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Ford Motor Company

Subsurface Investigation Work Plan – Work Element 1

Twin Cities Assembly Plant

St. Paul, Minnesota

ARCADIS

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Subsurface Investigation Work Plan – Work Element 1

Twin Cities Assembly Plant
966 South Mississippi Boulevard
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Table of Contents

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Tables

Figures

Appendices

1. Introduction

On behalf of Ford Motor Company (Ford), ARCADIS has prepared this *Subsurface Investigation Work Plan – Work Element 1* (Work Plan) for the Twin Cities Assembly Plant (TCAP; Site) in accordance with the requirements of the Minnesota Pollution Control Agency (MPCA) Voluntary Investigation and Cleanup (VIC) Program and Petroleum Brownfields Program (PBP). The property location and layout are depicted on Figure 1.

This Work Plan describes Work Element 1 of subsurface investigation activities to be completed to further evaluate impacts and eliminate data gaps identified during the completion of the Initial and Supplemental Phase II Exterior Investigations as well as activities completed to date as part of the Initial Interior Investigation (ARCADIS 2013b). With consideration of former Site operations, construction, geographical layout, and environmental activities completed to-date, the Site has been divided into 11 Focus Areas FAs as depicted on Figure 2 and described in the following table:

Focus Area	Location Description
FA-01	North Parking Area
FA-02	Open LUST Releases
FA-03	Main Assembly Building (East Portion)
FA-04	Former Hazardous Waste Storage Areas
FA-05	Pant Shop
FA-06	Former Hazardous Waste Storage and Disposal Areas
FA-07	Railroad Tracks
FA-08	Baseball Fields
FA-09	Main Assembly Building (West Portion)
FA-10	Area C
FA-11	Waste Water Treatment Plant

The scope of work consists of the completion of soil borings, installation of temporary monitoring wells, and soil and groundwater sampling within 9 of 11 FAs; FA-08 and FA-10 have been addressed under separate cover. Investigation activities will be implemented and completed within each individual FA as they become available following ongoing Site demolition activities.

1.1 Property Location and Description

The Site is located at 966 South Mississippi River Boulevard in St. Paul, Ramsey County, Minnesota at approximate Latitude (north) 44° 54' 50.8" and Longitude (west) 93° 11' 31.9". The Site is located in a mixed industrial, commercial and residential use area on the eastern shore of the Mississippi River, along the east side of South Mississippi River Boulevard, south of Ford Parkway and west of South Cleveland Avenue (Figure 1).

Operations at the Site formerly consisted of the assembly and painting of light duty trucks (Ford Ranger) using parts manufactured off-Site. Assembly processes included welding, metal cleaning, painting and curing, windshield and trim installation and preparation of the vehicles for final delivery. In addition, a wastewater treatment plant and steam plant operated at the Site and was associated with the former assembly operations. Manufacturing operations at the Site ceased on December 16, 2011 and demolition activities commenced on June 10, 2013.

2. Field Methodology

This section provides a summary of the means and methods to be utilized during this subsurface investigation. Field logbook/documentation procedures and the field quality assurance program will be implemented in accordance with the approved June 2007 Field Sampling Plan (FSP) (ARCADIS 2007). An addendum to FSP *Section 3: Location and Sample Nomenclature* has been completed and is included in Appendix A, along with updated standard operating procedures.

2.1 Utility Clearance

A full utility clearance will be performed prior to initiating any subsurface work at the Site. Activities will include:

- Notification of Gopher One Call for marking of all public utility lines servicing the Site,
- Location of private utilities in the areas identified for subsurface work, and
- Surficial inspection using available utility and historic operational maps for each proposed boring location.

After removing any surficial debris (i.e., asphalt or concrete), a hand auger will be used to: 1) confirm the presence/absence of utilities and 2) investigate the top five feet bgs if no utilities exist. When hand augering will not be possible due to subsurface material/utilities a hydro-vacuum unit will be used to clear the area. Note that this will not allow ARCADIS to collect soil samples for analytical testing if the hydro-vacuum unit is utilized.

2.2 Groundwater Investigation

Groundwater elevation, flow direction, and potential impacts will be determined through the completion of:

- A sitewide gauging event of existing groundwater monitoring wells,
- Re-development and sampling of a subset of existing monitoring wells, and
- Installation and sampling of temporary monitoring wells in defined areas within select FAs.

Further details for each activity are provided in the following sections.

2.2.1 Permanent Wells

Twenty five permanent monitoring wells are located throughout the Site and screened either within the perched or bedrock groundwater (Figure 2). Well construction details for each well are provided in Table 1. Each monitoring well will be gauged prior to commencing the subsurface field activities. Groundwater elevation data will be utilized to determine apparent groundwater flow direction, based on the potentiometric surface elevations. During the gauging event, depth to bottom measurements will be collected to determine casing integrity and siltation of the well screens. Monitoring wells demonstrating heavy siltation or that have not been sampled within the past five years will be selected for re-development. Well development will be performed in accordance with the FSP and completed at least 24 hours prior to groundwater sampling.

A subset of the existing groundwater monitoring will be sampled using the low-flow sampling method in accordance with the United States Environmental Protection Agency (USEPA) Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures (USEPA 1996). Groundwater will be purged using a peristaltic pump and dedicated tubing. Water quality parameters (pH, temperature, specific conductivity, oxidation reduction potential, and dissolved oxygen) will be measured while purging using a multi-parameter flow-through-cell and a separate turbidity meter. Once indicator parameters have stabilized, samples will be collected in laboratory supplied containers and placed on ice pending shipment to the laboratory. Following standard chain-of-custody procedures, all samples will be submitted to a designated laboratory for analysis of one or more of the following analytes:

- Volatile organic compounds (VOCs) using USEPA Method 8260,
- Semi-volatile organic compounds (SVOCs) using USEPA Method 8270,
- Gasoline range organics (GRO) using the Wisconsin (WI) Modified Method,
- Diesel range organics (DRO) using the WI Modified Method,
- Cyanide using USEPA Method 335.4,
- The eight Resource Conservation and Recovery Act (RCRA) Metals using USEPA Method 6010/ Method 7470,
- Lead using USEPA Method 6010, and
- Polychlorinated biphenyls (PCBs) using USEPA Method 8082.

All groundwater samples analyzed for metals will be field filtered using a 0.45-micron disposable filter prior to sample collection for dissolved metals analyses. A summary of the groundwater monitoring wells and analytical parameters is presented in Table 2.

2.2.2 Temporary Wells

Temporary wells will be installed in select boreholes (discussed in Section 2. 3 below) to determine potential groundwater impacts within the perched aquitard. Temporary wells will be constructed of 1-inch diameter, 5-foot-long polyvinyl chloride (PVC) slotted well screens and associated PVC riser. The temporary wells will be purged of at least one gallon of groundwater using a peristaltic pump and disposable tubing prior to sampling to minimize turbidity. At least one groundwater water sample will be collected from the shallowest groundwater encountered at each location. Groundwater samples collected from temporary monitoring wells will be analyzed for one or more of the following analytes:

- VOCs using USEPA Method 8260,
- SVOCs using USEPA Method 8270,
- GRO using the WI Modified Method,
- DRO using the WI Modified Method,
- Target Analyte List Metals using USEPA Method 6010,
- RCRA Metals using USEPA Method 6010/7470, and
- PCBs using USEPA Method 8082.

All samples analyzed for metals will be field filtered using a 0.45-micron disposable filter prior to sample collection. A summary of the proposed temporary monitoring well locations and analytical parameters is presented in Tables 3A (Group A) and 3B (Group B).

2.3 Soil Investigation

Soil borings will be advanced using direct push technology in areas of known impacts. Each boring will be logged continuously by an ARCADIS field geologist and screened using a Photoionization Detector (PID) with an 11.7 electron volt (eV) lamp that has been calibrated at least twice a day. Soil boring logs will be created in the field and identify material encountered for each borehole to total depth using the United Soil Classification System (USCS). Upon completion, bentonite chips will be used to abandon each borehole if the borehole is unregulated. If the borehole is classified as a "regulated hole" according to Minnesota Department of Health (MDH) guidelines, the borehole will be sealed in accordance with MDH Guidelines and a Borehole Sealing Record will be prepared.

A minimum of one and up to four soil samples will be collected at each borehole. At proposed delineation locations, one soil sample will be collected from the interval depicting the highest PID reading or potential impacts through visual or olfactory observations. Although this interval is anticipated to correspond with exceedances observed at the original borehole location, if it does not a second soil sample will be collected from the interval corresponding to initially observed exceedances. A third soil sample will be collected from the interval below the observed exceedance to provide vertical delineation.

Soil samples will be collected in laboratory supplied containers and placed on ice pending shipment to the laboratory. Following standard chain-of-custody procedures, all samples will be submitted to a designated laboratory for analysis of one or more of the following analytes:

- VOCs using USEPA Method 8260,
- SVOCs using USEPA Method 8270,
- GRO using the WI Modified Method,
- DRO using the WI Modified Method,
- RCRA metals using USEPA Method 6010,
- TAL metals using USEPA Method 6010,
- PCBs using USEPA Method 8082, and
- Lead using USEPA Method 6010.

Anticipated boring depths and laboratory analysis parameters for each boring location is presented in Tables 3A (Group A) and 3B (Group B).

2.4 Vapor Intrusion

Soil-gas sampling will be completed, if warranted, after collection and review of groundwater data from Work Element 1 of the subsurface investigation. Initial groundwater data collected will first be compared to Groundwater Screening Values for Vapor Intrusion Pathway (GWISV) in accordance with MPCA Guidance Document C-

S4-06 Tier 1 screening to determine whether Tier 2 of the Vapor Intrusion Pathway evaluation is required. If Tier 2 work is required, a separate Work Plan for Investigation will be prepared and submitted to the MPCA.

2.5 Investigation-Derived Waste

Investigation-Derived Waste (IDW) generated during the course of the subsurface investigation will include soil cuttings, purge water, personal protective equipment (PPE) and disposable sampling equipment (i.e. filters, tubing, PVC).

- Soil cuttings will be segregated in the field prior to disposal pursuant to field screening results; segregation parameters will be of 0 parts per million (ppm) to <10 ppm, 10 ppm to <100 ppm, and greater than 100 ppm. One composite sample will be collected for laboratory analysis from each staging area for every five 55 gallon drums generated. Laboratory analysis will be utilized for the determination of potential site re-use or offsite disposal.

- Purge water generated during groundwater monitoring activities will be drummed for off-site disposal after review of laboratory analysis.

- PPE and disposal sampling equipment will be segregated and disposed of upon review of subsurface investigation results.

2.6 Surveying

All borings and monitoring wells will be surveyed for X, Y and Z (ground surface) coordinates referencing the National Geodetic Vertical Datum of 1929 (NGVD 29) and North American Datum of 1983 (NAD 83) at the completion of subsurface investigation activities.

3. Scope of Work

With consideration of former Site operations, construction, geographical layout, and environmental activities completed to-date, the Site has been divided into 11 FAs as depicted on Figure 2. Furthermore, the FAs have been divided into two groups (A and B) with geographic consideration. Group A includes FA-01 through -09, located east of Mississippi River Boulevard, and Group B includes FA-10 and FA-11 located west of Mississippi River Boulevard.

The total number of borings, depth, and analytical sampling requirements were developed based on analytical results from previous investigations completed at the Site. Detailed sampling and analysis information is presented in Tables 3A (Group A) and 3B (Group B).

Investigation activities will commence with the completion of a site-wide gauging event and verification of monitoring well integrity. A subset of these monitoring wells will be sampled for laboratory analysis with consideration of previous results and/or location (Table 2). These results will also be utilized to determine the need of additional groundwater delineation, which will be performed by installation and sampling of temporary wells (Table 3A). If needed, at least one groundwater sample will be collected from the interval corresponding to the permanent well screen interval and a subsequent sample collected below this depth. Collection of the sample is contingent upon encountering water in the borehole.

3.1 Group A

Group A includes FA-01 through FA-09, with the exception of FA-08 (baseball fields). Investigation results for FA-08 was addressed in 2008 and reported in the Response Action Implementation Report – Baseball Fields – Feature 139 (ARCADIS 2008). Investigation activities within Group A FAs will include:

- Sampling of seven existing monitoring wells previously exhibiting exceedances of MDH Health Risk Limits (HRLs) or the USEPA Maximum Contaminant Level (MCL) for arsenic in groundwater,

- Sampling of two existing downgradient monitoring wells and three monitoring wells associated with the former solvent underground storage tank sump system,

- Delineation of exceedances of residential Soil Reference Values (SRVs) in soil,

- Delineation of exceedances of MDH HRLs and the USEPA Arsenic MCL in groundwater through the installation and sampling of temporary wells, and

- Soil and groundwater investigation within FA-03, -05, and -09 utilizing a 1-acre grid system if a well or boring location currently does not exist for additional characterization of the FAs (i.e. data gaps).

