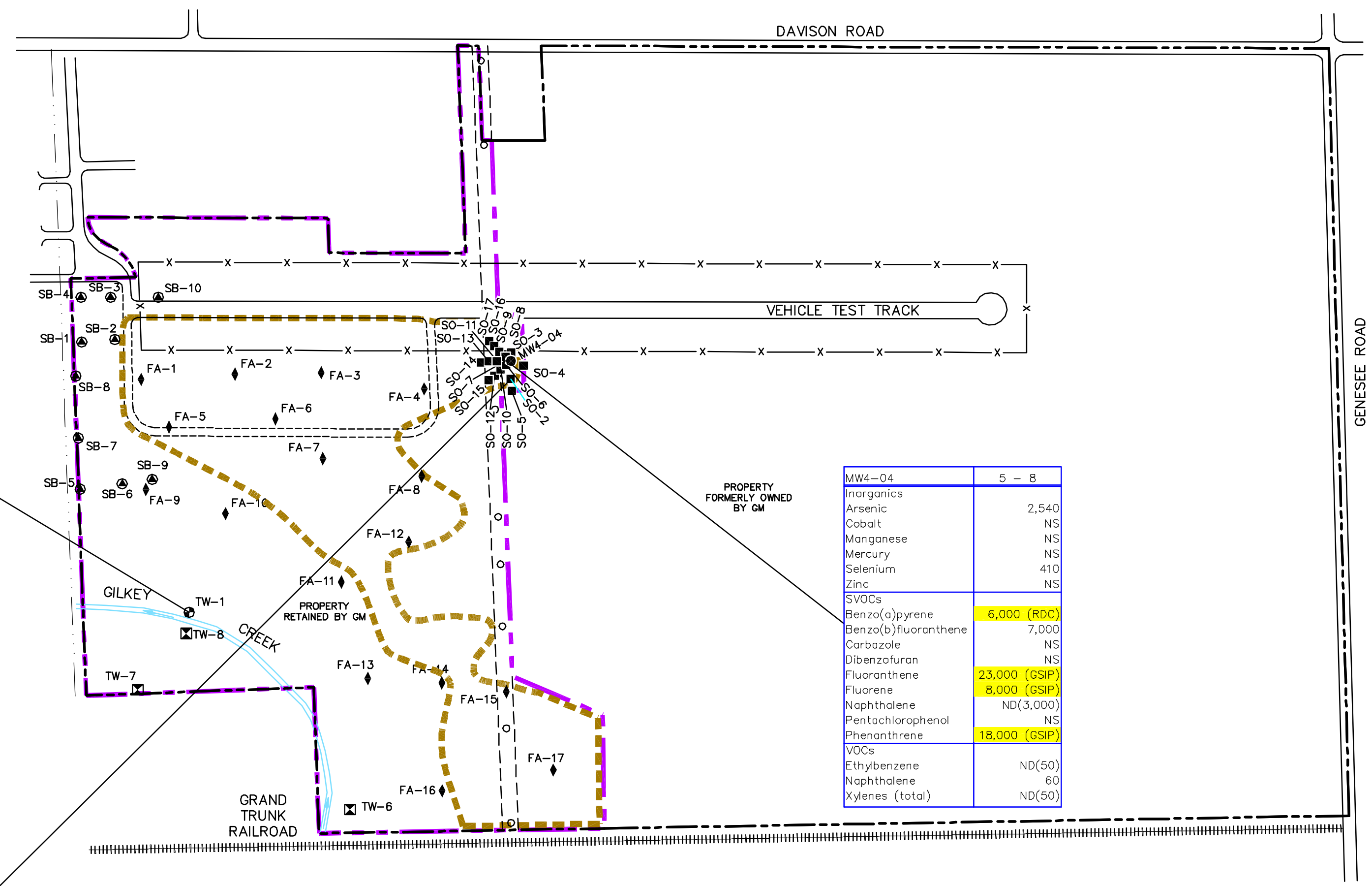
0 200' 400'
GRAPHIC SCALE

FLINT DELPHI EAST
BURTON, MICHIGAN
BURTON 56 PROPERTY
FLINT DELPHI EAST FINAL SITE REPORT

GROUNDWATER FLOW MAP

ARCADIS BBL
infrastructure, environment, facilities

FIGURE
3



TW-1	0 – 2	5.5 – 7.5
Inorganics		
Arsenic	7,900 (RDC)/8,250 (RDC)	1,810
Cobalt	2,600/2,720	1,600
Manganese	149,000/287,000	46,600
Mercury	110/110	ND(100)
Selenium	560 (GSIP)/730 (GSIP)	ND(200)
Zinc	28,300/30,900	7,100
SVOCs		
Benzo(a)pyrene	ND(330)/ND(330)	ND(330)
Benzo(b)fluoranthene	ND(330)/ND(330)	ND(330)
Carbazole	ND(330)/ND(330)	ND(330)
Dibenzofuran	ND(330)/ND(330)	ND(330)
Fluoranthene	10/10	ND(330)
Fluorene	ND(330)/ND(330)	ND(330)
Naphthalene	ND(330)/ND(330)	ND(330)
Pentachlorophenol	ND(700)/ND(700)	ND(700)
Phenanthrene	ND(330)/ND(330)	ND(330)
VOCs		
Ethylbenzene	20/20	20
Naphthalene	NS/NS	NS
Xylenes (total)	ND(70)/ND(70)	ND(60)

SO2	6 – 8
Inorganics	
Arsenic	1,810
Cobalt	NS
Manganese	NS
Mercury	NS
Selenium	390
Zinc	NS
SVOCs	
Benzo(a)pyrene	10,700 (IDC,RDC)
Benzo(b)fluoranthene	13,900
Carbazole	NS
Dibenzofuran	NS
Fluoranthene	28,000 (GSIP)
Fluorene	1,900
Naphthalene	900 (GSIP)
Pentachlorophenol	NS
Phenanthrene	18,200 (GSIP)
VOCs	
Ethylbenzene	ND(50)
Naphthalene	ND(50)
Xylenes (total)	ND(50)

MW4-04	5 – 8
Inorganics	
Arsenic	2,540
Cobalt	NS
Manganese	NS
Mercury	NS
Selenium	410
Zinc	NS
SVOCs	
Benzo(a)pyrene	6,000 (RDC)
Benzo(b)fluoranthene	7,000
Carbazole	NS
Dibenzofuran	NS
Fluoranthene	23,000 (GSIP)
Fluorene	8,000 (GSIP)
Naphthalene	ND(3,000)
Pentachlorophenol	NS
Phenanthrene	18,000 (GSIP)
VOCs	
Ethylbenzene	ND(50)
Naphthalene	60
Xylenes (total)	ND(50)

LEGEND

- FORMER PROPERTY BOUNDARY
- PROPERTY RETAINED BY GM
- APPROXIMATE EXTENT OF FILL AREA
- EXISTING ROAD
- RAILROAD
- FENCE
- ELECTRIC TRANSMISSION LINE
- CREEK
- DIRECTION OF CREEK FLOW
- SANITARY SEWER MANHOLE
- SANITARY SEWER EASEMENT
- TW-1 TEMPORARY MONITORING WELL (12/03)
- FE-A1 SOIL BORING (12/03)
- FA-1 SOIL BORING COMPLETED (3/04)
- MW4-04 TEMPORARY MONITORING WELL (4/04)
- SO-2 SOIL BORING COMPLETED (5/04)
- SB-1 SOIL BORING (8/07)
- TW-7 TEMPORARY MONITORING WELL (8/07)
- CONSTITUENT CONCENTRATION EXCEEDS SCREENING CRITERIA

MICHIGAN PART 201 GENERIC SCREENING CRITERIA FOR SOILS

RDC – RESIDENTIAL DIRECT CONTACT
IDC – INDUSTRIAL DIRECT CONTACT
RDWP – RESIDENTIAL DRINKING WATER PROTECTION
IDWP – INDUSTRIAL DRINKING WATER PROTECTION
GSIP – GROUNDWATER–SURFACE WATER INTERFACE PROTECTION
C4DC – COMMERCIAL IV DIRECT CONTACT

NOTES:

1. 2003/2004 SAMPLING LOCATIONS COMPLETED BY BBL WERE SURVEYED BY BMJ ENGINEERS & SURVEYORS, INC; HOWEVER, ALL LOCATIONS ILLUSTRATED ARE APPROXIMATE.
2. THE MW4–04 STEPOUT LOCATIONS (MW4–04S01 THROUGH MW4–04S017) ARE PLOTTED USING AN ABBREVIATED LOCATION NAME (SO–1 THROUGH SO–17) DUE TO SPACE LIMITATIONS.
3. BASE MAP PROVIDED BY GM.
4. ALL CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER KILOGRAM (ug/kg).
5. ONLY 2003/2004 DATA ARE PRESENTED.

0 300' 600'
GRAPHIC SCALE

FLINT DELPHI EAST
BURTON, MICHIGAN
BURTON 56 PROPERTY
FLINT DELPHI EAST FINAL SITE REPORT

SOIL ANALYTICAL DATA MAP

ARCADIS BBL
infrastructure, environment, facilities

FIGURE
4

BRI-85-PFS LAYER: ON=*, OFF=*REF*
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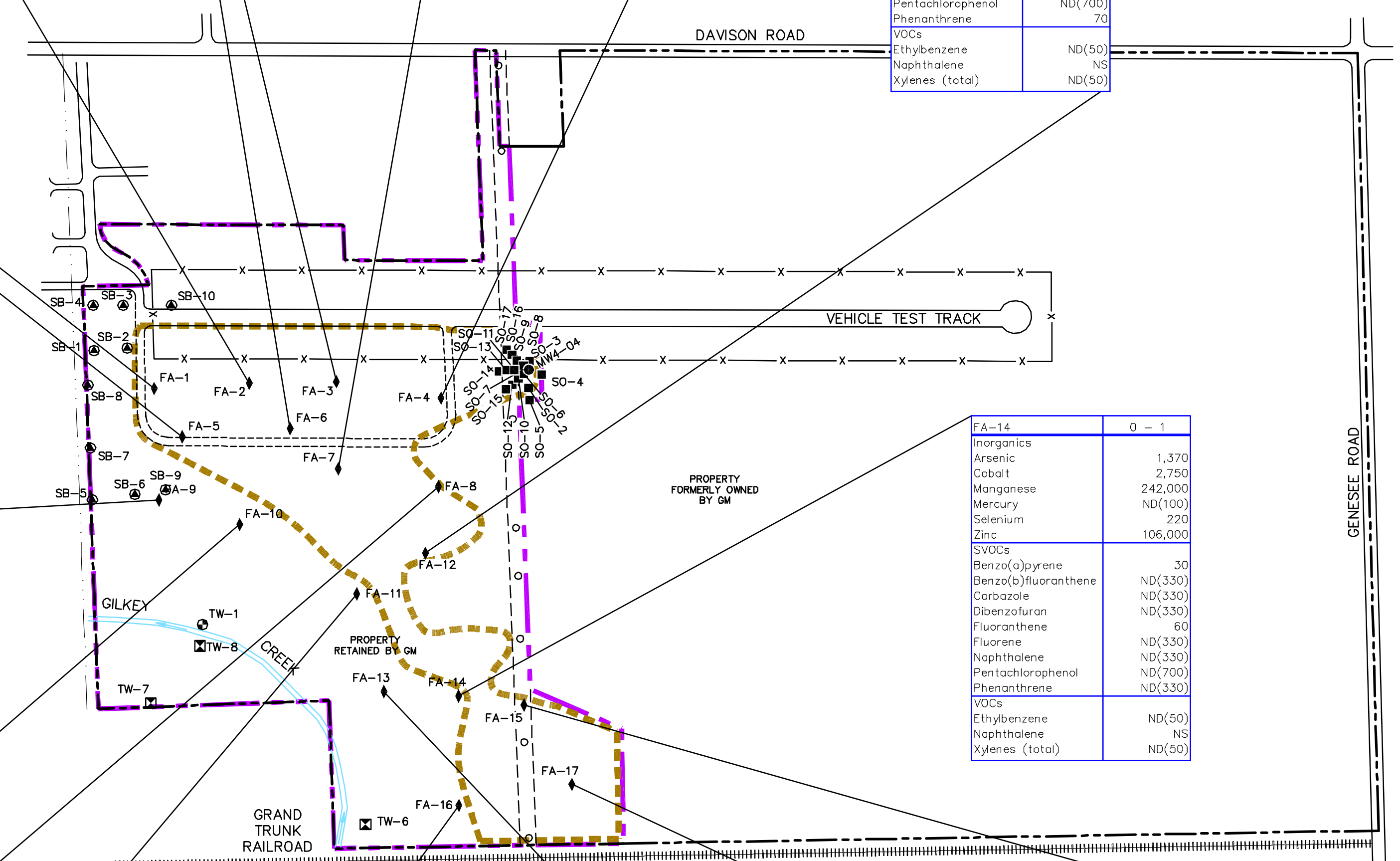