3.2 Group B

Group B consists of FA-10 and FA-11, but only includes investigation at FA-11. Investigation results for FA-10 were reported under separate cover to the MPCA in the May 2013 Draft-Final Area C –Comprehensive Site History and Investigation Report (ARCADIS 2013a). Investigation activities within Group B will include:

- Delineation of exceedances of recreational SRVs in soil,

- Sampling of two existing monitoring wells previously exhibiting exceedances of MDH HRLs, and

- Delineation of exceedances of MDH HRLs in groundwater through the installation and sampling of temporary wells.

4. Reporting

The results of this investigation will be summarized in a summary report and submitted to the MPCA. The submittal will discuss information collected during the site characterization activities and will include a technical overview of the site characterization, results, findings, and recommendations.

5. Scheduling

The subsurface investigation is anticipated to begin in the third quarter of 2013, as ongoing demolition activities allow. Investigation activities will commence with a site-wide gauging event and sampling of permanent monitoring wells. The remainder of the scope of work will be completed independently within each FA, successive to demolition activities in the FA when possible.

6. References

ARCADIS, 2007. Field Sampling Plan, Ford Motor Company, Twin Cities Assembly Plant, St. Paul, Minnesota. June 2007.

ARCADIS, 2008. Response Action Implementation Report – Baseball Fields – Feature 139, Ford Motor Company, Twin Cities Assembly Plant, St. Paul, Minnesota. March 2008.

ARCADIS, 2013a. Draft-Final Area C –Comprehensive Site History and Investigation Report, Ford Motor Company, Twin Cities Assembly Plant, St. Paul, Minnesota. May 2013.

ARCADIS, 2013b. Supplemental Phase II – Exterior Investigation Report (Revised), Ford Motor Company, Twin Cities Assembly Plant, St. Paul, Minnesota. May 2013.

USEPA, 1996. Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. April 1996.

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Tables

Table 1. Monitoring Well Construction
Subsurface Investigation Work Plan - Work Element 1
Twin Cities Assembly Plant, St. Paul, Minnesota

Well ID	Unique Well Number	Date Installed	Surface Elevation (ft msl)	Top Of Casing Elevation (ft msl)	Bottom of Well Elevation (ft msl)	Screen Interval (Elev. - Elev.) (ft msl)	Surface Completion Type
AMW-01	751337	9-Jul-07	810.32	813.03	774.03	784.03 - 774.03	Above Ground
AMW-02	751330	22-Jun-07	810.35	812.86	772.86	782.86 - 772.86	Above Ground
AMW-03A	751333	2-Jul-07	812.03	811.80	771.80	781.80 - 771.80	Flush Mount
AMW-03B	751332	29-Jun-07	811.93	811.72	660.72	670.72 - 660.72	Flush Mount
AMW-04	751334	10-Jul-07	830.13	829.92	768.92	778.92 - 768.92	Flush Mount
AMW-05	751339	2-Jul-07	722.07	725.25	696.25	706.25 - 696.25	Above Ground
AMW-05B	756582	19-Jul-07	721.79	723.99	670.99	680.99 - 670.99	Above Ground
AMW-06	751331	3-Jul-07	811.56	814.06	773.06	783.06 - 773.06	Above Ground
AMW-07	751338	4-Jul-07	733.71	733.48	688.48	698.48 - 688.48	Flush Mount
AMW-08	751336	20-Jun-07	831.07	830.80	785.80	795.80 - 785.80	Flush Mount
AMW-09	751335	21-Jun-07	858.39	858.13	768.13	778.13 - 768.13	Flush Mount
AMW-10	756581	20-Jul-07	808.77	811.27	771.27	781.27 - 771.27	Above Ground
AMW-11	784720	13-Sep-11	808.99	808.86	799.47	804.47 - 799.47	Flush Mount
AMW-12	784724	13-Sep-11	808.83	808.74	797.3	802.30 - 797.30	Flush Mount
AMW-13	784723	14-Sep-11	809.93	809.89	797.92	802.92 - 797.92	Flush Mount
AMW-14	784726	14-Sep-11	809.57	809.57	797.57	802.57 - 797.57	Flush Mount
AMW-15	784725	14-Sep-11	809.91	809.84	796.79	801.79 - 796.79	Flush Mount
AMW-16	784721	14-Sep-11	812.157	811.94	801.28	806.28 - 801.28	Flush Mount
AMW-17	784722	14-Sep-11	808.898	811.04	801.15	806.15 - 801.15	Above Ground
AMW-18	784719	15-Sep-11	812.83	812.7	798.22	803.22 - 798.22	Flush Mount
AMW-19	784743	3-Nov-11	705.6	707.84	681.29	691.29 - 681.29	Above Ground
AMW-20	784744	3-Nov-11	707.58	710.02	684.09	694.09 - 684.09	Above Ground
MW-4	487652	6-May-91	830.73	833.66	825.53	825.53 - 823.53	Above Ground
MW-5	487653	6-May-91	827.86	827.76	823.56	823.56 - 821.56	Flush Mount
MW-6	487654	6-May-91	827.86	827.76	823.42	823.42 - 821.42	Flush Mount

Notes:
ft msl Feet above mean sea level
AMW ARCADIS Monitoring Well
MW Monitoring Well
Elev. Elevation

Table 2. Summary of Groundwater Sampling Program
Subsurface Investigation Work Plan - Work Element 1
Ford Twin Cities Assembly Plant, St. Paul, Minnesota

			Groundwater Analytical (Analytical Method)							
Focus Area	**Rationale**	**Well ID**	**VOCs (8260)**	**SVOCs (8270)**	**GRO (Wi)**	**DRO (Wi)**	**Dissolved RCRA Metals (6010/7470)**	**PCBs (8082)**	**Dissolved Lead (6010)**	**Cyanide (335.4)**
FOCUS AREA ASSESSMENT										
1	Perimeter wells to confirm lack of off-Site migration (Mississippi Boulevard and Ford Parkway) and confirm previously observed exceedances (AMW-08 and AMW-17)	AMW-01	X	X	X	X	X			
		AMW-08			X	X	X			
		AMW-17	X	X	X	X			X	
2	Confirm previous exceedances detected	AMW-15	X	X	X	X	X			
		AMW-16	X	X	X	X	X			
5	Confirm previous exceedances detected	AMW-09		X	X	X	X			
6	Monitoring of the former solvent UST sump system	MW-4	X		X	X	X			
		MW-5	X		X	X	X			
		MW-6	X		X	X	X			
7	Confirm previous exceedances detected	AMW-12	X	X	X	X	X			
9	Perimeter wells to confirm lack of off-Site migration (Mississippi Boulevard) and confirm previously observed exceedances (AMW-06)	AMW-06	X	X	X	X	X			
		AMW-10	X	X	X	X	X			
11	Perimeter wells to confirm lack of off-Site migration (Mississippi River) and confirm previously observed exceedances	AMW-05B	X	X	X	X	X	X		
		AMW-07	X	X	X	X	X	X		X
QA/QC SAMPLES										
MS/MSD Samples			2	2	2	2	2	1	1	1
Field Duplicates			2	2	2	2	2	1	1	1
		Totals	16	14	18	18	17	4	3	3

Note:
AMW - ARCADIS Monitoring Well
DRO - Diesel Range Organics
GRO - Gasoline Range Organics
MS/MSD - Matrix Spike/Matrix Spike Duplicate
MW - Monitoring Well
PCBs - Polychlorinated biphenyls
RCRA - Resource Conservation and Recovery Act
SVOCs -Semi-volatile organic compounds
UST - Underground Storage Tank
VOCs - Volatile organic compounds
Wi - Wisconsin

Table 3A. **Summary of Subsurface Investigation for Group A Focus Areas**
Subsurface Investigation Work Plan - Work Element 1
Twin Cities Assembly Plant, St. Paul, Minnesota

	Original Location			Drilling/Inspection		Soil Analytical								Groundwater Analytical**							
Focus Area	Location ID	Rationale[1]	Sample ID	Initial Number of Borings	Initial Target Depth (ft bgs)	VOCs (8260)	SVOCs (8270)	GRO (Wi)	DRO (Wi)	RCRA Metals (6010)	TAL Metals (6010)	PCBs (8082)	Lead (6010)	VOCs (8260)	SVOCs (8270)	GRO (Wi)	DRO (Wi)	Dissolved RCRA Metals (6010/7470)	Dissolved TAL Metals (6010)	Dissolved Lead (6010)	PCBs (8082)
FOCUS AREA ASSESSMENT																					
1	ASB-115	**4-9**	ASB-0101W	1	12									X			X				
			ASB-0101S	1	12									X			X				
	ASB-120	**6-11**	ASB-0102W	1	15									X		X	X				
	ASB-123	2-4, **6-8**	ASB-0103W	1	12	X															
			ASB-0103N	1	12	X															
			ASB-0103E	1	12	X															
	ASB-128	**0-2, 6-8 5-10**	ASB-0104W	1	12					X							X	X			
			ASB-0104N	1	12					X							X	X			
			ASB-0104E	1	12					X							X	X			
			ASB-0104S	1	12					X							X	X			
	ASB-134	**2-4**	ASB-0105W	1	10	X															
			ASB-0105N	1	10	X															
			ASB-0105E	1	10	X															
			ASB-0105S	1	10	X															
	AMW-08	**35-45**	ASB-0106	1	50	X*								X*				X*			
	AMW-17	**6-11**	ASB-107N	1	15	X								X							
			ASB-107E	1	15	X								X							
2	ASB-001/AMW-14	**7-12/ 7-12**	ASB-0201W	1	15	X		X	X					X		X	X	X			
	ASB-030	**3-8**	ASB-0202S	1	12									X	X	X	X	X			
	ASB-047/AMW-16	**5-10/ 2.75-7.75**	ASB-0203N	1	15									X	X	X	X	X			
			ASB-0203S	1	15									X					X		
	ASB-099	**7-12**	ASB-0205NW	1	15														X		
	ASB-118	**7-12**	ASB-0206W	1	15									X			X				
			ASB-0206N	1	15									X			X				
			ASB-0206E	1	15									X			X				
	ASB-121	**5-7, 8-10**	ASB-0207W	1	15	X	X	X	X												
			ASB-0207N	1	15	X	X	X	X												
			ASB-0207E	1	15	X	X	X	X												
			ASB-0207S	1	15	X	X	X	X												
	ASB-122	2-4, **6-8**	ASB-0208W	1	12	X		X	X												
			ASB-0208N	1	12	X		X	X												
			ASB-0208E	1	12	X		X	X												
			ASB-0208E	1	12	X		X	X												
	ASB-136	**1-3**	ASB-0209W	1	10	X			X												
			ASB-0209N	1	10	X			X												
			ASB-0209E	1	10	X			X												
			ASB-0209S	1	10	X			X												
	ASB-147	0-2, **6-8**	ASB-0210E	1	12		X	X													
	ASB-212	**10-15**	ASB-0211W	1	20										X						
	ASB-209	**10-15**	ASB-0212NW	1	20										X						
			ASB-0212NE	1	20										X						
	ASB-234	**9-14**	ASB-0213W	1	20										X				X		
	ASB-235	**13-18**	ASB-0214NW	1	22										X				X		
			ASB-0214NE	1	22										X				X		
	NA	Data Gap	ASB-0218	1	15	X	X		X	X				X	X		X	X			

Table 3A. **Summary of Subsurface Investigation for Group A Focus Areas**
Subsurface Investigation Work Plan - Work Element 1
Twin Cities Assembly Plant, St. Paul, Minnesota

	Original Location			Drilling/Inspection		Soil Analytical								Groundwater Analytical**							
Focus Area	Location ID	Rationale[1]	Sample ID	Initial Number of Borings	Initial Target Depth (ft bgs)	VOCs (8260)	SVOCs (8270)	GRO (Wi)	DRO (Wi)	RCRA Metals (6010)	TAL Metals (6010)	PCBs (8082)	Lead (6010)	VOCs (8260)	SVOCs (8270)	GRO (Wi)	DRO (Wi)	Dissolved RCRA Metals (6010/7470)	Dissolved TAL Metals (6010)	Dissolved Lead (6010)	PCBs (8082)
3	ASB-095	**7-12**	ASB-0301	1	15														X		X
3	ASB-252	**9-14**	ASB-0302	1	20														X		
3	ASB-215	**10-15**	ASB-0303	1	20									X					X		
3	ASB-218	**5-7**	ASB-0304W	1	10					X											
3	ASB-218	**5-7**	ASB-0304N	1	10					X											
3	ASB-218	**5-7**	ASB-0304E	1	10					X											
3	ASB-218	**5-7**	ASB-0304S	1	10					X											
3	ASB-219	2-3, **8-9**	ASB-0305W	1	12	X															
3	ASB-219	2-3, **8-9**	ASB-0305N	1	12	X															
3	ASB-219	2-3, **8-9**	ASB-0305E	1	12	X															
3	ASB-219	2-3, **8-9**	ASB-0305S	1	12	X															
3	ASB-227	**0-2**	ASB-0306W	1	10						X										
3	ASB-227	**0-2**	ASB-0306N	1	10						X										
3	ASB-227	**0-2**	ASB-0306E	1	10						X										
3	ASB-227	**0-2**	ASB-0306S	1	10						X										
4	ASB-011	**0-2**	ASB-0401NE	1	10		X														
4	ASB-011	**0-2**	ASB-0401SE	1	10		X														
4	ASB-017	**0-2**	ASB-0402W	1	10		X														
4	ASB-017	**0-2**	ASB-0402E	1	10		X														
4	ASB-038	**8-10**	ASB-0403S	1	15						X										
4	ASB-170	**0-2, 4-6**	ASB-0404NE	1	10		X				X										
4	ASB-170	**0-2, 4-6**	ASB-0404SE	1	10		X				X										
4	ASB-171	**1-3**	ASB-0405W	1	10						X										
4	ASB-171	**1-3**	ASB-0405N	1	10						X										
4	ASB-174	**4-6**	ASB-0406W	1	10		X				X										
4	ASB-174	**4-6**	ASB-0406E	1	10		X				X										
4	ASB-174	**4-6**	ASB-0406S	1	10		X				X										
4	ASB-176	**8-10**	ASB-0407W	1	15	X	X				X										
4	ASB-176	**8-10**	ASB-0407N	1	15	X	X				X										
4	ASB-176	**8-10**	ASB-0407E	1	15	X	X				X										
4	ASB-236	**11-16**	ASB-0408	1	20														X		
4	ASB-254	**0-2,** 4-5	ASB-0409W	1	8		X														
4	ASB-254	**0-2,** 4-5	ASB-0409N	1	8		X														
4	ASB-254	**0-2,** 4-5	ASB-0409E	1	8		X														
4	ASB-254	**0-2,** 4-5	ASB-0409S	1	8		X														
5	G5-01	Data Gap	ASB-0501	1	12	X	X					X	X	X	X					X	X
5	G5-04	Data Gap	ASB-0513	1	12	X	X					X	X	X	X					X	X
5	G5-06	Data Gap	ASB-0514	1	12	X	X					X	X	X	X					X	X
5	G5-15	Data Gap	ASB-0526	1	12	X	X					X	X	X	X					X	X
5	G5-16	Data Gap	ASB-0527	1	12	X	X					X	X	X	X					X	X
5	G5-17	Data Gap	ASB-0528	1	12	X	X					X	X	X	X					X	X

Table 3A. Summary of Subsurface Investigation for Group A Focus Areas
Subsurface Investigation Work Plan - Work Element 1
Twin Cities Assembly Plant, St. Paul, Minnesota

	Original Location			Drilling/Inspection		Soil Analytical								Groundwater Analytical**							
Focus Area	Location ID	Rationale[1]	Sample ID	Initial Number of Borings	Initial Target Depth (ft bgs)	VOCs (8260)	SVOCs (8270)	GRO (Wi)	DRO (Wi)	RCRA Metals (6010)	TAL Metals (6010)	PCBs (8082)	Lead (6010)	VOCs (8260)	SVOCs (8270)	GRO (Wi)	DRO (Wi)	Dissolved RCRA Metals (6010/7470)	Dissolved TAL Metals (6010)	Dissolved Lead (6010)	PCBs (8082)
6	ASB-019	**2-4**	ASB-0601W	1	8	X															
	ASB-020	**0-2**	ASB-0602E	1	8	X															
			ASB-0602S	1	8	X															
	ASB-032	**2-4**	ASB-0603NW	1	8						X										
			ASB-0603SW	1	8						X										
	ASB-034	**0-2**	ASB-0604W	1	8						X										
			ASB-0604E	1	8						X										
			ASB-0604S	1	8						X										
	ASB-177	**4-6**	ASB-0605E	1	10		X				X										
	ASB-179	**0-2**	ASB-0606N	1	8						X										
			ASB-0606E	1	8						X										
	ASB-180	**0-2, 2-4**	ASB-0607N	1	8						X										
	ASB-181	**6-8**	ASB-0608W	1	12		X				X										
			ASB-0608N	1	12		X				X										
			ASB-0608S	1	12		X				X										
	ASB-182	**2-4**	ASB-0609N	1	8	X	X				X										
			ASB-0609S	1	8	X	X				X										
	ASB-183	**0-2**	ASB-0610N	1	8		X				X										
			ASB-0610E	1	8		X				X										
	ASB-202	**8-10**	ASB-0611W	1	15						X										
			ASB-0611N	1	15						X										
7	ASB-013	**4-6**	ASB-0701N	1	10						X										
			ASB-0701E	1	10						X										
			ASB-0701S	1	10						X										
	ASB-014	**4-6**	ASB-0702S	1	10						X										
	ASB-165	**0-2**	ASB-0703N	1	8						X										
	ASB-166/ASB-167	**2-4/0-2, 6-8, 8-10**	ASB-0704E	1	15						X								X		
	ASB-172	**1-3**	ASB-0705N	1	8		X				X										
			ASB-0705E	1	8		X				X										
	ASB-173	**1-3**	ASB-0706W	1	8		X				X										
	ASB-175	**4-6**	ASB-0707W	1	10	X	X				X										
			ASB-0707N	1	10	X	X				X										
			ASB-0707E	1	10	X	X				X										
	ASB-258	**1-3,** 6-7	ASB-0708N	1	10					X											
			ASB-0708E	1	10					X											
	ASB-259	**1-2,** 4-6	ASB-0709E	1	10					X											
	ASB-260	**1-2, 7-8**	ASB-0710W	1	12					X											
	ASB-261	**0.5-2,** 9-11	ASB-0711W	1	12					X											
			ASB-0711S	1	12					X											
	ASB-003/AMW-12	**6-8, 10-12/ 6-11**	ASB-0712W	1	15	X												X			

Table 3A. **Summary of Subsurface Investigation for Group A Focus Areas**
Subsurface Investigation Work Plan - Work Element 1
Twin Cities Assembly Plant, St. Paul, Minnesota

	Original Location			Drilling/Inspection		Soil Analytical								Groundwater Analytical**							
Focus Area	**Location ID**	**Rationale[1]**	**Sample ID**	**Initial Number of Borings**	**Initial Target Depth (ft bgs)**	**VOCs (8260)**	**SVOCs (8270)**	**GRO (Wi)**	**DRO (Wi)**	**RCRA Metals (6010)**	**TAL Metals (6010)**	**PCBs (8082)**	**Lead (6010)**	**VOCs (8260)**	**SVOCs (8270)**	**GRO (Wi)**	**DRO (Wi)**	**Dissolved RCRA Metals (6010/7470)**	**Dissolved TAL Metals (6010)**	**Dissolved Lead (6010)**	**PCBs (8082)**
9	ASB-256	**3-4,** 9-10	ASB-0901W	1	12	X															
			ASB-0901S	1	12	X															
	G9-01	Data Gap	ASB-0902	1	14	X	X		X	X				X	X		X	X			
	G9-06	Data Gap	ASB-0906	1	14	X	X		X	X				X	X		X	X			
	G9-07	Data Gap	ASB-0907	1	14	X	X		X	X				X	X		X	X			
	G9-08	Data Gap	ASB-0908	1	14	X	X		X	X				X	X		X	X			
	G9-10	Data Gap	ASB-0910	1	14	X	X		X	X				X	X		X	X			
	G9-13	Data Gap	ASB-0911	1	14	X	X		X	X				X	X		X	X			
	G9-15	Data Gap	ASB-0912	1	14	X	X		X	X				X	X		X	X			
	G9-17	Data Gap	ASB-0913	1	14	X	X		X	X				X	X		X	X			
	G9-20	Data Gap	ASB-0918	1	14	X	X		X		X	X		X	X		X		X		X
	G9-23	Data Gap	ASB-0921	1	14	X	X		X	X				X	X		X	X			
	G9-24	Data Gap	ASB-0922	1	14	X	X		X	X				X	X		X	X			
	G9-26	Data Gap	ASB-0923	1	14	X	X		X	X				X	X		X	X			
	G9-28	Data Gap	ASB-0924	1	14	X	X		X	X				X	X		X	X			
	G9-30	Data Gap	ASB-0925	1	14	X	X		X	X				X	X		X	X			
	G9-32	Data Gap	ASB-0926	1	14	X	X		X	X				X	X		X	X			
QA/QC SAMPLES																					
MS/MSD Samples						5	5	1	4	2	3	2	1*	3	3	1	4	2	2	1	2
Field Duplicates						5	5	1	4	2	3	2	1*	3	3	1	4	2	2	1	2
			Totals	149	1851	78	73	13	43	34	56	16	6	47	42	7	43	28	19	8	17

Notes, Acronyms & Abbreviations:

1	Indicates analyzed interval (ft bgs) within the original boring/well or the need for additional characterization (i.e. data gap)
*	Soil sampling contingent on results of groundwater sample from permanent well
**	All temporary well groundwater samples are contingent on the presence of groundwater in the borehole
BOLD	Interval with observed exceedance of applicable standard(s)
ft bgs	feet below ground surface
ASB	ARCADIS Soil Boring
DRO	Diesel Range Organics
GRO	Gasoline Range Organics
MS/SD	Matrix spike/matrix spike duplicate
NA	Not Applicable
PCBs	Polychlorinated biphenyls
RCRA	Resource Conservation and Recovery Act
SVOCs	Semi-volatile compounds
TAL	Target Analyte List
VOCs	Volatile organic compounds
Wi	Wisconsin

Table 3B. **Summary of Subsurface Investigation for Group B Focus Areas**
Subsurface Investigation Work Plan - Work Element 1
Twin Cities Assembly Plant, St. Paul, Minnesota