FA-1	0 – 1
Inorganics	
Arsenic	730/650
Cobalt	670/570
Manganese	99,300/75,900
Mercury	ND(100)/ND(100)
Selenium	ND(200)/ND(200)
Zinc	13,000/15,900
SVOCs	
Benzo(a)pyrene	ND(330)/ND(330)
Benzo(b)fluoranthene	ND(330)/50
Carbazole	ND(330)/ND(330)
Dibenzofuran	ND(330)/ND(330)
Fluoranthene	20/50
Fluorene	ND(330)/ND(330)
Naphthalene	60/60
Pentachlorophenol	ND(700)/ND(700)
Phenanthrene	50/70
VOCs	
Ethylbenzene	ND(50)/ND(50)
Naphthalene	NS/NS
Xylenes (total)	20/ND(50)

FA-2	0 – 1
Inorganics	
Arsenic	770
Cobalt	1,100
Manganese	92,600
Mercury	ND(100)
Selenium	ND(200)
Zinc	10,700
SVOCs	
Benzo(a)pyrene	ND(330)
Benzo(b)fluoranthene	ND(330)
Carbazole	ND(330)
Dibenzofuran	20
Fluoranthene	40
Fluorene	ND(330)
Naphthalene	100
Pentachlorophenol	200 (IDWP,RDWP)
Phenanthrene	100
VOCs	
Ethylbenzene	9
Naphthalene	NS
Xylenes (total)	50

FA-6	0 – 1
Inorganics	
Arsenic	990
Cobalt	3,190
Manganese	191,000
Mercury	ND(100)
Selenium	ND(200)
Zinc	16,700
SVOCs	
Benzo(a)pyrene	40
Benzo(b)fluoranthene	60
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	70
Fluorene	ND(330)
Naphthalene	ND(330)
Pentachlorophenol	ND(700)
Phenanthrene	40
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	26

FA-3	0 – 1
Inorganics	
Arsenic	900
Cobalt	5,460
Manganese	306,000
Mercury	120
Selenium	ND(200)
Zinc	32,300
SVOCs	
Benzo(a)pyrene	700
Benzo(b)fluoranthene	1,000
Carbazole	90
Dibenzofuran	ND(600)
Fluoranthene	1,000
Fluorene	ND(600)
Naphthalene	ND(600)
Pentachlorophenol	ND(600)
Phenanthrene	600
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

FA-7	0 – 1
Inorganics	
Arsenic	2,450
Cobalt	2,080
Manganese	166,000
Mercury	ND(100)
Selenium	ND(200)
Zinc	26,200
SVOCs	
Benzo(a)pyrene	50
Benzo(b)fluoranthene	70
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	100
Fluorene	ND(330)
Naphthalene	ND(330)
Pentachlorophenol	ND(700)
Phenanthrene	50
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

FA-4	0 – 1
Inorganics	
Arsenic	730
Cobalt	4,960
Manganese	250,000
Mercury	ND(100)
Selenium	ND(200)
Zinc	35,300
SVOCs	
Benzo(a)pyrene	ND(330)
Benzo(b)fluoranthene	ND(330)
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	30
Fluorene	ND(330)
Naphthalene	20
Pentachlorophenol	ND(700)
Phenanthrene	30
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	20

FA-12	0 – 1
Inorganics	
Arsenic	1,130
Cobalt	1,540
Manganese	297,000
Mercury	ND(100)
Selenium	ND(200)
Zinc	10,100
SVOCs	
Benzo(a)pyrene	60
Benzo(b)fluoranthene	90
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	70
Fluorene	ND(330)
Naphthalene	40
Pentachlorophenol	ND(700)
Phenanthrene	70
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

FA-5	0 – 1
Inorganics	
Arsenic	2,370
Cobalt	7,980 (GSIP,IDWP,RDWP)
Manganese	453,000 (GSIP,IDWP,RDWP)
Mercury	1,580 (GSIP)
Selenium	ND(200)
Zinc	64,600
SVOCs	
Benzo(a)pyrene	400
Benzo(b)fluoranthene	700
Carbazole	70
Dibenzofuran	ND(600)
Fluoranthene	900
Fluorene	50
Naphthalene	ND(600)
Pentachlorophenol	ND(600)
Phenanthrene	700
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	20

FA-9	0 – 1
Inorganics	
Arsenic	1,230
Cobalt	9,010 (GSIP,IDWP,RDWP)
Manganese	475,000 (GSIP,IDWP,RDWP)
Mercury	ND(100)
Selenium	240
Zinc	52,000
SVOCs	
Benzo(a)pyrene	200
Benzo(b)fluoranthene	1,000
Carbazole	200
Dibenzofuran	60
Fluoranthene	1,600
Fluorene	100
Naphthalene	60
Pentachlorophenol	ND(600)
Phenanthrene	1,300
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

FA-14	0 – 1
Inorganics	
Arsenic	1,370
Cobalt	2,750
Manganese	242,000
Mercury	ND(100)
Selenium	220
Zinc	106,000
SVOCs	
Benzo(a)pyrene	30
Benzo(b)fluoranthene	ND(330)
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	60
Fluorene	ND(330)
Naphthalene	ND(330)
Pentachlorophenol	ND(700)
Phenanthrene	ND(330)
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

FA-10	0 – 1
Inorganics	
Arsenic	1,160
Cobalt	10,600 (GSIP,IDWP,RDWP)
Manganese	681,000 (GSIP,IDWP,RDWP)
Mercury	ND(100)
Selenium	270
Zinc	38,600
SVOCs	
Benzo(a)pyrene	200
Benzo(b)fluoranthene	300
Carbazole	30
Dibenzofuran	40
Fluoranthene	200
Fluorene	ND(600)
Naphthalene	100
Pentachlorophenol	ND(600)
Phenanthrene	200
VOCs	
Ethylbenzene	10
Naphthalene	NS
Xylenes (total)	70

FA-8	0 – 1
Inorganics	
Arsenic	1,080/1,470
Cobalt	4,120/2,420
Manganese	284,000/283,000
Mercury	110/160 (GSIP)
Selenium	220/ND(200)
Zinc	59,600/45,000
SVOCs	
Benzo(a)pyrene	200/200
Benzo(b)fluoranthene	300/400
Carbazole	ND(600)/ND(500)
Dibenzofuran	ND(600)/ND(500)
Fluoranthene	300/500
Fluorene	ND(600)/ND(500)
Naphthalene	ND(600)/ND(500)
Pentachlorophenol	ND(600)/ND(1,000)
Phenanthrene	200/400
VOCs	
Ethylbenzene	ND(50)/ND(50)
Naphthalene	NS/NS
Xylenes (total)	ND(50)/ND(50)

FA-11	0 – 1
Inorganics	
Arsenic	980
Cobalt	3,860
Manganese	328,000
Mercury	ND(100)
Selenium	ND(200)
Zinc	48,700
SVOCs	
Benzo(a)pyrene	ND(600)
Benzo(b)fluoranthene	ND(600)
Carbazole	ND(600)
Dibenzofuran	ND(600)
Fluoranthene	70
Fluorene	ND(600)
Naphthalene	ND(600)
Pentachlorophenol	ND(600)
Phenanthrene	70
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	9

FA-16	0 – 1
Inorganics	
Arsenic	2,350
Cobalt	3,270
Manganese	133,000
Mercury	210 (GSIP)
Selenium	340
Zinc	359,000 (GSIP)
SVOCs	
Benzo(a)pyrene	30
Benzo(b)fluoranthene	ND(330)
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	60
Fluorene	ND(330)
Naphthalene	50
Pentachlorophenol	ND(700)
Phenanthrene	60
VOCs	
Ethylbenzene	7
Naphthalene	NS
Xylenes (total)	30

FA-13	0 – 1
Inorganics	
Arsenic	1,360
Cobalt	3,010
Manganese	229,000
Mercury	ND(100)
Selenium	260
Zinc	17,900
SVOCs	
Benzo(a)pyrene	10
Benzo(b)fluoranthene	ND(330)
Carbazole	ND(330)
Dibenzofuran	ND(330)
Fluoranthene	20
Fluorene	ND(330)
Naphthalene	ND(330)
Pentachlorophenol	ND(700)
Phenanthrene	10
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

FA-17	0 – 1
Inorganics	
Arsenic	670
Cobalt	4,680
Manganese	732,000 (GSIP,IDWP,RDWP)
Mercury	100
Selenium	ND(200)
Zinc	190,000
SVOCs	
Benzo(a)pyrene	16,000 (C4DC,IDC,RDC)
Benzo(b)fluoranthene	27,000 (RDC)
Carbazole	5,000 (GSIP)
Dibenzofuran	2,000 (GSIP)
Fluoranthene	40,000 (GSIP)
Fluorene	4,000
Naphthalene	3,000 (GSIP)
Pentachlorophenol	ND(4,000)
Phenanthrene	35,000 (GSIP)
VOCs	
Ethylbenzene	7
Naphthalene	NS
Xylenes (total)	8

FA-15	0 – 1
Inorganics	
Arsenic	1,040
Cobalt	5,170
Manganese	1,350,000 (GSIP,IDWP,RDWP)
Mercury	180 (GSIP)
Selenium	ND(200)
Zinc	188,000
SVOCs	
Benzo(a)pyrene	1,400
Benzo(b)fluoranthene	2,100
Carbazole	300
Dibenzofuran	200
Fluoranthene	3,600
Fluorene	300
Naphthalene	200
Pentachlorophenol	ND(600)
Phenanthrene	2,700
VOCs	
Ethylbenzene	ND(50)
Naphthalene	NS
Xylenes (total)	ND(50)

LEGEND

- FORMER PROPERTY BOUNDARY
- PROPERTY RETAINED BY GM
- APPROXIMATE EXTENT OF FILL AREA
- EXISTING ROAD
- RAILROAD
- FENCE
- ELECTRIC TRANSMISSION LINE
- CREEK
- DIRECTION OF CREEK FLOW
- SANITARY SEWER MANHOLE
- SANITARY SEWER EASEMENT
- TW-1 TEMPORARY MONITORING WELL (12/03)
- FE-A1 SOIL BORING (12/03)
- FA-1 SOIL BORING COMPLETED (3/04)
- MW4-04 TEMPORARY MONITORING WELL (4/04)
- SO-2 SOIL BORING COMPLETED (5/04)
- SB-1 SOIL BORING (8/07)
- TW-7 TEMPORARY MONITORING WELL (8/07)
- CONSTITUENT CONCENTRATION EXCEEDS SCREENING CRITERIA

MICHIGAN PART 201 GENERIC SCREENING CRITERIA FOR SOILS

RDC – RESIDENTIAL DIRECT CONTACT
IDC – INDUSTRIAL DIRECT CONTACT
RDWP – RESIDENTIAL DRINKING WATER PROTECTION
IDWP – INDUSTRIAL DRINKING WATER PROTECTION
GSIP – GROUNDWATER-SURFACE WATER INTERFACE PROTECTION
C4DC – COMMERCIAL IV DIRECT CONTACT

NOTES:

1. 2003/2004 SAMPLING LOCATIONS COMPLETED BY BBL WERE SURVEYED BY BMJ ENGINEERS & SURVEYORS, INC; HOWEVER, ALL LOCATIONS ILLUSTRATED ARE APPROXIMATE.
2. THE MW4-04 STEPOUT LOCATIONS (MW4-04S01 THROUGH MW4-04S017) ARE PLOTTED USING AN ABBREVIATED LOCATION NAME (SO-1 THROUGH SO-17) DUE TO SPACE LIMITATIONS.
3. BASE MAP PROVIDED BY GM.
4. ALL CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER KILOGRAM (ug/kg).
5. ONLY 2003/2004 DATA ARE PRESENTED.