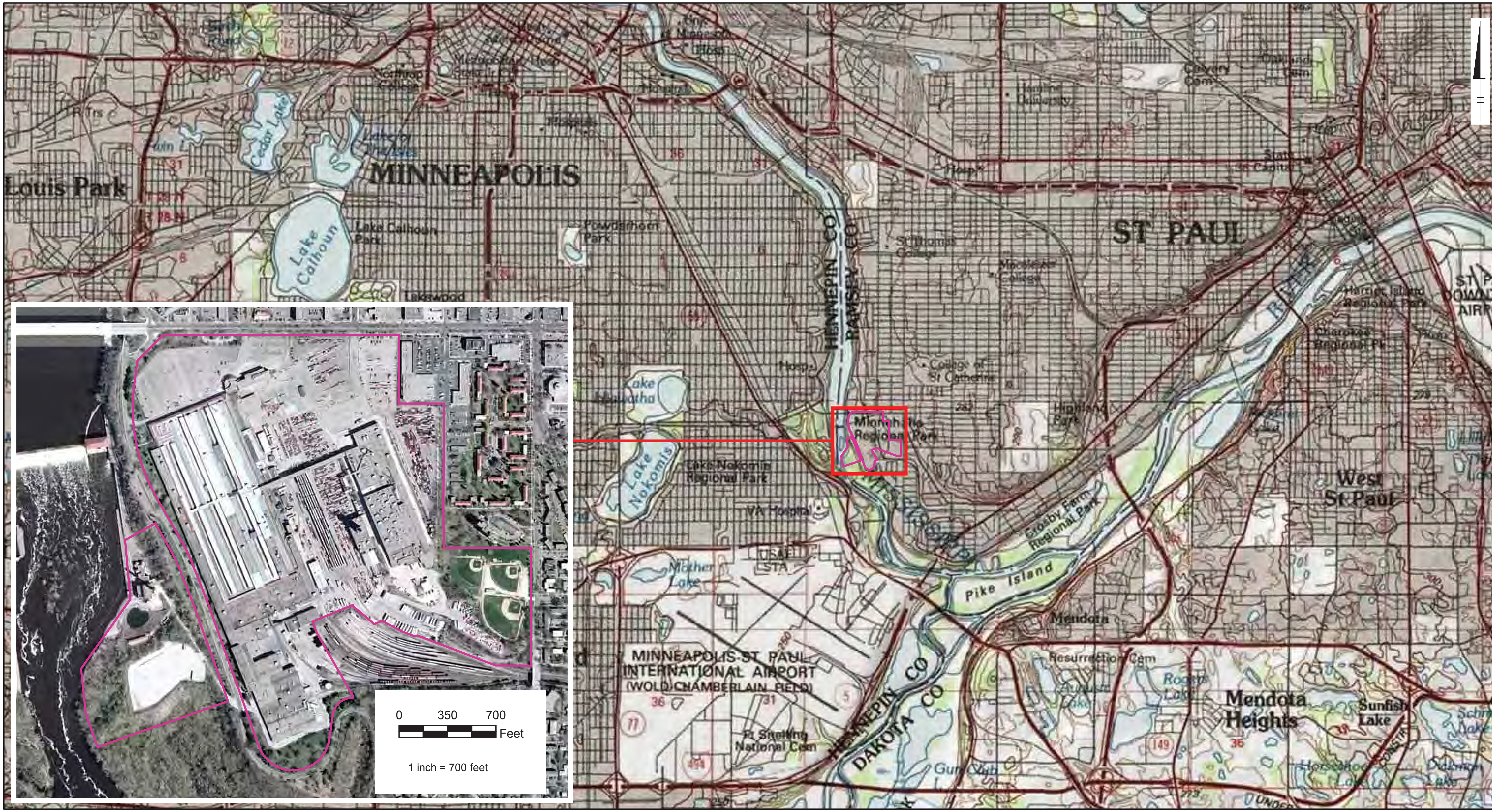
				Drilling/Inspection		Soil Analytical						Groundwater Analytical			
Focus Area	**Location ID**	**Rationale[1]**	**Sample ID**	**Initial Number of Borings**	**Target Depth (ft bgs)**	**VOCs (8260)**	**SVOCs (8270)**	**RCRA Metals (6010)**	**TAL Metals (6010)**	**Lead (6010)**	**Cyanide (335.4)**	**VOCs (8260)**	**SVOCs (8270)**	**Dissolved RCRA Metals (6010)**	**Cyanide (335.4)**
FOCUS AREA ASSESSMENT															
11	ASB-025	**12-14**	ASB-1101W	1	15					X					
			ASB-1101N	1	15					X					
			ASB-1101E	1	15					X					
			ASB-1101S	1	15					X					
	ASB-026	**4-6**	ASB-1102N	1	10				X						
			ASB-1102E	1	10				X						
	ASB-027	**4-6**	ASB-1103NW	1	15					X					
	ASB-195	**6-8, 8-10**	ASB-1104NE	1	BR		X								
			ASB-1104SW	1	BR		X								
	ASB-196	**4-6**	ASB-1105N	1	15				X						
	ASB-197	**4-6**	ASB-1106NE	1	15				X						
	ASB-198	**6-8**	ASB-1107N	1	15		X								
			ASB-1107SE	1	15		X								
	NA	Feature 153	ASB-1108	1	BR	X	X	X			X	X	X	X	X
QA/QC SAMPLES															
MS/MSD Samples				1	--	1	1	1	1	1	1	1	1	1	1
Field Duplicates				1	--	1	1	1	1	1	1	1	1	1	1
			Totals	16	155	3	7	3	6	7	3	3	3	3	3

Notes, Acronyms & Abbreviations:

1	Indicates either the analyzed interval (ft bgs) within the original boring, or the Feature requiring additional characterization
BOLD	Interval with exceedance
ft bgs	feet below ground surface
BR	Competent bedrock
MS/SD	Matrix spike/matrix spike duplicate
PCBs	Polychlorinated biphenyls
RCRA	Resource Conservation and Recovery Act
SVOCs	Semi-volatile compounds
TAL	Target Analyte List
VOCs	Volatile organic compounds

ARCADIS

Figures



LEGEND:

Ford Property Boundary

NOTES:

Imagery Source: United States Geological Survey
High Resolution Orthoimagery for the Minneapolis-St. Paul, Minnesota Urban Area

Topographic Map Source:
© 2007 National Geographic Society

0 1 2
Miles

1 inch = 1 miles

Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota
Phase II Supplemental Exterior Investigation

Site Location / Property Layout

ARCADIS

FIGURE
1

CITY: Minneapolis, MN DB: MGress PM: BZinda
Project: MN000593
G:\GIS\Projects\Ford Ranger\ArcMap\2012\2012-03\Fig1_Site_Location_Topo.mxd

LEGEND:

- A Monitoring Well
- ? Soil Boring
- (Hand Auger
- 0 Surface Soil
- < Sump
- Ford Property Boundary
- Proposed Certificate of Completion Focus Areas

NOTES:

1) This Figure is not to be used for completing Land Splits, Land Unit Development, Plats, or generating new Tax Identification numbers.

2) The Figure is not to be used for any Real Estate Planning or Discussion purposes.

3) This Figure is to be used for obtaining Certificates of Completion during the environmental investigation/remediation process only.

4) Imagery Source: MnGeo WMS service, 2010 color 7-county http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 12/3/2012

0 400 800 Feet

1 inch = 400 feet

Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Areas Location Map

ARCADIS

FIGURE 2

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
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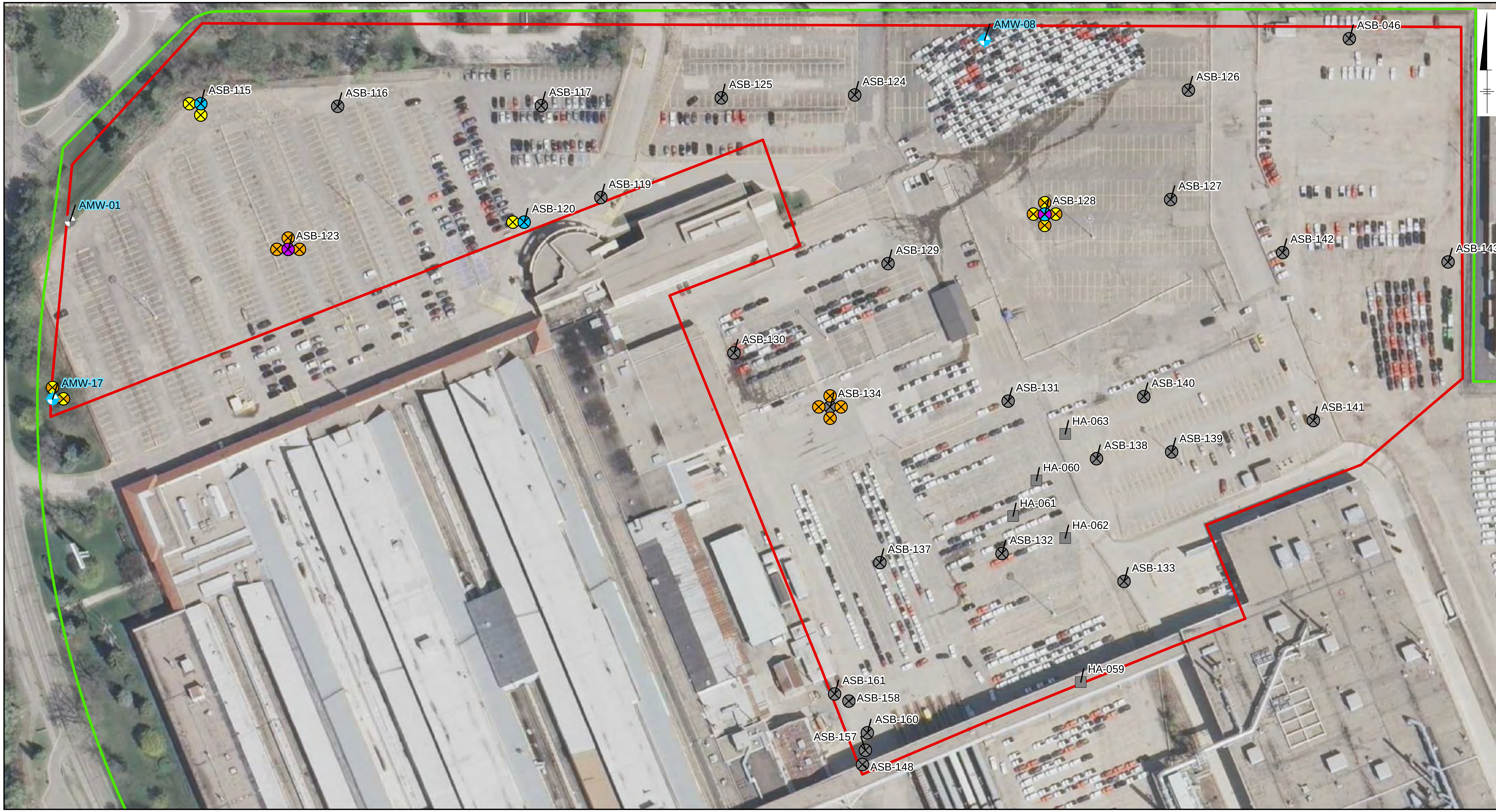


LEGEND:

- Monitoring Well
- AMW-## Groundwater Sampling Location
- Ford Property Boundary
- Soil Boring
- Proposed Soil Boring Location
- Focus Area
- Hand Auger
- Groundwater Delineation Location
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 65 130 260 Feet
1 inch = 130 feet

Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 1 - North Parking Lot Area

ARCADIS

FIGURE 3

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA1_Locations_20130701.mxd

LEGEND:

- Monitoring Well
- AMW-## Groundwater Sampling Location
- Postponed Location, Drill Requirement
- Soil Boring
- Proposed Soil Boring Location
- Ford Property Boundary
- Groundwater Delineation Location
- Focus Area
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 65 130 260 Feet

1 inch = 130 feet

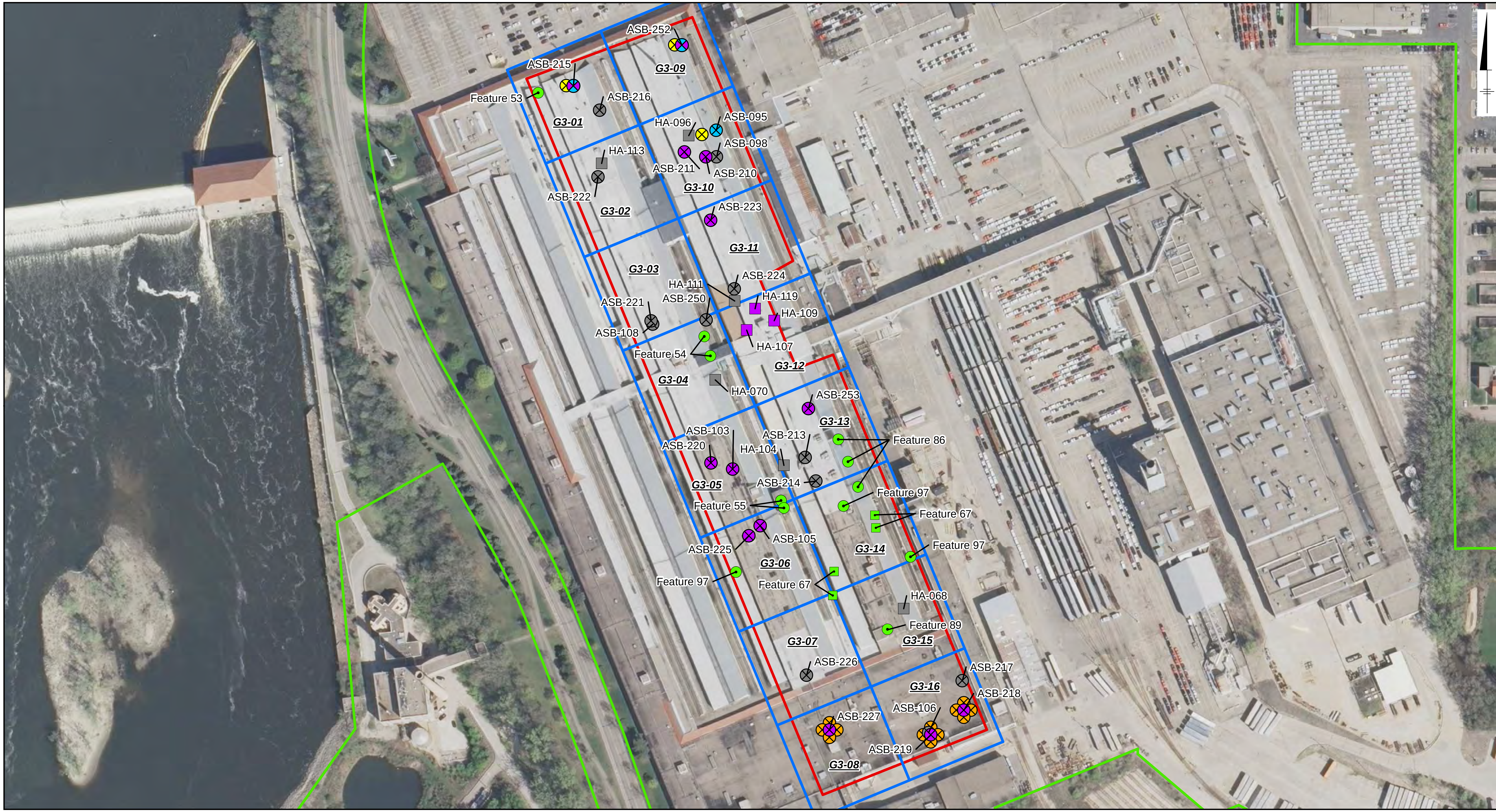
Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 2 - Open LUST Releases