0 300' 600'
GRAPHIC SCALE

FLINT DELPHI EAST
BURTON, MICHIGAN
BURTON 56 PROPERTY
FLINT DELPHI EAST FINAL SITE REPORT

SOIL ANALYTICAL DATA MAP

ARCADIS BBL
Infrastructure, environment, facilities

FIGURE
5

MW4-04SO17	0 – 2	8 – 10	11 – 13
Inorganics			
Arsenic	1,210	790	800
Cobalt	2,440	1,190	1,150
Manganese	162,000	114,000	111,000
Mercury	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	ND(200)	ND(200)
Zinc	11,100	4,500	5,300
SVOCs			
Benzo(a)pyrene	ND(330)	ND(330)	ND(330)
Benzo(b)fluoranthene	ND(330)	ND(330)	ND(330)
Carbazole	ND(330)	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)	ND(330)
Fluoranthene	ND(330)	ND(330)	ND(330)
Fluorene	ND(330)	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)	ND(700)
Phenanthrene	ND(330)	ND(330)	ND(330)
VOCs			
Ethylbenzene	ND(50)	ND(50)	ND(50)
Naphthalene	NS	NS	NS
Xylenes (total)	ND(50)	ND(50)	ND(50)

MW4-04SO8	0 – 2	8 – 10	10 – 11
Inorganics			
Arsenic	2,600	2,270	3,260/3,580
Cobalt	2,520	1,950	2,250/2,410
Manganese	562,000 (GSIP,IDWP,RDWP)	95,000	271,000/320,000
Mercury	ND(100)	ND(100)	ND(100)/ND(100)
Selenium	ND(200)	ND(200)	ND(200)/300
Zinc	39,700	25,600	20,100/26,900
SVOCs			
Benzo(a)pyrene	ND(600)	ND(330)	ND(1,000)/ND(330)
Benzo(b)fluoranthene	700	ND(330)	ND(1,000)/ND(330)
Carbazole	ND(600)	ND(330)	ND(1,000)/ND(330)
Dibenzofuran	ND(600)	ND(330)	ND(1,000)/ND(330)
Fluoranthene	1,000	ND(330)	ND(1,000)/ND(330)
Fluorene	ND(600)	ND(330)	ND(1,000)/ND(330)
Naphthalene	ND(600)	ND(330)	ND(1,000)/ND(330)
Pentachlorophenol	ND(600)	ND(700)	ND(1,000)/ND(700)
Phenanthrene	ND(600)	ND(330)	ND(1,000)/ND(330)
VOCs			
Ethylbenzene	ND(50)	ND(50)	ND(50)/ND(50)
Naphthalene	NS	NS	NS/NS
Xylenes (total)	ND(50)	ND(50)	ND(50)/ND(50)

MW4-04SO3	0 – 2	8 – 10
Inorganics		
Arsenic	660	860
Cobalt	1,510	720
Manganese	550,000 (GSIP,IDWP,RDWP)	91,900
Mercury	ND(100)	ND(100)
Selenium	ND(200)	ND(200)
Zinc	4,200	4,100
SVOCs		
Benzo(a)pyrene	ND(330)	ND(330)
Benzo(b)fluoranthene	ND(330)	ND(330)
Carbazole	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)
Fluoranthene	ND(330)	ND(330)
Fluorene	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)
Phenanthrene	ND(330)	ND(330)
VOCs		
Ethylbenzene	ND(50)	ND(50)
Naphthalene	NS	NS
Xylenes (total)	ND(50)	ND(50)

MW4-04SO7	0 – 2	8 – 10	10 – 12
Inorganics			
Arsenic	2,420	2,010	2,250
Cobalt	2,580	1,980	2,610
Manganese	393,000	197,000	189,000
Mercury	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	210	ND(200)
Zinc	41,000	33,200	24,700
SVOCs			
Benzo(a)pyrene	730	ND(3,000)	ND(2,000)
Benzo(b)fluoranthene	1,110	ND(3,000)	ND(2,000)
Carbazole	ND(330)	ND(3,000)	ND(2,000)
Dibenzofuran	ND(330)	ND(3,000)	ND(2,000)
Fluoranthene	1,710	3,000	ND(2,000)
Fluorene	ND(330)	ND(3,000)	ND(2,000)
Naphthalene	ND(330)	ND(3,000)	ND(2,000)
Pentachlorophenol	ND(700)	ND(3,000)	ND(2,000)
Phenanthrene	1,030	ND(3,000)	ND(2,000)
VOCs			
Ethylbenzene	ND(50)	ND(50)	ND(50)
Naphthalene	NS	NS	NS
Xylenes (total)	ND(50)	ND(50)	ND(50)

MW4-04SO9	0 – 2	8 – 10
Inorganics		
Arsenic	2,700	660
Cobalt	2,800	900
Manganese	570,000 (GSIP,IDWP,RDWP)	91,200
Mercury	ND(100)	ND(100)
Selenium	ND(200)	ND(200)
Zinc	38,900	4,300
SVOCs		
Benzo(a)pyrene	430	ND(330)
Benzo(b)fluoranthene	670	ND(330)
Carbazole	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)
Fluoranthene	950	ND(330)
Fluorene	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)
Phenanthrene	500	ND(330)
VOCs		
Ethylbenzene	ND(50)	ND(50)
Naphthalene	NS	NS
Xylenes (total)	ND(50)	ND(50)

MW4-04SO4	0 – 2	8 – 10
Inorganics		
Arsenic	1,270	520
Cobalt	4,740	1,830
Manganese	286,000	157,000
Mercury	ND(100)	ND(100)
Selenium	ND(200)	ND(200)
Zinc	13,600	3,200
SVOCs		
Benzo(a)pyrene	ND(330)	ND(330)
Benzo(b)fluoranthene	ND(330)	ND(330)
Carbazole	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)
Fluoranthene	ND(330)	ND(330)
Fluorene	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)
Phenanthrene	ND(330)	ND(330)
VOCs		
Ethylbenzene	ND(50)	ND(50)
Naphthalene	NS	NS
Xylenes (total)	ND(50)	ND(50)

MW4-04SO14	0 – 2	8 – 10	10 – 12
Inorganics			
Arsenic	2,050	560	840
Cobalt	2,890	1,130	980
Manganese	281,000	101,000	95,000
Mercury	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	ND(200)	ND(200)
Zinc	43,200	3,600	5,700
SVOCs			
Benzo(a)pyrene	450	ND(330)	ND(330)
Benzo(b)fluoranthene	820	ND(330)	ND(330)
Carbazole	ND(330)	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)	ND(330)
Fluoranthene	890	ND(330)	ND(330)
Fluorene	ND(330)	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)	ND(700)
Phenanthrene	410	ND(330)	ND(330)
VOCs			
Ethylbenzene	ND(50)	ND(50)	ND(50)
Naphthalene	NS	NS	NS
Xylenes (total)	ND(50)	ND(50)	ND(50)

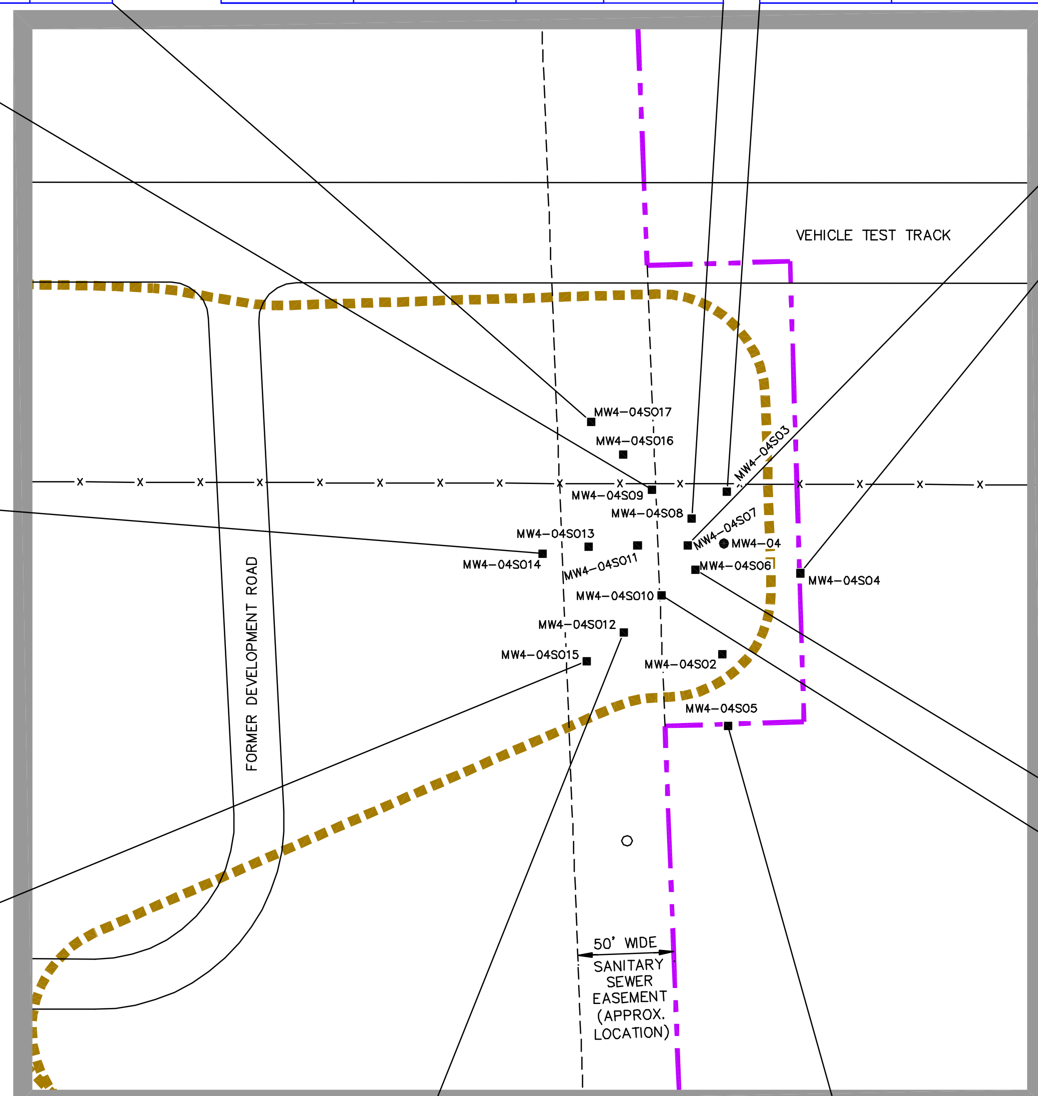
MW4-04SO6	0 – 2	8 – 10	10 – 11
Inorganics			
Arsenic	2,200	2,390	5,230
Cobalt	2,990	2,450	2,790
Manganese	329,000	237,000	357,000
Mercury	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	ND(200)	ND(200)
Zinc	116,000	23,900	27,500
SVOCs			
Benzo(a)pyrene	640	ND(7,000)	ND(330)
Benzo(b)fluoranthene	990	ND(7,000)	ND(330)
Carbazole	ND(330)	ND(7,000)	ND(330)
Dibenzofuran	ND(330)	ND(7,000)	ND(330)
Fluoranthene	1,370	ND(7,000)	ND(330)
Fluorene	ND(330)	ND(7,000)	ND(330)
Naphthalene	ND(330)	ND(7,000)	ND(330)
Pentachlorophenol	ND(700)	ND(7,000)	ND(700)
Phenanthrene	720	ND(7,000)	ND(330)
VOCs			
Ethylbenzene	ND(50)	250	410 (GSIP)
Naphthalene	NS	NS	NS
Xylenes (total)	ND(50)	1,570 (GSIP)	2,350 (GSIP)