ARCADIS

FIGURE 4

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA2_Locations_20130701.mxd



LEGEND:

- Soil Boring
- Hand Auger
- Proposed Soil Boring Location
- Groundwater Delineation Location
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance
- Postponed Location, Drill Requirement
- Hydraulic Lift Inspection Upon Removal
- Ford Property Boundary
- Focus Area
- G3-## 1 - Acre Grid

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 100 200 400 Feet
1 inch = 200 feet

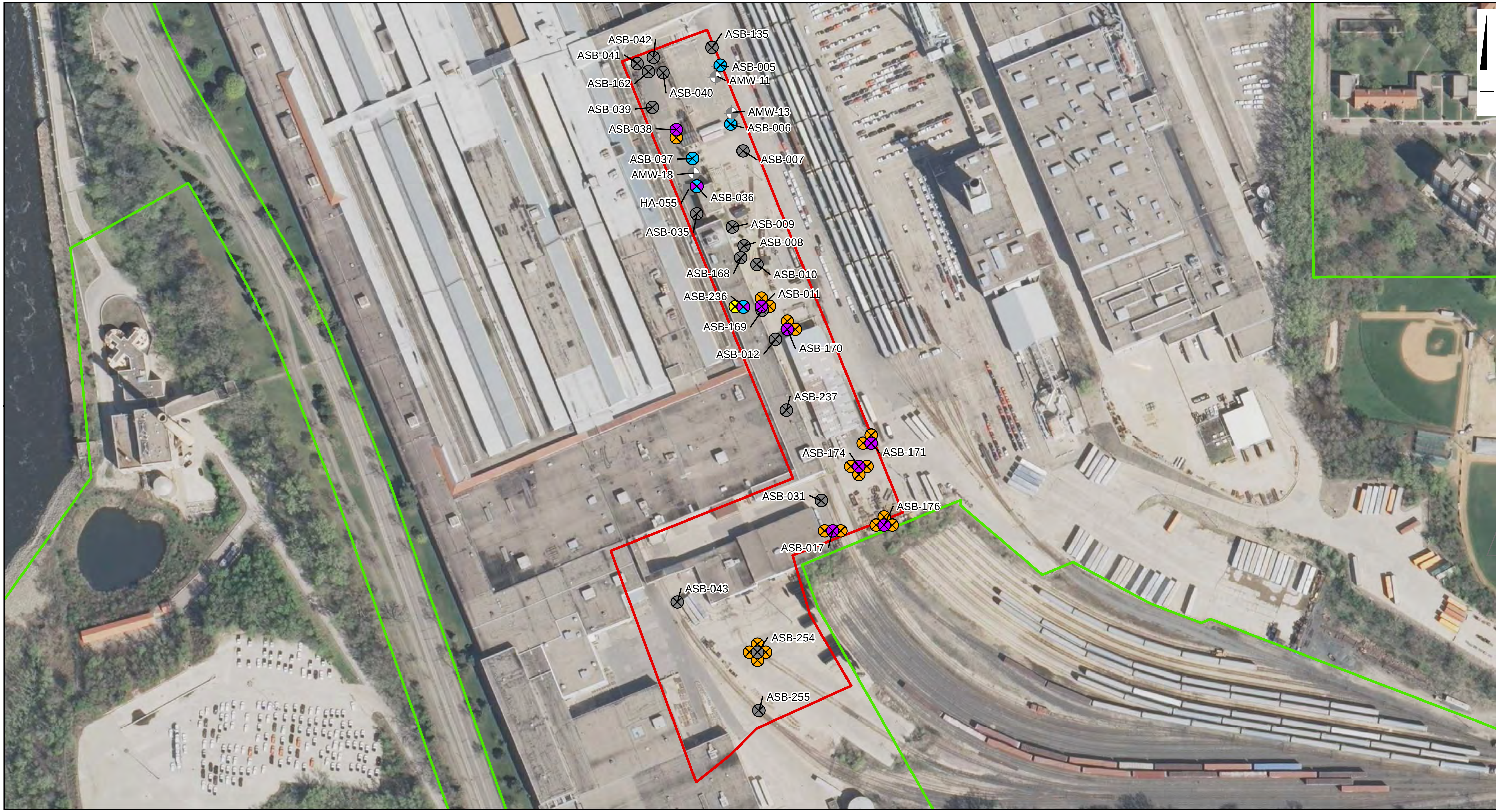
Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 3 - Main Assembly Plant

ARCADIS

FIGURE 5

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA3_Locations_20130702.mxd



LEGEND:

- Monitoring Well
- Soil Boring
- Hand Auger
- Proposed Soil Boring Location
- Groundwater Delineation Location
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance
- Ford Property Boundary
- Focus Area

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 90 180 360 Feet

1 inch = 180 feet

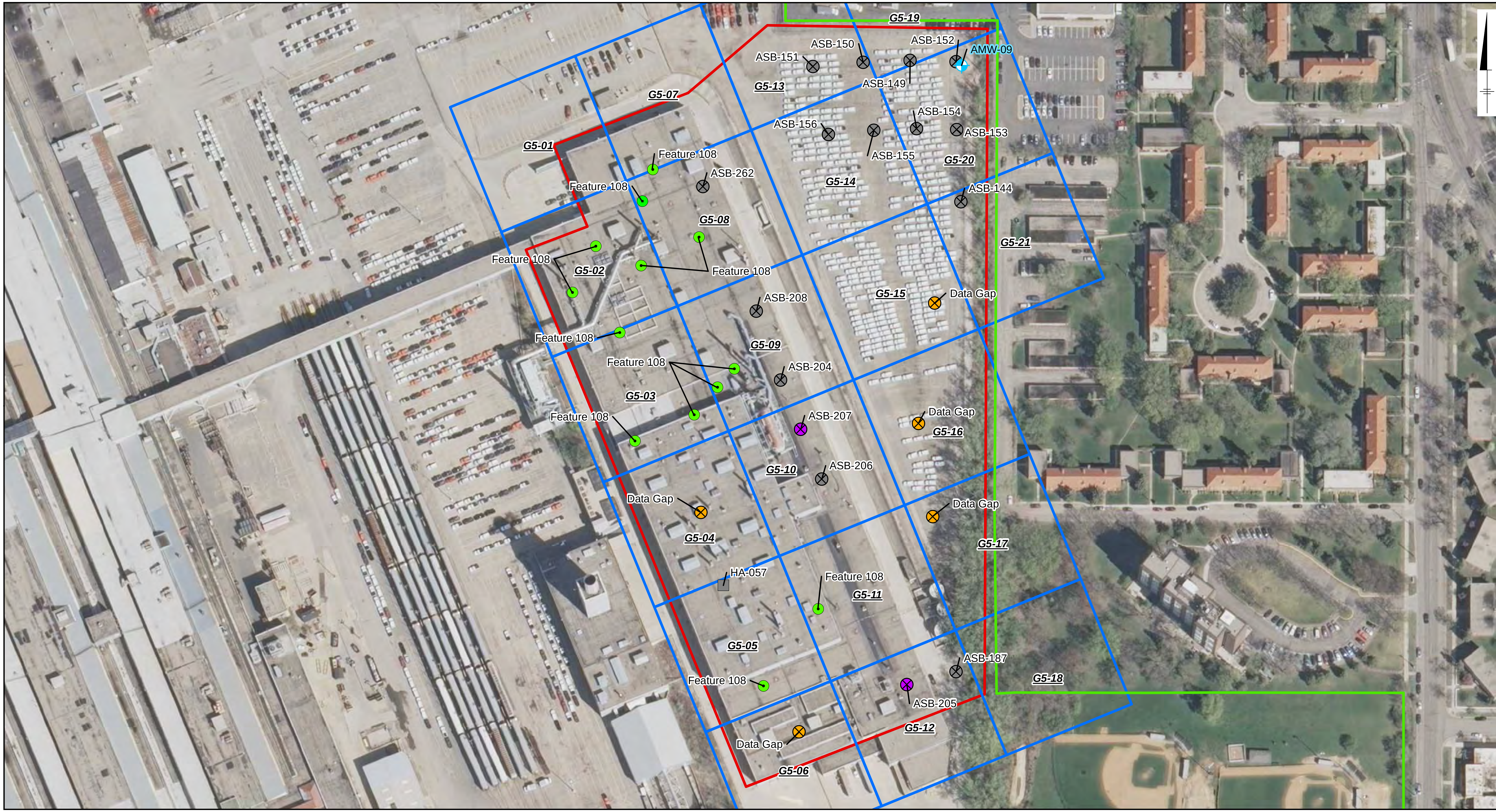
Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 4 -
Former Hazardous Waste Storage Areas

ARCADIS

FIGURE 6

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA4_Locations_20130702.mxd



LEGEND:

- Monitoring Well
- AMW-## Groundwater Sampling Location
- Soil Boring
- Proposed Soil Boring Location
- Hand Auger
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance
- Postponed Location, Drill Requirement
- Ford Property Boundary
- Focus Area
- G5-## 1 - Acre Grid

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 75 150 300 Feet
1 inch = 150 feet