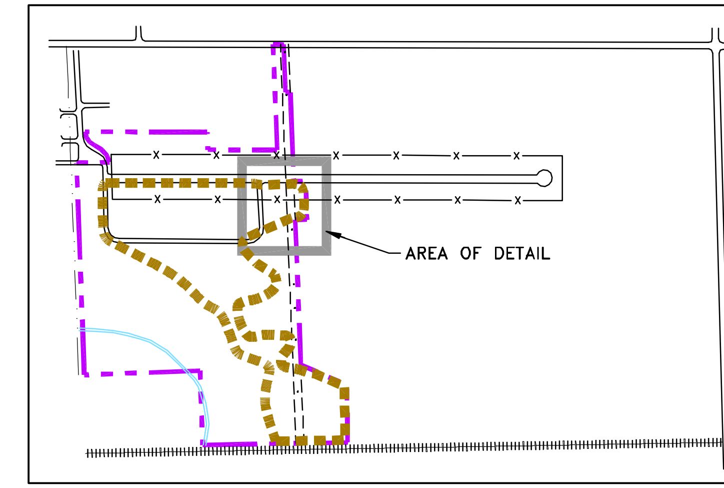
MW4-04SO15	0 – 2	5 – 7	8 – 10	10 – 12
Inorganics				
Arsenic	1,900	840	1,240	1,320
Cobalt	2,850	1,490	1,460	1,000
Manganese	308,000	132,000	177,000	98,000
Mercury	ND(100)	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	ND(200)	ND(200)	220
Zinc	81,500	4,100	4,900	11,400
SVOCs				
Benzo(a)pyrene	370	ND(330)	ND(330)	ND(330)
Benzo(b)fluoranthene	570	ND(330)	ND(330)	ND(330)
Carbazole	ND(330)	ND(330)	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)	ND(330)	ND(330)
Fluoranthene	760	ND(330)	ND(330)	ND(330)
Fluorene	ND(330)	ND(330)	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)	ND(700)	ND(700)
Phenanthrene	600	ND(330)	ND(330)	ND(330)
VOCs				
Ethylbenzene	ND(50)	ND(50)	ND(50)	ND(50)
Naphthalene	NS	NS	NS	NS
Xylenes (total)	ND(50)	ND(50)	ND(50)	ND(50)

MW4-04SO10	0 – 2	7 – 8	8 – 10	10 – 11
Inorganics				
Arsenic	1,320	920	1,710	1,960
Cobalt	2,180	1,040	1,050	1,630
Manganese	340,000	72,300	115,000	178,000
Mercury	ND(100)	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	ND(200)	ND(200)	ND(200)
Zinc	57,100	4,300	4,800	17,100
SVOCs				
Benzo(a)pyrene	2,570 (RDC)	ND(330)	ND(330)	ND(400)
Benzo(b)fluoranthene	4,370	ND(330)	ND(330)	ND(400)
Carbazole	ND(330)	ND(330)	ND(330)	ND(400)
Dibenzofuran	ND(330)	ND(330)	ND(330)	ND(400)
Fluoranthene	7,680 (GSIP)	ND(330)	ND(330)	ND(400)
Fluorene	ND(330)	ND(330)	ND(330)	ND(400)
Naphthalene	ND(330)	ND(330)	ND(330)	ND(400)
Pentachlorophenol	ND(700)	ND(700)	ND(700)	ND(700)
Phenanthrene	1,600	ND(330)	ND(330)	ND(400)
VOCs				
Ethylbenzene	ND(50)	ND(50)	ND(50)	ND(50)
Naphthalene	NS	NS	NS	NS
Xylenes (total)	ND(50)	ND(50)	ND(50)	ND(50)

MW4-04SO12	0 – 2	7 – 8	8 – 10	10 – 11
Inorganics				
Arsenic	1,640	880	1,010	1,040/1,200
Cobalt	2,710	1,410	1,530	1,400/1,600
Manganese	339,000	146,000	143,000	132,000/147,000
Mercury	ND(100)	ND(100)	ND(100)	ND(100)/ND(100)
Selenium	ND(200)	ND(200)	ND(200)	ND(200)/ND(200)
Zinc	56,100	5,600	5,500	5,700/10,800
SVOCs				
Benzo(a)pyrene	620	ND(330)	ND(330)	ND(330)/ND(330)
Benzo(b)fluoranthene	1,040	ND(330)	ND(330)	ND(330)/ND(330)
Carbazole	ND(330)	ND(330)	ND(330)	ND(330)/ND(330)
Dibenzofuran	ND(330)	ND(330)	ND(330)	ND(330)/ND(330)
Fluoranthene	1,300	ND(330)	ND(330)	ND(330)/ND(330)
Fluorene	ND(330)	ND(330)	ND(330)	ND(330)/ND(330)
Naphthalene	ND(330)	ND(330)	ND(330)	ND(330)/ND(330)
Pentachlorophenol	ND(700)	ND(700)	ND(700)	ND(700)/ND(700)
Phenanthrene	740	ND(330)	ND(330)	ND(330)/ND(330)
VOCs				
Ethylbenzene	ND(50)	ND(50)	ND(50)	ND(50)/ND(50)
Naphthalene	NS	NS	NS	NS/NS
Xylenes (total)	ND(50)	ND(50)	ND(50)	ND(50)/ND(50)

MW4-04SO5	0 – 2	8 – 10	11 – 13
Inorganics			
Arsenic	580	470	1,110
Cobalt	1,940	1,020	2,150
Manganese	61,300	95,500	148,000
Mercury	ND(100)	ND(100)	ND(100)
Selenium	ND(200)	ND(200)	ND(200)
Zinc	7,700	2,500	8,000
SVOCs			
Benzo(a)pyrene	ND(330)	ND(330)	ND(330)
Benzo(b)fluoranthene	ND(330)	ND(330)	ND(330)
Carbazole	ND(330)	ND(330)	ND(330)
Dibenzofuran	ND(330)	ND(330)	ND(330)
Fluoranthene	ND(330)	ND(330)	ND(330)
Fluorene	ND(330)	ND(330)	ND(330)
Naphthalene	ND(330)	ND(330)	ND(330)
Pentachlorophenol	ND(700)	ND(700)	ND(700)
Phenanthrene	ND(330)	ND(330)	ND(330)
VOCs			
Ethylbenzene	ND(50)	ND(50)	ND(50)
Naphthalene	NS	NS	NS
Xylenes (total)	ND(50)	ND(50)	ND(50)





NOT TO SCALE

LEGEND:

- PROPERTY RETAINED BY GM
- APPROXIMATE EXTENT OF FILL AREA
- ROAD
- FENCE
- SANITARY SEWER MANHOLE
- APPROXIMATE LOCATION OF SANITARY SEWER EASEMENT
- MW4-04SO5 SOIL BORING (5/04)
- MW4-04 TEMPORARY MONITORING WELL (4/04)
- CONSTITUENT CONCENTRATION EXCEEDS SCREENING CRITERIA

MICHIGAN PART 201 GENERIC SCREENING CRITERIA FOR SOILS
RDC – RESIDENTIAL DIRECT CONTACT
RDWP – RESIDENTIAL DRINKING WATER PROTECTION
IDWP – INDUSTRIAL DRINKING WATER PROTECTION
GSIP – GROUNDWATER-SURFACE WATER INTERFACE PROTECTION
C4DC – COMMERCIAL IV DIRECT CONTACT

NOTES:

1. 2003/2004 SAMPLING LOCATIONS COMPLETED BY BBL WERE SURVEYED BY BMJ ENGINEERS & SURVEYORS, INC; HOWEVER, ALL LOCATIONS ILLUSTRATED ARE APPROXIMATE.
2. BASE MAP PROVIDED BY GM.
3. ALL CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER KILOGRAM (ug/kg).
4. ONLY 2003/2004 DATA ARE PRESENTED.