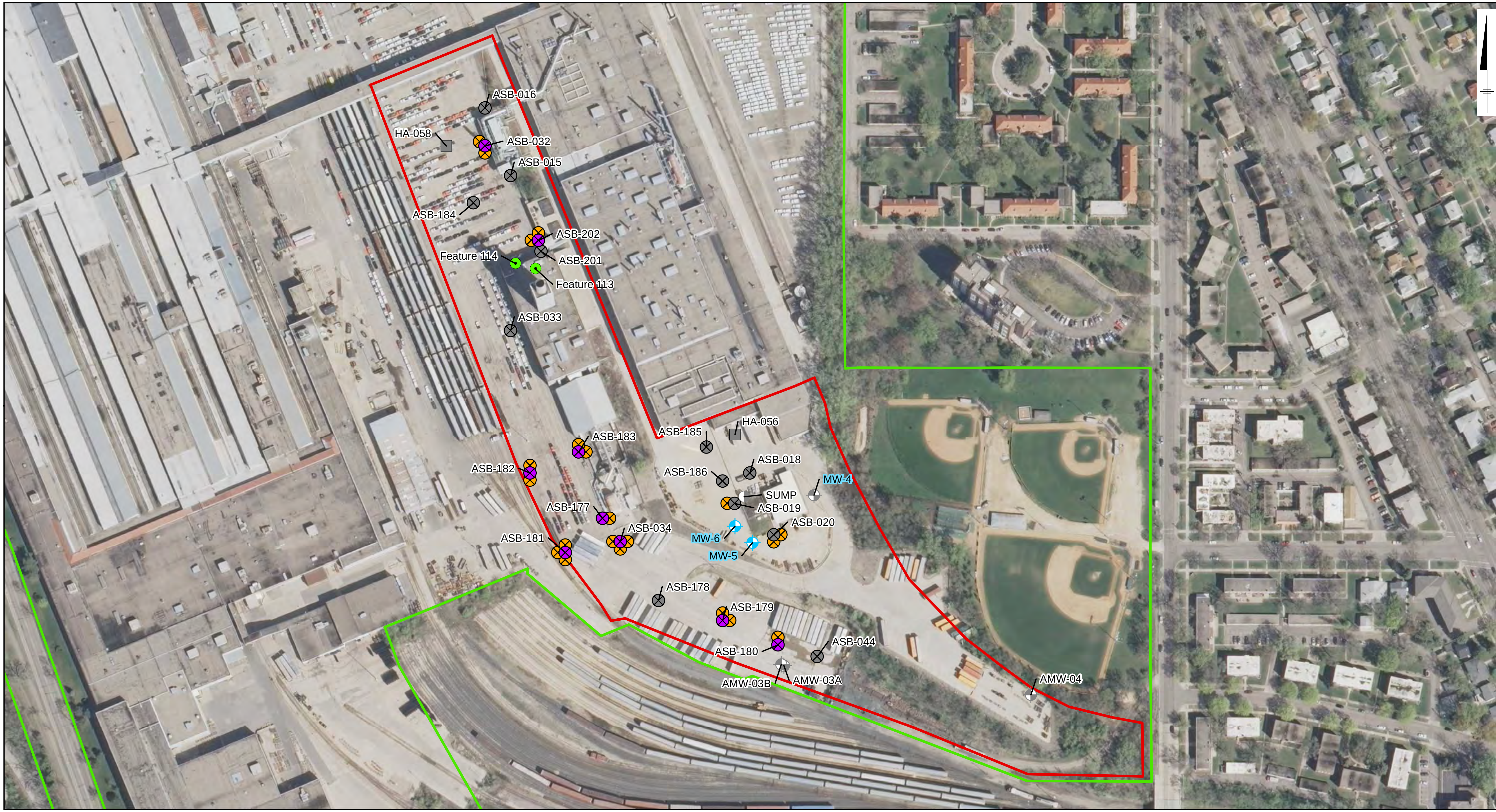
Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 5 - Paint Shop

ARCADIS

FIGURE
7

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA5_Locations_20130702.mxd



LEGEND:

- Monitoring Well
- Soil Boring
- Hand Auger
- Sump
- MW-## Groundwater Sampling Location
- Proposed Soil Boring Location
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance
- Postponed Location, Drill Requirement
- Ford Property Boundary
- Focus Area

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 100 200 400 Feet

1 inch = 200 feet

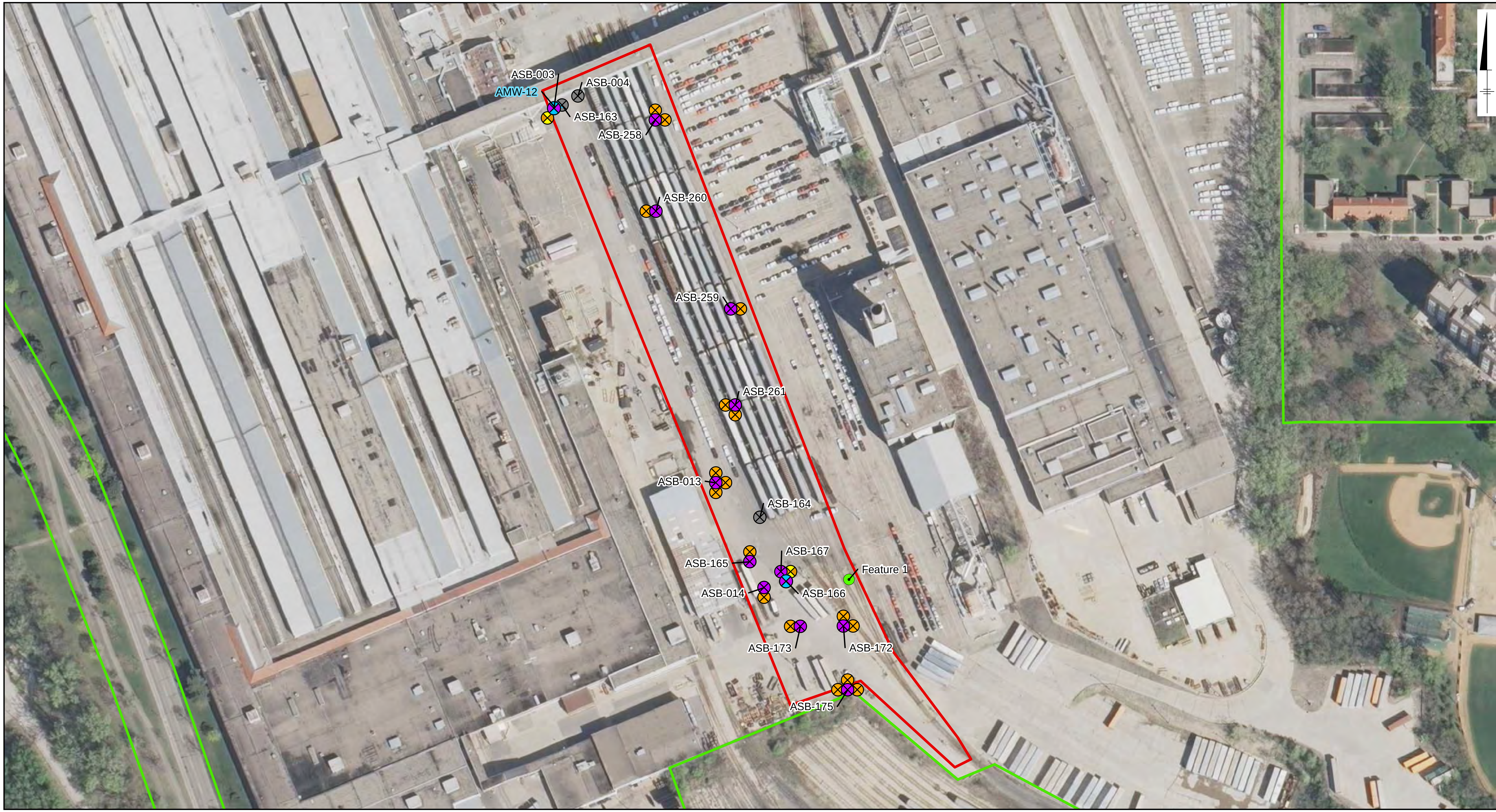
Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 6 - Former Hazardous Waste Storage and Disposal Areas

ARCADIS

FIGURE 8

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA6_Locations_20130702.mxd



LEGEND:

- Monitoring Well
- Soil Boring
- AMW-## Groundwater Sampling Location
- Proposed Soil Boring Location
- Groundwater Delineation Location
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance
- Postponed Location, Drill Requirement
- Ford Property Boundary
- Focus Area

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 75 150 300 Feet

1 inch = 150 feet

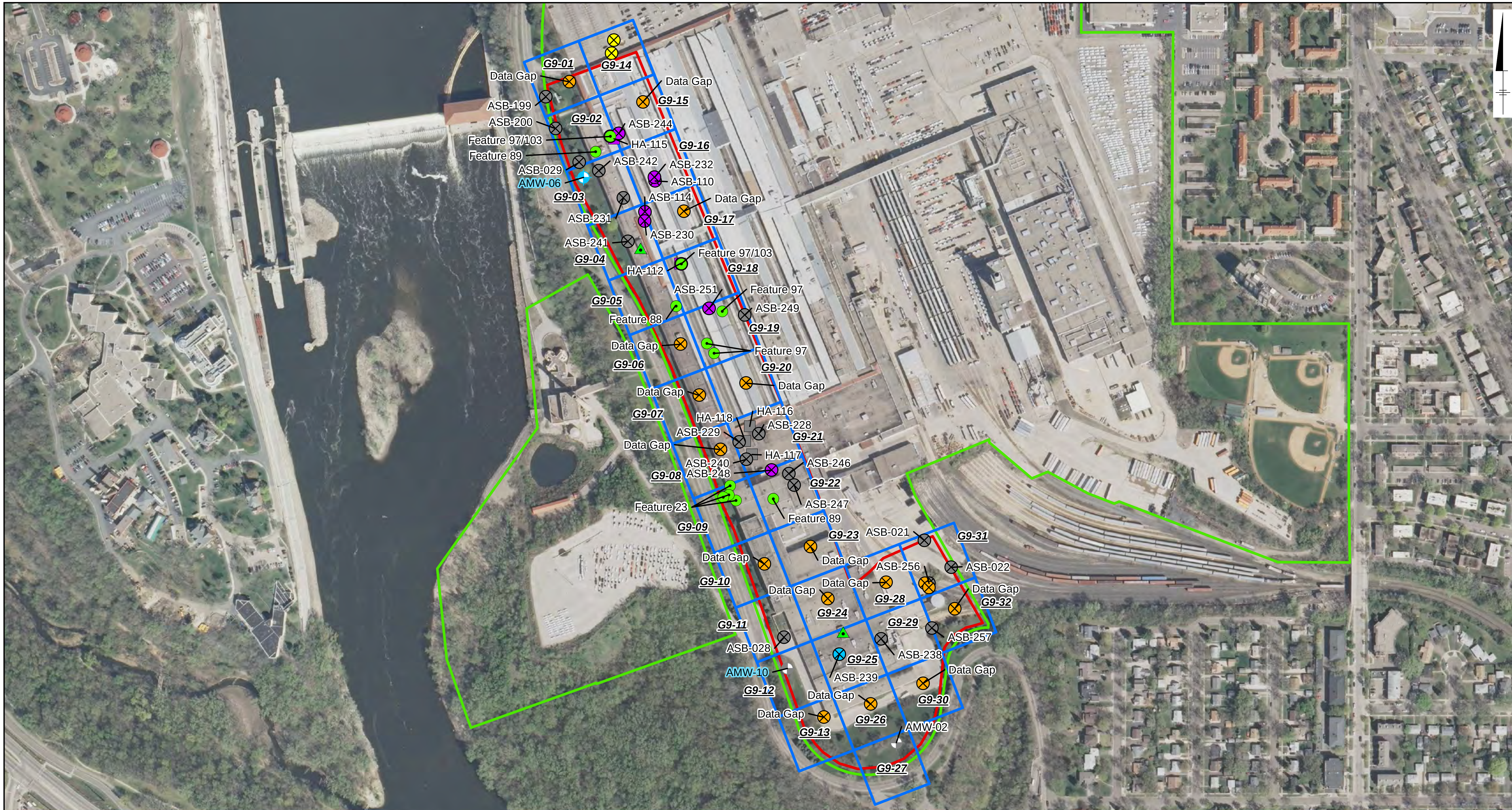
Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 7 - Railroad Tracks

ARCADIS

FIGURE 9

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA7_Locations_20130702.mxd



LEGEND:

- Monitoring Well
- Soil Boring
- Hand Auger
- AMW-## Groundwater Sampling Location
- Proposed Soil Boring Location
- Groundwater Delineation Location
- MPCA Tier 1 Residential SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance
- Postponed Location, Drill Requirement
- Postponed Location, Roof Level
- Ford Property Boundary
- Focus Area
- G9-## 1 - Acre Grid

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 175 350 700 Feet

1 inch = 350 feet

Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 9 - Main Assembly Building (Specific to Residential Cleanup)

ARCADIS

FIGURE
10

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA9_Locations_20130702.mxd

LEGEND:

- Monitoring Well
- AMW-## Groundwater Sampling Location
- Ford Property Boundary
- Soil Boring
- Proposed Soil Boring Location
- Focus Area
- MPCA Tier 2 Recreational SRV Exceedance or MPCA Tier 2 Industrial SRV Exceedance
- MDH HRL/HBV/RAA or EPA Arsenic MCL Exceedance

NOTES:

AMW = ARCADIS Monitoring Well
ASB = ARCADIS Soil Boring
EPA = Environmental Protection Agency
HBV = Health Based Value
HRL = Health Risk Limit
MCL - Maximum Contaminant Level
MDH = Minnesota Department of Health
MPCA = Minnesota Pollution Control Agency
RAA = Risk Assessment Advice
SRV = Soil Reference Value
Imagery Source: MnGeo WMS service, 2010 color 7-county
http://geoint.lmic.state.mn.us/cgi-bin/wms? Accessed 6/10/2013