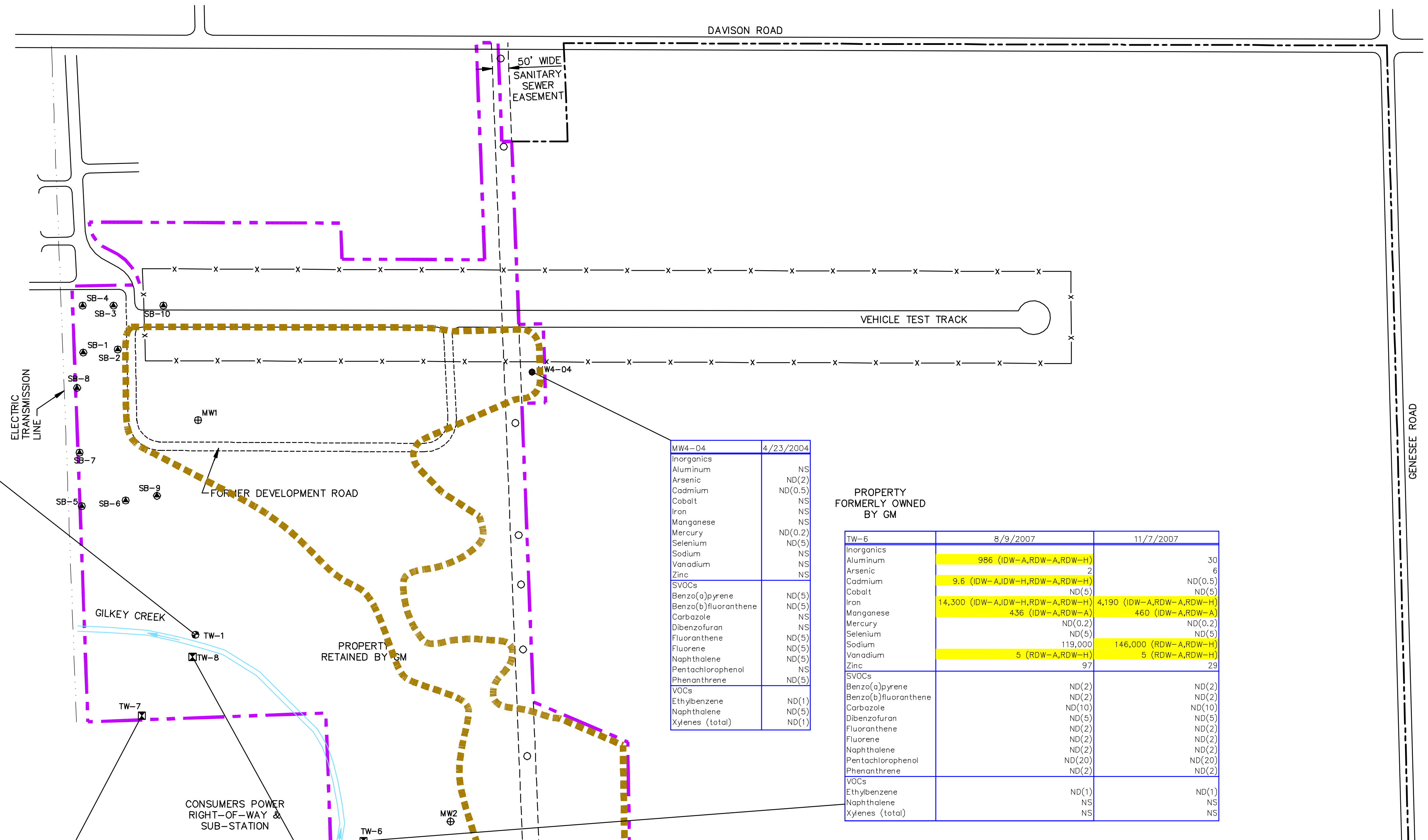
0 50' 100'
GRAPHIC SCALE

GENERAL MOTORS CORPORATION
BURTON, MICHIGAN
BURTON 56 PROPERTY
FLINT DELPHI EAST FINAL SITE REPORT

SOIL ANALYTICAL DATA MAP

ARCADIS BBL
infrastructure, environment, facilities

FIGURE
6



TW-1	12/29/2003
Inorganics	
Aluminum	NS
Arsenic	5
Cadmium	ND(0.5)
Cobalt	ND(10)
Iron	NS
Manganese	1,200 (IDW-A,RDW-A,RDW-H)
Mercury	ND(0.1)
Selenium	ND(5)
Sodium	NS
Vanadium	ND(5)
Zinc	ND(10)
Inorganics-Filtered	
Arsenic	4
Cadmium	ND(0.5)
Cobalt	ND(10)
Manganese	1,200 (IDW-A,RDW-A,RDW-H)
Mercury	ND(0.1)
Selenium	ND(5)
Vanadium	ND(5)
Zinc	ND(10)
SVOCs	
Benzo(a)pyrene	ND(5)
Benzo(b)fluoranthene	ND(5)
Carbazole	ND(10)
Dibenzofuran	ND(5)
Fluoranthene	ND(5)
Fluorene	ND(5)
Naphthalene	ND(5)
Pentachlorophenol	ND(20)
Phenanthrene	ND(5)
VOCs	
Ethylbenzene	ND(1)
Naphthalene	NS
Xylenes (total)	ND(1)

MW4-04	4/23/2004
Inorganics	
Aluminum	NS
Arsenic	ND(2)
Cadmium	ND(0.5)
Cobalt	NS
Iron	NS
Manganese	NS
Mercury	ND(0.2)
Selenium	ND(5)
Sodium	NS
Vanadium	NS
Zinc	NS
SVOCs	
Benzo(a)pyrene	ND(5)
Benzo(b)fluoranthene	ND(5)
Carbazole	NS
Dibenzofuran	NS
Fluoranthene	ND(5)
Fluorene	ND(5)
Naphthalene	ND(5)
Pentachlorophenol	NS
Phenanthrene	ND(5)
VOCs	
Ethylbenzene	ND(1)
Naphthalene	ND(5)
Xylenes (total)	ND(1)

TW-6	8/9/2007	11/7/2007
Inorganics		
Aluminum	986 (IDW-A,RDW-A,RDW-H)	30
Arsenic	2	6
Cadmium	9.6 (IDW-A,IDW-H,RDW-A,RDW-H)	ND(0.5)
Cobalt	ND(5)	ND(5)
Iron	14,300 (IDW-A,IDW-H,RDW-A,RDW-H)	4,190 (IDW-A,RDW-A,RDW-H)
Manganese	436 (IDW-A,RDW-A)	460 (IDW-A,RDW-A)
Mercury	ND(0.2)	ND(0.2)
Selenium	ND(5)	ND(5)
Sodium	119,000	146,000 (RDW-A,RDW-H)
Vanadium	5 (RDW-A,RDW-H)	5 (RDW-A,RDW-H)
Zinc	97	29
SVOCs		
Benzo(a)pyrene	ND(2)	ND(2)
Benzo(b)fluoranthene	ND(2)	ND(2)
Carbazole	ND(10)	ND(10)
Dibenzofuran	ND(5)	ND(5)
Fluoranthene	ND(2)	ND(2)
Fluorene	ND(2)	ND(2)
Naphthalene	ND(2)	ND(2)
Pentachlorophenol	ND(20)	ND(20)
Phenanthrene	ND(2)	ND(2)
VOCs		
Ethylbenzene	ND(1)	ND(1)
Naphthalene	NS	NS
Xylenes (total)	NS	NS

TW-7	8/9/2007	11/7/2007
Inorganics		
Aluminum	26	7
Arsenic	ND(1)	ND(1)
Cadmium	ND(0.5)	ND(0.5)
Cobalt	ND(5)	ND(5)
Iron	150	190
Manganese	27	5
Mercury	ND(0.2)	ND(0.2)
Selenium	ND(5)	ND(5)
Sodium	2,810	2,940
Vanadium	ND(4)	ND(4)
Zinc	18	8
SVOCs		
Benzo(a)pyrene	ND(2)	ND(2)
Benzo(b)fluoranthene	ND(2)	ND(2)
Carbazole	ND(10)	ND(10)
Dibenzofuran	ND(5)	ND(5)
Fluoranthene	ND(2)	ND(2)
Fluorene	ND(2)	ND(2)
Naphthalene	ND(2)	ND(2)
Pentachlorophenol	ND(20)	ND(20)
Phenanthrene	ND(2)	ND(2)
VOCs		
Ethylbenzene	ND(1)	ND(1)
Naphthalene	NS	NS
Xylenes (total)	NS	NS

TW-8	8/9/2007	11/7/2007
Inorganics		
Aluminum	ND(5)	15
Arsenic	17 (IDW-A,IDW-H,RDW-A,RDW-H)	16 (IDW-A,IDW-H,RDW-A,RDW-H)
Cadmium	ND(0.5)	ND(0.5)
Cobalt	ND(5)	ND(5)
Iron	1,510 (IDW-A,RDW-A)	1,510 (IDW-A,RDW-A)
Manganese	182 (IDW-A,RDW-A)	161 (IDW-A,RDW-A)
Mercury	ND(0.2)	ND(0.2)
Selenium	ND(5)	ND(5)
Sodium	7,980	8,350
Vanadium	ND(4)	ND(4)
Zinc	ND(5)	76
SVOCs		
Benzo(a)pyrene	ND(2)	ND(2)
Benzo(b)fluoranthene	ND(2)	ND(2)
Carbazole	ND(10)	ND(10)
Dibenzofuran	ND(5)	ND(5)
Fluoranthene	ND(2)	ND(2)
Fluorene	ND(2)	ND(2)
Naphthalene	ND(2)	ND(2)
Pentachlorophenol	ND(20)	ND(20)
Phenanthrene	ND(2)	ND(2)
VOCs		
Ethylbenzene	ND(1)	ND(1)
Naphthalene	NS	NS
Xylenes (total)	NS	NS

LEGEND

- FORMER PROPERTY BOUNDARY
- PROPERTY RETAINED BY GM
- APPROXIMATE EXTENT OF FILL AREA
- EXISTING ROAD
- RAILROAD
- FENCE
- ELECTRIC TRANSMISSION LINE
- CREEK
- DIRECTION OF CREEK FLOW
- SANITARY SEWER MANHOLE
- SANITARY SEWER EASEMENT
- MW1 HISTORICAL OBSERVATION WELL (5/96)
- TW-1 TEMPORARY MONITORING WELL (12/03)
- MW4-04 TEMPORARY MONITORING WELL (4/04)
- TW-6 TEMPORARY MONITORING WELL (8/07)
- SB-6 SOIL BORING (8/07)
- CONSTITUENT CONCENTRATION EXCEEDS SCREENING CRITERIA

MICHIGAN PART 201 GENERIC SCREENING CRITERIA FOR GROUNDWATER

RDW-A – RESIDENTIAL DRINKING WATER-AESTHETIC
RDW-H – RESIDENTIAL DRINKING WATER-HEALTH
IDW-A – INDUSTRIAL DRINKING WATER-AESTHETIC
IDW-H – INDUSTRIAL DRINKING WATER-HEALTH

NOTES:

1. 2003/2004 SAMPLING LOCATIONS COMPLETED BY BBL WERE SURVEYED BY BMJ ENGINEERS & SURVEYORS, INC; HOWEVER, ALL LOCATIONS ILLUSTRATED ARE APPROXIMATE.
2. BASE MAP PROVIDED BY GM.
3. ALL CONCENTRATIONS ARE PRESENTED IN MICROGRAMS PER LITER (ug/L).
4. ONLY 2003/2004/2007 DATA ARE PRESENTED.

0 200' 400'
GRAPHIC SCALE

FLINT DELPHI EAST
BURTON, MICHIGAN
BURTON 56 PROPERTY
FLINT DELPHI EAST FINAL SITE REPORT

GROUNDWATER ANALYTICAL DATA MAP

ARCADIS BBL
infrastructure, environment, facilities

FIGURE 7

Appendix B

ARCADIS Standard Operating Procedures

Imagine the result

Monitoring Well Installation

Rev. #: 3

Rev Date: February 2, 2011

Approval Signatures

Prepared by: ____________________________ Date: 2/2/2011

Reviewed by: ____________________________ Date: 2/2/2011
(Technical Expert)

I. Scope and Application

The procedures set out herein are designed to produce standard groundwater monitoring wells suitable for: (1) groundwater sampling, (2) water level measurement, (3) bulk hydraulic conductivity testing of formations adjacent to the open interval of the well.

Monitoring well boreholes in unconsolidated (overburden) materials are typically drilled using the hollow-stem auger drilling method. Other drilling methods that are also suitable for installing overburden monitoring wells, and are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary with core barrel or roller bit. Direct-push techniques (e.g., Geoprobe or cone penetrometer) and driven well points may also be used in some cases within the overburden. Monitoring wells within consolidated materials such as bedrock are commonly drilled using water-rotary (coring or tri-cone roller bit), air rotary or Rotasonic methods. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling/well depths, site or regional geologic knowledge, type of monitoring to be conducted using the installed well, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools). No polyvinyl chloride (PVC) glue/cement will be used in constructing or retrofitting monitoring wells that will be used for water-quality monitoring. No coated bentonite pellets will be used in the well drilling or construction process. Specifications of materials to be installed in the well will be obtained prior to mobilizing onsite, including:

- well casing;
- bentonite;
- sand; and
- grout.

Well materials will be inspected and, if needed, cleaned prior to installation.

II. Personnel Qualifications

Monitoring well installation activities will be performed by persons who have been trained in proper well installation procedures under the guidance of an experienced field geologist, engineer, or technician. Where field sampling is performed for soil or bedrock characterization, field personnel will have undergone in-field training in soil or bedrock description methods, as described in the appropriate SOP(s) for those activities.

III. Equipment List

The following materials will be available during soil boring and monitoring well installation activities, as required:

- Site Plan with proposed soil boring/well locations;
- Work Plan or Field Sampling Plan (FSP), and site Health and Safety Plan (HASP);
- personal protective equipment (PPE), as required by the HASP;
- traffic cones, delineators, caution tape, and/or fencing as appropriate for securing the work area, if such are not provided by drillers;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);
- soil and/or bedrock logging equipment as specified in the appropriate SOPs;
- appropriate sample containers and labels;
- drum labels as required for investigation derived waste handling;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID);
- ziplock style bags;
- water level or oil/water interface meter;
- locks and keys for securing the well after installation;
- decontamination equipment (bucket, distilled or deionized water, cleansers appropriate for removing expected chemicals of concern, paper towels);

- field notebook.

Prior to mobilizing to the site, ARCADIS personnel will contact the drilling subcontractor or in-house driller (as appropriate) to confirm that appropriate sampling and well installation equipment will be provided. Specifications of the sampling and well installation equipment are expected to vary by project, and so communication with the driller will be necessary to ensure that the materials provided will meet the project objectives. Equipment typically provided by the driller could include:

- drilling equipment required by the American Society of Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- drums for investigation derived waste;
- drilling and sampling equipment decontamination materials;
- decontamination pad materials, if required; and
- well construction materials.

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be delineated by the drilling contractor or an independent underground utility locator service. See separate SOP for utility clearance.

Some regulatory agencies require a minimum annular space between the well or permanent casing and the borehole wall. When specified, the minimum clearance is typically 2 inches on all sides (e.g., a 2-inch diameter well requires a 6-inch diameter borehole). In addition, some regulatory agencies have specific requirements regarding grout mixtures. Determine whether the oversight agency has any such requirements prior to finalizing the drilling and well installation plan.

If dense non-aqueous phase liquids (DNAPL) are known or expected to exist at the site, refer to the DNAPL Contingency Plan SOP for additional details regarding drilling and well installation to reduce the potential for inadvertent DNAPL remobilization.

Similarly, if light non-aqueous phase liquids (LNAPLs) are known or expected to be present as “perched” layers above the water table, refer to the DNAPL Contingency

Plan. Follow the general provisions and concepts in the DNAPL contingency plan during drilling above the water table at known or expected LNAPL sites.

Avoid using drilling fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

Similarly, consider the material compatibility between the well materials and the surrounding environment. For example, PVC well materials are not preferred when DNAPL is present. In addition, some groundwater conditions leach metals from stainless steel.

Water used for drilling and sampling of soil or bedrock, decontamination of drilling/sampling equipment, or grouting boreholes upon completion will be of a quality acceptable for project objectives. Testing of water supply should be considered.

Specifications of materials used for backfilling bore hole will be obtained, reviewed and approved to meet project quality objectives. Bentonite is not recommended where DNAPLs are likely to be present. In these situations, neat cement grout is preferred.

No coated bentonite pellets will be used in monitoring well construction, as the coating could impact the water quality in the completed well.

Monitoring wells may be installed with Schedule 40 polyvinyl chloride (PVC) to a maximum depth of 200 feet below ground surface (bgs). PVC monitoring wells between 200 and 400 feet total depth will be constructed using Schedule 80 PVC. Monitoring wells deeper than 400 feet will be constructed using steel.

V. Health and Safety Considerations

Field activities associated with monitoring well installation will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedures

The procedures for installing groundwater monitoring wells are presented below:

Hollow-Stem Auger, Drive-and-Wash, Spun Casing, Fluid/Mud Rotary, Rotasonic, and Dual-Rotary Drilling Methods

1. Locate boring/well location, establish work zone, and set up sampling equipment decontamination area.

2. Advance boring to desired depth. Collect soil and/or bedrock samples at appropriate interval as specified in the Work Plan and/or FSP. Collect, document, and store samples for laboratory analysis as specified in the Work Plan and/or FSP. Decontaminate equipment between samples in accordance with the Work Plan and/or FSP. A common sampling method that produces high-quality soil samples with relatively little soil disturbance is the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils. Split-spoon samples are obtained during drilling using hollow-stem auger, drive-and-wash, spun casing, and fluid/mud rotary. Rotasonic drilling produces large-diameter soil cores that tend to be more disturbed than split-spoon samples due to the vibratory action of the drill casing. Dual-rotary removes cuttings by compressed air and allows only a general assessment of geology. High-quality bedrock samples can be obtained by coring.

3. Describe each soil or bedrock sample as outlined in the appropriate SOP. Record descriptions in the field notebook and/or personal digital assistant (PDA). It should be noted that PDA logs must be electronically backed up and transferred to a location accessible to other project team members as soon as feasible to retain and protect the field data. During soil boring advancement, document all drilling events in field notebook, including blow counts (number of blows required to advance split-spoon sampler in 6-inch increments) and work stoppages. Blow counts will not be available if Rotasonic, dual-rotary, or direct-push methods are used. When drilling in bedrock, the rate of penetration (minutes per foot) is recorded.

4. If it is necessary to install a monitor well into a permeable zone below a confining layer, particularly if the deeper zone is believed to have water quality that differs significantly from the zone above the confining layer, then a telescopic well construction should be considered. In this case, the borehole is advanced approximately 3 to 5 feet into the top of the confining layer, and a permanent casing (typically PVC, black steel or stainless steel) is installed into the socket drilled into the top of the confining layer. The casing is then grouted in place. The preferred methods of grouting telescoping casings include: pressure-injection grouting using an inflatable packer installed temporarily into the base of the casing, such that grout is injected out the bottom of the casing until it is observed at ground surface outside the casing; displacement-method grouting (also known as the Halliburton method), which entails filling the casing with grout and displacing the grout out the bottom of the casing by pushing a drillable plug, typically made of wood to the bottom of the casing, following by tremie grouting the remainder of the annulus outside the casing; or tremie grouting the annulus surrounding the casing using a tremie pipe installed to the base of the borehole. In all three cases, the casing is grouted to the ground

surface, and the grout is allowed to set prior to drilling deeper through the casing. Site-specific criteria and work plans should be created for the completion of non-standard monitoring wells, including telescopic wells.

5. In consolidated formations such as competent bedrock, a monitoring well may be completed with an open borehole interval without a screen and sandpack. In these cases, the borehole is advanced to the targeted depth of the top of the open interval. A permanent casing is then grouted in place following the procedures described in Step 4 above. After the grout sets, the borehole is advanced by drilling through the permanent casing to the targeted bottom depth of the open interval, which then serves as the monitoring interval for the well. If open-borehole interval stability is found to be questionable or if a specific depth interval is later selected for monitoring, a screened monitoring well may later be installed within the open-borehole interval, depending on the annular space and well diameter requirements.

6. Before installing a screened well – or after drilling an open-bedrock well –, it is important to confirm that the borehole has been advanced into the saturated zone. This is particularly important for wells installed to monitor the water table and/or the shallow saturated zone, as the capillary fringe may cause soils above the water table to appear saturated. If one or more previously installed monitoring wells exist nearby, use the depth to water at such well(s) to estimate the water-table depth at the new borehole location.

   To verify that the borehole has been advanced into the saturated zone, it is necessary to measure the water level in the borehole. For boreholes drilled without using water (e.g., hollow-stem auger, cable-tool, air rotary, air hammer), verify the presence of groundwater (and /or LNAPL, if applicable) in the borehole using an electronic water level probe, oil-water interface probe, or a new or decontaminated bailer. For boreholes drilled using water (e.g., drive and wash, spun-casing with roller-bit wash, rotasonic, or water rotary with core or roller bit), monitor the water level in the borehole as it re-equilibrates to the static level. In low-permeability units like clay, fine-grained glacial tills, shale and other bedrock formations, it may be necessary to wait overnight to allow the water level to equilibrate. To the extent practicable, ensure that the depth of the well below the apparent water table is deep enough so that the installed well can monitor groundwater year-round, accounting for seasonal water-table fluctuations. In most cases, the well should be installed at least five feet below the water-table depth, determined as described above. When in doubt, err on the side of slightly deeper well installation.

If necessary, the borehole should be drilled deeper to ensure that the well may intersects the water table or a permeable water-bearing zone.

7. Upon completing the borehole to the desired depth, if a screened well construction is desired, install the monitoring well by lowering the screen and casing assembly with sump through the augers or casing. Monitoring wells typically will be constructed of 2-inch-diameter, flush-threaded PVC or stainless steel slotted well screen and blank riser casing. Smaller diameters may be used if wells are installed using direct-push methodology or if multiple wells are to be installed in a single borehole. The screen length will be specified in the Work Plan or FSP based on regulatory requirements and specific monitoring objectives. Monitoring well screens are usually 5 to 10 feet long, but may be up to 25 feet long in very low permeability, thick geologic formations. The screen length will depend on the purpose for the well and the objectives of the groundwater investigation. Typically, the slot size will be 0.010 inch and the sand pack will be 20-40, Morie No. 0, or equivalent. In very fine-grained formations where sample turbidity needs to be minimized, it may be preferred to use a 0.006-inch slot size and 30-65, Morie No. 00, or equivalent sand pack. Alternatively, where monitoring wells are installed in coarse-grained deposits and higher well yield is required, a 0.020-inch slot size and 10-20, Morie No. 1, or equivalent sand pack may be preferred. To the extent practicable, the slot size and sand pack gradation may be predetermined in the Work Plan or FSP based on site-specific grain-size analysis or other geologic considerations or monitoring objectives. A blank sump may be attached below the well screen if the well is being installed for DNAPL recovery/monitoring purposes. If so, the annular space around the sump will be backfilled with neat cement grout to the bottom of the well screen prior to placing the sand pack around the screen. A blank riser will extend from the top of the screen to approximately 2.5 feet above grade or, if necessary, just below grade where conditions warrant a flush-mounted monitoring well. For wells greater than 50 feet deep, centralizers may be desired to assist in centralizing the monitoring well in the borehole during construction.

8. When the monitoring well assembly has been set in place and the grout has been placed around the sump (if any), place a washed silica sand pack in the annular space from the bottom of the boring to a height of 1 to 2 feet above the top of the well screen. The sand pack is placed and drilling equipment extracted in increments until the top of the sand pack is at the appropriate depth. The sand pack will be consistent with the screen slot size and the soil particle size in the screened interval, as specified in the Work Plan or FSP. A hydrated bentonite seal (a minimum of 2 feet thick) will then be placed in the annular space above the sand pack. If non-hydrated bentonite is used, the bentonite

should be permitted to hydrate in place for a minimum of 30 minutes before proceeding. No coated bentonite pellets will be used in monitoring well drilling or construction. Potable water may be added to hydrate the bentonite if the seal is above the water table. Monitor the placement of the sand pack and bentonite with a weighted tape measure. During the extraction of the augers or casing, a cement/bentonite or neat cement grout will be placed in the annular space from the bentonite seal to a depth approximately 2 feet bgs.

9. Place a locking, steel protective casing (extended at least 1.5 feet below grade and 2 feet above grade) over the riser casing and secure with a neat cement seal. Alternatively, for flush-mount completions, place a steel curb box with a bolt-down lid over the riser casing and secure with a neat cement seal. In either case, the cement seal will extend approximately 1.5 to 2.0 feet below grade and laterally at least 1 foot in all directions from the protective casing, and should slope gently away to promote drainage away from the well. Monitoring wells will be labeled with the appropriate designation on both the inner and outer well casings or inside of the curb box lid.