0 65 130 260 Feet

1 inch = 130 feet

Twin Cities Assembly Plant
Ford Motor Company
St. Paul, Minnesota

Focus Area 11 - Wastewater Treatment Plant

ARCADIS

FIGURE
11

CITY: Minneapolis, MN DB: MGress PM: Bryan Zinda
Project MN000593
Path: G:\GIS\Projects\Ford Ranger\ArcMap\2013\2013-07\FA11_Locations_20130702.mxd

Appendix A

Standard Operating Procedures

EXECUTIVE SUMMARY

Damaging an underground or above ground utility can result in serious injury and loss of life, disrupt essential services, and create significant liability to ARCADIS, clients and subcontractors. Therefore, it is ARCADIS' policy that the presence of all existing utilities will be investigated and cleared (to the extent feasible) by locating, marking, and, where appropriate, visually verifying before the start of any field operation. The following requirements are mandatory under this policy:

- A minimum of three (3) reliable lines of evidence are required for an acceptable utility clearance.
- Additional lines of evidence are required if the primary three lines of evidence cannot adequately identify subsurface, submarine or above ground utilities within the area of proposed intrusive work.
- The lines of evidence used will be reasonable and appropriate for the conditions expected to be encountered (soil type, water table, etc.) and the type of utilities expected to be encountered (e.g., gas line versus an irrigation line).
- For point clearance (single intrusive point, used as 1 of the 3 required lines of evidence) the borehole must be cleared to 110% of the diameter of the intrusive device (i.e. auger, drill head, etc.) or an additional 2 inches of overall diameter, whichever is greater.
- Utility clearance information will be documented on the ARCADIS Utility and Structures Checklist (USC) or equivalent client provided checklist or permit.
- Employees overseeing utility clearance activities will:
  - Be familiar with the contents of this standard;
  - Have one year field experience in the identification of utilities; and
  - Have training and six months experience in the proper operation and results interpretation of any clearance equipment used by ARCADIS employees, including without limitation, magnetometers and ground penetrating radar.
- All utility strikes must be reported to Corporate Health and Safety and Legal within 24 hours using the Utility Line Strike Investigation Form. **Do not enter the incident into 4-Sight until approved to do so by Corporate Legal. Refer to HSFS-019 Supplement 7, Emergency Action Plan guidelines for Utility Strikes.**

Report Utility Incident Now

1. POLICY

It is the practice of ARCADIS and its affiliated companies to implement appropriate, reasonable and practical standards within acceptable and customary industry practices to promote the health and safety of its employees, and avoid and mitigate exposure of risk in the performance of their work. In furtherance of this policy, ARCADIS promotes and encourages compliance by all employees with this policy and standards relating to work in the vicinity of subsurface, submarine or aboveground utilities.

2. PURPOSE AND SCOPE

2.1 Purpose

This standard directs general safety standards and best practices associated with the identification and management of subsurface, submarine and aboveground utilities on project sites.

2.2 Scope

This standard assigns responsibilities and expectations for proper utility clearance by both ARCADIS employees and ARCADIS subcontractors at project sites.

3. DEFINITIONS

Refer to ARC HSFS-019 Supplement 1 for definitions of terms used in this standard.

4. RESPONSIBILITIES

4.1 Project Manager Responsibilities

For every project site having the potential to come into contact with utilities, Project Managers must ensure that:

- The requirements of this standard are followed.
- Local regulations governing utility clearance are followed. This includes ensuring local and or state laws defining activities or depth of intrusive work/excavation requiring utility clearance are reviewed as they vary by location.
- Efforts are made to work with the client, project site representatives and subcontractors to identify the nature of any utilities, and to determine what control processes need to be implemented by ARCADIS and the subcontractors to prevent damage to these utilities and to properly manage the effects in the event there is utility damage.
- Utility clearance activities are only delegated to a Task Manager or other individual meeting the requirements of section 4.2 below, as appropriate. However, even if the Project Manager delegates certain responsibilities, the Project Manager maintains primary responsibility for a complete utility

clearance For additional information on PM responsibilities and best practices refer to ARC HSFS-019 Supplement 2

4.2 Field Personnel Responsibilities

ARCADIS field personnel conducting work on a project site having the potential to come into contact with utilities have the responsibility to:

- Read, understand, and follow this standard and complete the appropriate checklists during the on-site utility locate process.

- Complete a minimum of 1 year of utility clearance related experience before accepting responsibility for any utility clearance tasks.

- Complete training and have 6 months of experience in operating and interpreting the results of remote sensing technologies, including without limitation, magnetometers and ground penetrating radar, before operating such technologies. Field staff should understand the technologies being utilized by a private utility locate contractor, and how they are operating in comparison with the site conditions. Refer to ARC HSFS-019 Supplement 4 for more information.

- Use their Stop Work Authority to eliminate any reasonable concern if utilities cannot be reasonably located and contact the Project Manager to review the Stop Work situation and confirm the direction of action moving forward.

- Ensure that ARCADIS subcontractors conduct their own reasonable independent utility clearance efforts as required by ARCADIS' standard subcontract, and are aware of any ARCADIS clearance standards used onsite.

- Be on site during utility locate activities, and any active intrusive activities involving contractor under contract to ARCADIS.

4.3 ARCADIS Subcontractor Responsibilities

According to ARCADIS' standard subcontract, subcontractors have agreed to take responsibility for any damages resulting from a utility impact caused by their work. Therefore, ARCADIS subcontractors are expected to take reasonable time and diligence to conduct their own independent utility clearance using reasonable standards and processes. Subcontractors have the responsibility to stop their work if utility concerns are identified and will report those concerns to the ARCADIS employee overseeing their work activities. ARCADIS staff should reinforce these responsibilities with subcontractors during job safety briefings.

In jurisdictions where the actual contractor performing the intrusive work activity is required to perform utility clearance notifications, the contractor will perform the clearance notification and will provide evidence of the notification to ARCADIS (ticket or ticket number, etc). Refer to ARC HSFS-019 Supplement 5 for Best Practices for State One Call procedures.

5. STANDARD

5.1 General

Protocols to be followed during utility clearance activities are outlined in:

- Best Practices for Project Managers (or Their Delegates) Concerning Utility Clearance (ARC HSFS-019 Supplement 2).
- Best Practices for Field Personnel Concerning Utility Clearance (ARC HSFS-019 Supplement 3).
- Use and Limitations of Common Underground Locating Technologies and Clearance Methods (ARC HSFS-019 Supplement 4)
- Best Practices for State One Call Procedures (ARC HSFS-019 Supplement 5)
- HSFS-019 Supplement 6, Emergency Action Plan guidelines for Utility Strikes
- Utility Location Standard Operating Procedure for Aquatic Work Activities (ARC HSFS-019 Supplement 7)

5.2 Lines of Evidence

A minimum of 3 lines of evidence are required for an appropriate utility clearance as defined in this standard. Generally, the following lines of evidence may be utilized to meet this requirement:

- Contact the State One Call or equivalent service (Nationwide "811" is acceptable) if working within the right-of-way or public areas served by such services. For work on private property or in areas not served by such services, utilize a reputable private utility locating company to locate and mark the utilities. Use of a private utility locator is encouraged for all projects with subsurface or submarine utility issues. Note that One Call can provide valuable information regarding locations and types of utilities entering the private property, even when not marking the actual intrusive work area.
- In situations where the State One Call system or equivalent service does **not** cover the area of proposed intrusive activities, then an additional line of evidence is required. The additional line of evidence should be pertinent to the area of intrusive activities. This does not negate the completion of the State One Call or equivalent service.
- Use detailed scaled site utility plans, preferably in the form of an "as-built" or "record" drawing, to identify and/or confirm utility locations. Document request and/or receipt of utility drawings from the property owner/client on the Utilities and Structures Checklist.
- Conduct a detailed visual site inspection to identify and/or confirm utility locations. For underground utilities, conduct an inspection for structures that tend to indicate the presence and general location of such utilities, including, but not limited to manholes, vaults, valve covers, valve markers, telephone

View the Utilities and Structures Checklist

pedestals, transformer housings, fire hydrants, spigots, sprinkler heads, air relief valves, backflow preventers, meters, downspouts going into the subsurface, power poles with wring going into the subsurface and line markers. Saw cut lines and concrete /asphalt repairs often yield valuable information regarding utility locations. Always discuss the presence of utilities with the site owner, operator and/or occupant to identify any potential utilities that might not be readily identified by non-intrusive clearing methods or may be:

- At depths > 5 ft below ground surface; or
- At very shallow depths (< 2ft below ground surface) such as communication lines, electrical conduits/wiring, irrigation lines, etc.

If one of the above lines of evidence cannot be utilized, or if using the above lines of evidence does not adequately identify utilities with reasonable certainty, one or more additional lines of evidence must be utilized. Commonly used lines of evidence are listed on the Utility and Structures Checklist.

A discussion of use and limitations associated with common utility location and clearance methods is provided in ARC HSFS-019 Supplement 4.

Standard operating procedures for utility location in subaquatic settings are presented in ARC HSFS-019 Supplement 7.

The lines of evidence will be recorded on the Utility and Structures Checklist or equivalent client provided checklist or permit.

5.3 Color Codes Used for Utility Markings

The following colors are used for marking utilities. Some government agencies or large industrial facilities may use additional colors not provided below. ARCADIS policy is to assume any paint marking or pin flag color not provided below is a subsurface utility marking until proven otherwise.

COLOR	Utility Line
WHITE	Proposed Excavation
PINK	Temporary Survey Markings
RED	Electrical Power Lines, Cables, Conduit and Lighting Cables
YELLOW	Gas, Oil, Steam, Petroleum or Gaseous Materials
ORANGE	Communication, Alarm or Signal Lines, Cables or Conduit
BLUE	Potable Water
PURPLE	Reclaimed Water, Irrigation and Slurry Lines
GREEN	Sewer and Drain Lines

APWA and ANSI standard Z-53.1

5.4 Locating Technologies

There are several types of locating technologies that can be used to identify and locate utilities in the subsurface. Project teams need to work closely with private utility locators (PUL) in order to best match locating technology with site conditions. To provide the best results all possible locating technologies should be available for use and implementation at the project location. Any potential interferences should also be discussed up front and then at the project site during utility location activities. Potential interferences could be soil moisture, soil type, standing water on concrete/asphalt, rebar, fencing, and metal structures that are in the subsurface. Employees overseeing locating technology activities should have an understanding of device operation and limitations. For further information refer to HSFS-019 Supplement 4, Use and Limitations Associated with Location Technologies and Common Utility Clearance Methods

5.5 Clearance Methods

In some cases, proposed intrusive locations may be pre-cleared using other intrusive methods. Determine the clearance or soft dig method based on site conditions and utilize the least invasive method possible. The number of intrusive locations and soil type should be taken into consideration. The following clearance methods are listed from least invasive to most:

1. Vacuum Extraction/Potholing (air or water based),
2. air knifing,
3. hydro knifing,
4. probing,
5. hand auguring
6. hand digging, and
7. posthole digging.

Single point clearance must be 110% of the proposed intrusive area, or plus 2" (in the case of a boreole diameter). 3-Point clearance must be installed in a triangular pattern around the proposed borehole. Each method of clearance should be documented on the Utility and Structure Checklist.

Prior to the start of intrusive activities, all utilities must be located and measures instituted to avoid subsurface utility hazards. Do not conduct subsurface work within 30 inches of a line marking and around the utility in a 360^{o} direction. If subsurface work must take place within the 30 inch buffer zone of the line marking, the utility must be exposed (potholed) by soft dig / clearance methods prior to starting intrusive work (Refer to the Excavation Considerations in Supplement 2); **no mechanized equipment is permitted for the exposing of the utility**. Once the utility has been exposed, if mechanized equipment is planned for use within the 30 inch buffer zone of the utility, such activity must receive pre-approval by Corporate H&S and others, as necessary, to mitigate or accept the risk associated with the planned work. Additional excavation safety procedures may have to be developed as part of the approval to proceed. It should be noted that any disturbance within the 30 inches or disruption of the bedding materials could affect the integrity of the utility.

For horizontal borings, do not drill within 30 inches of the line in the vertical direction (above or below the top or bottom of the utility). Make sure to factor the diameter of the line when computing 30 inch buffer zone. When exposing utilities for horizontal borings the same exposing techniques would be required as above.

During well installations via mechanical equipment, the 30 inch buffer zone rule applies outward from the outside edge of the largest diameter auger or tool to be used for installation and abandonment (over drilling). In cases where wells have been previously installed and the 30 inch rule has not been followed, approval for using mechanized equipment to work within the 30 inch buffer zone will require approval from Corporate H&S.