   When an above-grade completion is used, the PVC riser will be sealed using an expandable locking plug and the top of the well will be vented by drilling a small-diameter (1/8 inch) hole near the top of the well casing or through the locking plug, or by cutting a vertical slot in the top of the well casing. When a flush-mount installation is used, the PVC riser will be sealed using an unvented, expandable locking plug.

10. During well installation, record construction details and actual measurements relayed by the drilling contractor and tabulate materials used (e.g., screen and riser footages; bags of bentonite, cement, and sand) in the field notebook.

11. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Direct-Push Method

The direct-push drilling method may also be used to complete soil borings and install monitoring wells. Examples of this technique include the Diedrich ESP vibratory probe system, GeoProbe®, or AMS Power Probe® dual-tube system. Environmental probe systems typically use a hydraulically operated percussion hammer. Depending on the equipment used, the hammer delivers 140- to 350-foot pounds of energy with each blow. The hammer provides the force needed to penetrate very stiff/medium dense soil formations. The hammer simultaneously advances an outer steel casing that contains a dual-tube liner for sampling soil. The outside diameter (OD) of the outer casing ranges from 1.75 to 2.4 inches and the OD of the inner sampling tube ranges from 1.1 to 1.8 inches. The outer casing isolates shallow layers and permits the unit to continue to probe at depth. The double-rod system provides a borehole that may be tremie-grouted from the bottom up. Alternatively, the inside diameter (ID) of the steel casing provides clearance for the installation of small-diameter (e.g., 0.75- to 1-inch ID) micro-wells. The procedures for installing monitoring wells in soil using the direct-push method are described below.

1. Locate boring/well location, establish work zone, and set up sample equipment decontamination area.

2. Advance soil boring to designated depth, collecting samples at intervals specified in the Work Plan. Samples will be collected using dedicated, disposable, plastic liners. Describe samples in accordance with the procedures outlined in Step 3 above. Collect samples for laboratory analysis as specified in the Work Plan and/or FSP.

3. Upon advancing the borehole to the desired depth, install the micro-well through the inner drill casing. The micro-well will consist of approximately 1-inch ID PVC or stainless steel slotted screen and blank riser. The sand pack, bentonite seal, and cement/bentonite grout will be installed as described, where applicable, in Step 7 and 8 above.

4. Install protective steel casing or flush-mount, as appropriate, as described in Step 9 above. During well installation, record construction details and tabulate materials used.

5. After completing the well installation, lock the well, clean the area, and dispose of materials in accordance with the procedures outlined in Section VII below.

Driven Well Point Installation

Well points will be installed by pushing or driving using a drilling rig or direct-push rig, or hand-driven where possible. The well point construction materials will consist of a 1- to 2-inch-diameter threaded steel casing with either 0.010- or 0.020-inch slotted stainless steel screen. The screen length will vary depending on the hydrogeologic conditions of the site. The casings will be joined together with threaded couplings and the terminal end will consist of a steel well point. Because they are driven or pushed to the desired depth, well points do not have annular backfill materials such as sand pack or grout.

VII. Waste Management

Investigation-derived wastes (IDW), including soil cuttings and excess drilling fluids (if used), decontamination liquids, and disposable materials (well material packages, PPE, etc.), will be placed in clearly labeled, appropriate containers, or managed as otherwise specified in the Work Plan, FSP, and/or IDW management SOP.

VIII. Data Recording and Management

Drilling activities will be documented in a field notebook. Pertinent information will include personnel present on site, times of arrival and departure, significant weather conditions, timing of well installation activities, soil descriptions, well construction specifications (screen and riser material and diameter, sump length, screen length and slot size, riser length, sand pack type), and quantities of materials used. In addition, the locations of newly-installed wells will be documented photographically or in a site sketch. If appropriate, a measuring wheel or engineer's tape will be used to determine approximate distances between important site features.

The well or piezometer location, ground surface elevation, and inner and outer casing elevations will be surveyed using the method specified in the site Work Plan. Generally, a local baseline control will be set up. This local baseline control can then be tied into the appropriate vertical and horizontal datum, such as the National Geodetic Vertical Datum of 1929 or 1988 and the State Plane Coordinate System. At a minimum, the elevation of the top of the inner casing used for water-level measurements should be measured to the nearest 0.01 foot. Elevations will be established in relation to the National Geodetic Vertical Datum of 1929. A permanent mark will be placed on top of the inner casing to mark the point for water-level measurements.

IX. Quality Assurance

All drilling equipment and associated tools (including augers, drill rods, sampling equipment, wrenches, and any other equipment or tools) that may have come in contact with soil will be cleaned in accordance with the procedures outlined in the appropriate SOP. Well materials will also be cleaned prior to well installation.

X. References

American Society of Testing and Materials (ASTM) D 1586 - *Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils*.

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Monitoring Well Development

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Approval Signatures

Prepared by: David S. Liprie Date: 03/22/2010

Reviewed by: Michael J. Gefell Date: 03/22/2010
(Technical Expert)

I. Scope and Application

Monitoring wells (or piezometers, well points, or micro-wells) will be developed to clear them of fine-grained sediment to enhance the hydraulic connection between the well and the surrounding geologic formation. Development will be accomplished by evacuating well water by either pumping or bailing. Prior to pumping or bailing, the screened interval will be gently surged using a surge block, bailer, or inertia pump with optional surgeblock fitting as appropriate. Accumulated sediment in the bottom of the well (if present) will be removed by bailing with a bottom-loading bailer or via pumping using a submersible or inertia pump with optional surge-block fitting. Wells will also be gently brushed with a weighted brush to assist in removing loose debris, silt or flock attached to the inside of the well riser and/or screen prior to development. Pumping methods will be selected based on site-specific geologic conditions, anticipated well yield, water table depth, and groundwater monitoring objectives, and may include one or more of the following:

- submersible pump
- inertial pump (Waterra™ pump or equivalent)
- bladder pump
- peristaltic pump
- centrifugal pump

When developing a well using the pumping method, the pump (or, with inertial pumps, the tubing) is lowered to the screened portion of the well. During purging, the pump or tubing is moved up and down the screened interval until the well yields relatively clear water.

Submersible pumps have a motor-driven impeller that pushes the groundwater through discharge tubing to the ground surface. Inertial pumps have a check valve at the bottom of stiff tubing which, when operated up and down, lifts water to the ground surface. Bladder pumps have a bottom check valve and a flexible internal bladder that fills from below and is then compressed using pressurized air to force water out the top of the bladder through the discharge tubing to the ground surface. These three types of pumps have a wide range of applicability in terms of well depth and water depth.

Centrifugal and peristaltic pumps use atmospheric pressure to lift water from the well, and therefore can only be practically used where the depth to water is less than 25 feet.

II. Personnel Qualifications

Monitoring well development activities will be performed by persons who have been trained in proper well development procedures under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

Materials for monitoring well development using a pump include the following:

- health and safety equipment, as required by the site Health and Safety Plan (HASP):
- cleaning equipment
- photoionization detector (PID) to measure headspace vapors
- pump
- polyethylene pump discharge tubing
- plastic sheeting
- power source (generator or battery)
- field notebook and/or personal digital assistant (PDA)
- graduated pails
- appropriate containers

- monitoring well keys
- water level indicator

Materials for monitoring well development using a bailer include the following:

- personal protective equipment (PPE) as required by the HASP
- cleaning equipment
- PID to measure headspace vapors
- bottom-loading bailer, sand bailer
- polypropylene or nylon rope
- plastic sheeting
- graduated pails
- appropriate containers
- keys to wells
- field notebook and/or PDA
- water level indicator
- weighted brush for well brushing

IV. Cautions

Where surging is performed to assist in removing fine-grained material from the sand pack, surging must be performed in a gentle manner. Excessive suction could promote fine-grained sediment entry into the outside of the sand pack from the formation.

Avoid using development fluids or materials that could impact groundwater or soil quality, or could be incompatible with the subsurface conditions.

In some cases it may be necessary to add potable water to a well to allow surging and development, especially for new monitoring wells installed in low permeability formations. Before adding potable water to a well, the Project Manager (PM) must be notified and the PM shall make the decision regarding the appropriateness and applicability of adding potable water to a well during well development procedures. If potable water is to be added to a well as part of development, the potable water source should be sampled and analyzed for constituents of concern, and the results evaluated by the PM prior to adding the potable water to the well. If potable water is added to a well for development purposes, at the end of development the well will be purged dry to remove the potable water, or if the well no longer goes dry then the well will be purged to remove at least three times the volume of potable water that was added.

V. Health and Safety Considerations

Field activities associated with monitoring well development will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

The procedures for monitoring well development are described below. (Note: Steps 7, 8, and 10 can be performed at the same time using an inertial pump with a surge-block fitting.)

1. Don appropriate PPE (as required by the HASP).

2. Place plastic sheeting around the well.

3. Clean all equipment entering each monitoring well, except for new, disposable materials that have not been previously used.

4. Open the well cover while standing upwind of the well, remove well cap. Insert PID probe approximately 4 to 6 inches into the casing or the well headspace and cover with gloved hand. Record the PID reading in the field notebook. If the well headspace reading is less than 5 PID units, proceed; if the headspace reading is greater than 5 PID units, screen the air within the breathing zone. If the PID reading in the breathing zone is below 5 PID units, proceed. If the PID reading is above 5 PID units, move upwind from well for 5 minutes to allow the volatiles to dissipate. Repeat the breathing zone test. If the reading is still above 5 PID units, don the appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings.

5. Obtain an initial measurement of the depth to water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

6. Prior to redeveloping older wells that may contain solid particulate debris along the inside of the well casing and screen, gently lower and raise a weighted brush along the entire length of the well screen and riser to free and assist in removing loose debris, silt or flock. Perform a minimum of 4 “passes” along the screened and cased intervals of the well below the static water level in the well. Allow the resulting suspended material to settle for a minimum of one day prior to continuing with redevelopment activities.

7. Lower a surge block or bailer into the screened portion of the well. Gently raise and lower the surge block or bailer within the screened interval of the well to force water in and out of the screen slots and sand pack. Continue surging for 15 to 30 minutes.

8. Lower a bottom-loading bailer, submersible pump, or inertia pump tubing with check valve to the bottom of the well and gently bounce the bailer, pump, pump tubing on the bottom of the well to collect/remove accumulated sediment, if any. Remove and empty the bailer, if used. Repeat until the bailed/pumped water is free of excessive sediment and the bottom of the well feels solid. Alternatively, measurement of the well depth with a water level indicator can be used to verify that sediment and/or silt has been removed to the extent practicable, based on a comparison with the well installation log or previous measurement of total well depth.

9. After surging the well and removing excess accumulated sediment from the bottom of the well, re-measure the depth-to-water and the total well depth from the reference point at the top of the well casing. Record these measurements in the field log book.

10. Remove formation water by pumping or bailing. Where pumping is used, measure and record the pre-pumping water level. Operate the pump at a relatively constant rate. Measure the pumping rate using a calibrated container and stop watch, and record the pumping rate in the field log book. Measure and record the water level in the well at least

once every 5 minutes during pumping. Note any relevant observations in terms of water color, visual level of turbidity, sheen, odors, etc. Pump or bail until termination criteria specified in the Field Sampling Plan (FSP) are reached. Record the total volume of water purged from the well.

11. If the well goes dry, stop pumping or bailing. Note the time that the well went dry. After allowing the well to recover, note the time and depth to water. Resume pumping or bailing when sufficient water has recharged the well.

12. Contain all water in appropriate containers.

13. When complete, secure the lid back on the well.

14. Place disposable materials in plastic bags for appropriate disposal and decontaminate reusable, downhole pump components and/or bailer.

VII. Waste Management

Materials generated during monitoring well installation and development will be placed in appropriate labeled containers and disposed of as described in the Work Plan or Field Sampling Plan.

VIII. Data Recording and Management

Well development activities will be documented in a proper field notebook and/or PDA. Pertinent information will include personnel present on site; times of arrival and departure; significant weather conditions; timing of well development activities; development method(s); observations of purge water color, turbidity, odor, sheen, etc.; purge rate; and water levels before and during pumping.

IX. Quality Assurance

All reused, non-disposable, downhole well development equipment will be cleaned in accordance with the procedures outlined in the Field Equipment Cleaning-Decontamination SOP.

X. References

Not applicable.

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Specific Capacity Testing and Data Reduction

Rev. #: 2

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Approval Signatures

Prepared by: ______________________ Date: 2/27/09
Michael Gefell

Reviewed by: ______________________ Date: 2/27/09
Jerry Shi (Technical Expert)

I. Scope and Application

Specific-capacity testing is a field method used to estimate the transmissivity of a saturated geologic medium surrounding the screened or open interval of a well. A specific-capacity test involves pumping groundwater from a well at a constant rate and quantifying the pumping rate and magnitude of drawdown inside the tested well after a known duration of pumping. Specific-capacity tests are also referred to as single-well pumping tests or constant-rate tests.

The transmissivity is calculated based on the pumping rate and drawdown measured inside the pumped well. Time-drawdown analysis can be performed with a semilog data plot to estimated transmissivity (Driscoll, 1986). Alternatively, an iterative calculation can be performed based on the pumping duration, the effective radius of the well, and storativity of the formation.

If the thickness of the effective water-bearing zone transmitting groundwater to the well intake is assumed to be approximately equal to the length of the intake, the hydraulic conductivity (K) can be estimated by dividing the transmissivity by the length of the intake.

II. Personnel Qualifications

Specific-capacity tests will be performed by persons who have been trained in the proper usage of pumping and water-level measurement equipment under the guidance of an experienced field geologist, engineer, or technician.

III. Equipment List

The equipment needed for specific-capacity testing includes:

- health and safety equipment, as required in the site Health and Safety Plan (HASP);
- cleaning equipment;
- pump (preferably submersible) capable of pumping at a controlled rate between a fraction of one gallon per minute (gpm) and several gpm, equipped with discharge line;
- power source for the pump;
- calibrated in-line totalizing flow meter or two calibrated buckets;

- stopwatch;
- electronic water-level indicator; and
- field notebook.

IV. Cautions

Wells and piezometers have different water-yielding characteristics as a function of their screen lengths, depth below the water table, and geologic materials in which they are installed. During the first minute of pumping, the water level should be continuously monitored and the pumping rate adjusted to avoid pumping the well dry. Additional cautionary statements pertinent to data reduction are included in Section I. Allowing discharge water to infiltrate next to the well can impact the test results and should be avoided.

V. Health and Safety Considerations

Field activities associated with specific-capacity testing will be performed in accordance with a site-specific HASP, a copy of which will be present on-site during such activities.

VI. Procedures

Pre-Test Set-Up

Prior to installing the pump into the well to be tested, the static water level inside the well is measured to the nearest 0.01 foot relative to a specified datum at the top of the well using the electronic water-level indicator. The water level and the time of measurement are recorded in the field notebook. The water level is measured again several minutes after the initial measurement. This measurement and time are also recorded. This procedure is repeated until two consecutive measurements are identical, indicating approximately static conditions. The static depth-to-water is recorded.

The pump is installed inserted into the well to at least 10 feet below the static water level, or within approximately 1 foot of the bottom of the well if the initial water column in the well is less than 11 feet. The depth of the pump intake below the static water level (indicating the length of the pre-test water column above the pump) is recorded. After the pump is installed inserted (but prior to pumping), the water level in the well is monitored until it has returned to within 0.01 foot of the static water level.

Test Procedures

The specific-capacity test is performed as follows:

1. Hold the water-level probe in the well just above the static water level. If an in-line totalizing flow meter is used, record the pre-test volume measurement in the field notebook. If no in-line flow meter is available, place the end of the discharge line into one of the two calibrated buckets. Record the total volumetric capacity of each bucket.

2. Simultaneously start the pump and stopwatch. Record the start time.

3. Immediately begin monitoring the water level in the well. If the water level inside the test well declines rapidly, quickly reduce the pumping rate to a slower, constant rate. To avoid pumping the well "dry" during the test, the drawdown after one minute of pumping should be less than or equal to 20% of the height of the pre-pumping water column above the pump. All pumping rate adjustments should be completed within 1 or 2 minutes of the start of pumping, after which no adjustment should be made other than minor adjustments that may be necessary to maintain a steady pumping rate.

4. Continue to pump for at least 20 minutes, recording the water level in the well at least once every 3 minutes during pumping. If an in-line flow meter is used, record the volume measurement on the totalizer gauge approximately every 2 minutes during the test. If calibrated buckets are used to measure the pumping rate, record the time at which the bucket reaches the known volumetric capacity of the bucket. Transfer the discharge line to the other (empty) calibrated bucket and record the time when it becomes full. Repeat this procedure for the duration of the test.

5. The specific-capacity test is complete after at least 20 minutes of pumping have elapsed. A longer pumping period is not necessary to estimate transmissivity from the test. However, increasing the length of the test may further increase the reliability of the resulting transmissivity estimate. Immediately before termination of pumping, record the final water-level measurement plus the time of the measurement.

6. Recovery data may be collected following pumping. Such data are highly recommended if the test well is in a location that may be tidally influenced. Also, recovery data provide backup data that may be used to estimate transmissivity. To collect recovery data, measure and record water level data according to the same schedule as used during pumping.

7. Calculate and record the total volume of groundwater removed from the well during the test and the total duration of the test. Divide the total volume (in gallons) by the total pumping duration (in minutes) to calculate and record the average test pumping rate (in gpm).

VII. Waste Management

Water generated during specific capacity testing will be placed in containers, if required per State or local regulations. Containerized waste will be managed and disposed of properly.

VIII. Data Recording and Management

Data from a specific-capacity test are reduced to a transmissivity estimate for the water-bearing formation surrounding the intake of the tested well. The transmissivity may be estimated using a single-well time-drawdown method with multiple drawdown measurements, or else using a specific-capacity procedure with one drawdown measurement. These options are described below.

Time-Drawdown Method

The time-drawdown method of analyzing transmissivity requires graphical data evaluation, but has several advantages. The method does not require an estimate of the formation storativity and the results are not influenced by well efficiency.

Plot the measured drawdown data (measurements in feet on Y-axis) versus the pumping time (minutes, logarithmic scale on X-axis). The semilog data plot typically shows an abrupt initial drawdown at early time, followed by a straight-line trend of data points. Draw a line through the straight-line trend of data points and extend the line through at least one complete log cycle (e.g., 10 to 100 minutes). The data points need not extend through the entire interval of the drawn line. The drawn line is extended to cover at least one complete log cycle for ease in data analysis. Determine the drawdown change (• s) over one log cycle of time for the line drawdown through the straight-line trend in the data points. The value of transmissivity can be solved using the following equation (Driscoll, 1986):

$$T = 264\, Q \,/ \triangle s,$$

where:

T = transmissivity of the water-bearing zone surrounding the intake of the tested well (gallons per day per foot);

Q = pumping rate during the period of the straight-line trend in data points (gpm); and

$\triangle s$ = drawdown change over one log cycle (ft).

Single Drawdown Measurement Method

This method is relatively easy to use, but it requires an estimate of the formation storativity and the results can be influenced by well efficiency. The transmissivity can be estimated using a single drawdown measurement via the following equation (Walton, 1962):

$$\frac{Q}{s} = \frac{T}{\left[264\log\left(\frac{Tt}{2{,}693 r_w^{\ 2} S}\right) - 65.5\right]}$$

Q/s = specific capacity of the well in gpm per foot

Q = average test pumping rate (gpm)

s = drawdown measured inside of tested well after a known duration of pumping (ft)

T = transmissivity of the water-bearing zone surrounding the intake of the tested well (gallons per day per foot)

S = estimated storativity of the aquifer

r_w = effective radius of the well (ft)

t = time between the start of pumping and the time when the drawdown was measured (minutes)

The value of T can be solved iteratively using a specific-capacity test data reduction computer program. If the well screen is surrounded by a sand pack that may be assumed to be substantially more permeable than the formation, the effective radius of the well is taken to be that of the borehole.

The value of S may be estimated without introducing serious error into the results. For confined aquifers, S should be estimated as 0.0001. For unconfined aquifers, the short-term storativity may be comparable to that of a confined aquifer. Only after a protracted pumping duration (several hours or more) does the storativity begin to approximate the aquifer-specific yield of approximately 0.2 to 0.3 (Nwankwor et al., 1984). In the calculation of transmissivity from a specific-capacity test of less than several hours duration, an estimated storativity value of 0.01 can be used.

To obtain an estimate of the K of the water-bearing zone that transmits groundwater to the well, the calculated transmissivity value may be divided by the estimated thickness of the water-bearing zone. In a stratified formation in which the horizontal K may be expected to greatly exceed the vertical K, the thickness of the water-bearing zone may be estimated as the length of the well intake to obtain an estimate of the K immediately surrounding the well intake.

Cautionary Considerations

It should be noted that the above-listed methods are based on the modified non-equilibrium equation. According to Kruseman and de Ridder (1990), these methods are useful provided that:

$$u = \frac{r^2 s}{4Tt}$$

r = effective well radius
S = storativity
T = transmissivity of the test zone (formation interval adjacent to saturated sand pack)
t = the pumping duration

Following data analysis, the value of u should be calculated to confirm that the above condition is satisfied. If u > 0.15, then a different K test method should be employed. These cases are rare when using drawdown data from the pumped well, because the radius is a small number. The S value used in this calculation can be selected on previous site-specific pumping test results using observation well data, or else estimated as described in the previous subsection.

In circumstances when the pumping rate is low (e.g., less than 1 gpm) and the drawdown is high or occurs within the sand pack, the water removed from the well and sand pack storage should be calculated and subtracted from the pumped volume to estimate the volume of water produced by the formation. The volume of water produced by the formation should be divided by the pumping duration to obtain an effective pumping rate for use in calculating T and K.

In situations where the water level in the test well may be influenced by tidal fluctuations, drawdown and recovery data should both be measured and recorded on the same schedule. In these cases, to correct for potential tidal influence, calculate the average magnitude of the drawdown and recovery measured for the same duration during either pumping or drawdown. For example, if the pumping period lasted 30 minutes, calculate the average of the drawdown at 30 minutes and the magnitude of recovery that occurred during the first 30 minutes after shutting off the pump. This average value accounts for the tidal influence assuming that the rate of tidal change was approximately equal during the drawdown and recovery periods, and it should be considered the “effective drawdown” for use in the specific capacity method of Walton (1962). This correction should be useful in many situations, but may not adequately address tidal impacts if the drawdown due to pumping is small compared to the magnitude of the tidal influence. In these cases, it may be necessary to induce more drawdown during the test and/or time the test to coincide with slack tide conditions.

IX. Quality Assurance

QA Quality assurance calculations must be reviewed by a qualified hydrogeologist. Calculations will be provided with backup documentation, such as raw data and graphs of the data.

X. References

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