Manual clearing methods such as shoveling, using pick axes, digging bars and other hand tools should be avoided completely or only used when absolutely necessary and used with caution. Excessive down force, prying or use in poor/obstructed visibility conditions is prohibited as these tools can damage utilities.

Surface cover (e.g., asphalt) removal methods that pose excessive down force such as Jackhammering should be used with extreme caution. Methods that only cut the surface cover (coring or saw cutting) present less risk due to the absence of the downward force which could cause collateral damage to shallow subsurface utilities. Note that utilities are often present at the concrete or pavement/soil interface or encased within the concrete or pavement and are easily damaged during concrete coring or pavement removal. Always work slowly, methodically and frequently stop work to evaluate conditions during these work activities.

For borings and excavations, if the utility is known to be at depths where hand clearing is not feasible or creates additional safety concerns, no work will be performed within 30 inches vertically or horizontally of the utility unless manual clearing is performed under the oversight of an Excavation Competent Person as defined in the ARCADIS Excavation and Trenching H&S standard (ARC HSCS005).

For horizontal borings, to avoid potential of utility strike, damage from vibration, damage by pressure of the advancing boring, do not plan the drill boring location within 30 inches of utilities. This requirement applies even if the operating contractor has technology that places the location to within a few inches. Make sure to factor the diameter of the utility when determining the 30 inch buffer zone.

Additional cautions for horizontal borings include gravity utilities such as sewers and storm drains as the depth of these utilities will change (sometimes significantly) as they run across the project site. Always obtain the utility depth at the location where the boring will actually cross the line.

5.6 Acceptable Clearance for Working in Vicinity of Overhead Power Lines

No work will be performed by ARCADIS or our subcontractor near overhead power lines where any Unqualified Person or equipment is within the limits specified below, unless the power line has been properly covered or de-energized by the owner or operator of the power line. Qualified Person approach distances are defined in Exhibit 5 of the ARCADIS Electrical Standard (ARC HSFS0006).

Power Line Voltage Phase to phase (kV)	Minimum Safe Clearance (feet)
50 or below	10
Above 50 to 200	15
Above 200 to 350	20
Above 350 to 500	25
Above 500 to 750	35
Above 750 to 1,000	45

ANSI standard B30.5-1994, 5-3.4.5

5.6.1 Reducing Vehicle and Mechanical Equipment Clearance Requirements

Any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines shall be operated so that a clearance of 10 ft. (305 cm) is maintained. If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10kV over that voltage. However, under any of the following conditions, the clearance may be reduced:

- If the vehicle is in transit with its structure lowered, the clearance may be reduced to 4 ft. (122 cm). If the voltage is higher than 50kV, the clearance shall be increased 4 in. (10 cm) for every 10 kV over that voltage.
- If insulating barriers are installed to prevent contact with the lines, and if the barriers are rated for the voltage of the line being guarded and are not a part of or an attachment to the vehicle or its raised structure, the clearance may be reduced to a distance within the designed working dimensions of the insulating barrier.
- If the equipment is an aerial lift insulated for the voltage involved, and if the work is performed by a qualified person, the clearance (between the uninsulated portion of the aerial lift and the power line) may be reduced to the distance given in Exhibit 1 - Table S-5.

Employees standing on the ground may not contact the vehicle or mechanical equipment or any of its attachments unless:

- The employee is using protective equipment rated for the voltage; or
  - The equipment is located so that no uninsulated part of its structure (that portion of the structure that provides a conductive path to employees on the ground) can come closer to the line than permitted in this section of this standard.

If any vehicle or mechanical equipment capable of having parts of its structure elevated near energized overhead lines is intentionally grounded, employees working on the ground near the point of grounding may not stand at the grounding location whenever there is a possibility of overhead line contact. Additional precautions, such as the use of barricades or insulation, shall be taken to protect employees from hazardous ground potentials, depending on earth resistivity and fault currents, which can develop within the first few feet or more outward from the grounding point.

When a machine is in contact with an overhead power line, do not allow anyone to come near or touch the machine. Stay away from the machine and summon outside assistance.

5.7 Reporting Utility Incidents

ARCADIS field personnel involved with any subsurface, submarine, and above-ground utility strikes should immediately stop work and contact the Project Manager to discuss the incident. The utility strike must be reported to Corporate Health and Safety and Legal Departments immediately, and no later than 24 hours. Use the Utility Line Strike Investigation Form as part of the notification process.

Selected utility strike incidents may also utilize a conference call with operations management to review findings and lessons learned. The Divisional Health and Safety Director will make the determination concerning the need to have the incident review call, and will arrange the call, if deemed necessary.

5.8 Relationship of this standard to the Project Specific HASP

With the exception of the Utility and Structures Checklist, this standard, including most supplements, are not designed to be printed off and attached to project HASPs. During project health and safety planning, this standard will be reviewed and applicable clearance technologies and methods will be documented on the Utility and Structures Checklist.

Additionally, emergency action standards specific to utility strikes should be addressed. ARC HSFS-019 Supplement 6 provides general guidelines for emergency response to utility strikes. Applicable information may be attached to the Utility and Structures Checklist to facilitate communication of response expectations.

5.9 Required Contract Terms and Conditions

ARCADIS' standard client and subcontractor contracts contain required terms and conditions defining responsibility for utility clearance and the allocation of risk associated with an impacted utility. These terms and conditions have prescribed language concerning subsurface work that is presented in ARCADIS client contracts and ARCADIS subcontractor contracts. If such provisions cannot be agreed upon, the reasons are documented and other risk-management actions should be identified, such as limits of liability, add additional physical investigations, additional lines of evidence or utility location, assignment of risk to subcontractors, etc. In addition, any changes to these terms and conditions require approval by Legal Services.

6. TRAINING

Employees responsible for coordinating or conducting utility clearance activities will be familiar with the requirements of this standard. ARCADIS in-house 8-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) refresher provides awareness-level training regarding this utility location and clearance standard.

7. REFERENCES

- Utility and Structures Checklist
- Utility Line Strike Investigation Form
- HSFS-019 Supplement 1, Utility Definitions
- HSFS-019 Supplement 2, Best Practices for Project Managers (or Their Delegates) Concerning Utility Clearance
- HSFS-019 Supplement 3, Best Practices for Field Personnel Concerning Utility Clearance
- HSFS-019 Supplement 4, Use and Limitations Associated with Location Technologies and Common Utility Clearance Methods
- HSFS-019 Supplement 5, Best Practices for State One Call Procedures and Notifications
- HSFS-019 Supplement 6, Emergency Action Plan guidelines for Utility Strikes
- HSFS-019 Supplement 7, Utility Location SOP for Aquatic Work Activities
- ARC HSCS005 Excavation and Trenching
- Required client contract language concerning subsurface work
- Required subcontractor language concerning subsurface work

8. RECORDS

8.1 Utility Clearance Records

All records (maps, checklists and documentation of communications) used to determine the location of utilities should be retained and kept in the project file.

9. APPROVALS AND HISTORY OF CHANGE

Approved By: Tony Tremblay, CSP – Infrastructure Division, Director of H&S

History of Change

Revision Date	Revision Number	Reason for change
13 December 2006	01	Original document
26 March 2007	02	Put in new company format
15 May 2007	03	Added nation-wide 811 number
6 September 2007	04	Changing over to new template format
22 February 2008	05	Changing over to new template format
13 January 2009	06	Define lines of evidence
4 October 2010	07	Reformatting and addition of utility clearance information
13 February 2012	08	Modified link information for utility strike reporting, clarified local/state requirements in section 4.1 and 4.3
28 January 2013	09	Utility and Structures Checklist revised; hyperlink updated
12 February 2013	10	Clarified clearance boundaries for Unqualified staff in Section 5.7 and added information about vehicles and equipment being used near power lines in Section 5.7.1
15 March 2013	11	Added additional text to standard for recent lessons learned, added section 5.4 (Locating Technologies) and 5.5 (Clearance Methodologies), added additional details to section 5.6 when working in close proximity to subsurface utilities, and added Supplement 6 - Utility Location SOP for Aquatic Work Activities.

Imagine the result

Field Log Book Entries

Rev. #: 0

Rev Date: 11 August 2009

Approval Signatures

Prepared by: ______________________ Date: 8/11/09

Reviewed by: ______________________ Date: 8/11/09
(Technical Expert)

I. Scope and Application

This ARCADIS Standard Operating Procedure covers the entries needed in a field log book for environmental investigations.

This SOP does not address all of the entries that may be needed for a specific project, and does not address health and safety, equipment decontamination, field parameter measurements, sample preservation, chain-of-custody, or laboratory analysis. For direction on requirements in these areas, refer to other ARCADIS SOPs, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan, as appropriate.

II. Personnel Qualifications

ARCADIS personnel participating in fieldwork and making entries into the field log book should have a minimum of one (1) year of field experience (or be under the supervision and accompanied in the field by someone who does) and current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. Field personnel will also be compliant with client-specific training requirements. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

III. Equipment List

- Field Log Book
- Ball point (medium point) pen with blue or black ink (black preferred). A fine point Sharpie pen may be used if the ink does not bleed through the page and become visible on back side of the page. If weather conditions prevent the use of a pen, indicate so in the log and use an alternate writing instrument .
- Zip-lock baggie or other weather-proof container to protect the field log book from the elements.

IV. Cautions

All entries in the field log must be legible and archivable. Do not leave the field log book exposed to the elements or other conditions that might moisten the pages and smear/dissolve the entries. When not in the field, the log book should be stored in a location that is easily accessible to field crews.

V. Health and Safety Considerations

ARCADIS field personnel will be familiar and compliant with Client-specific health and safety requirements.

VI. Procedure

- Print legibly. Do not use cursive writing.
- The name of the project, project number and project location should be written in indelible ink on the outside of the field log book.
- On the inside of the front cover, write “If Found, Please Return to ARCADIS” and include the appropriate address and phone number, the name of the person to which the book is assigned, and the name of the project manager.
- Reserve the first page of the book for a Table of Contents.
- Reserve the last five (5) pages of the book for important contacts, notes, reminders, etc.
- Each day of field work, the following should be recorded in the field log book as applicable:

    a) Project Name

    b) Date and time arrived

    c) Work Site Location

    d) Names of people on-site related to the project including ARCADIS employees, visitors, subcontractor employees, agency personnel, client representative, etc.

    e) Describe the work to be performed briefly, and list the equipment on-site

    f) Indicate the health and safety (H&S) level to be used

    g) Record instrument calibrations and checks

    h) Record time and general content of H&S briefing

    i) Describe the weather conditions, including temperature, precipitation, and wind speed and direction

    j) List periodic time entries in the far left hand column of each page

    k) Minimize unused space on each page

- The tailgate meeting must be recorded in the log book and the tailgate form completed. If H&S monitoring is performed, record the time and results of initial and followup monitoring.

- Note factual observations including collection of QA/QC samples, delays, well damage, accidents, work plan deviations, instrument problems, and problem resolutions.

- Describe work performed and how documented such as photographs, sample core logs, water sampling logs, etc.

- Describe bases for field decisions including pertinent conversations with visitors, regulators, or project personnel.

- Note final instrument calibrations and checks.

- Sign the log book at the end of each day at a minimum. Draw a line to the end of the page to indicate no further entries on that page. Sign the bottom of each page if possible.

- If an entry to the log book is changed, strike out the deleted text or item with a single line such that the entry remains legible, and initial and date the change. Such changes should only be made by the same person that made the initial entry.

- Field log book entries must be made in the field at the site, not at a later time at a different location. Supplemental entries to the log book may be made at a later date. The supplemental entry must be clearly identified as such and the entry must be signed and dated as described in this SOP.

- Problems noted in the field log book must be brought to the attention of the project manager and task manager in a timely fashion. Problems may be reported in person, on the telephone, or in a written daily log form. If daily logs are prepared and you will not be able to personally give the daily log to the project manager, send the daily log via FAX or overnight courier to the project manager and task manager.

VII. Waste Management

Investigation-derived waste will be managed as described in the Investigation-Derived Waste Handling and Storage SOP. A drum/waste inventory should be maintained on a pre-designated page in the field log book.

VIII. Data Recording and Management

Each page of the field log book should be scanned for electronic/digital archiving at periodic intervals. This will ensure that copies of the field notes are available in the event the field book is lost or damaged, and that field data can be easily disseminated to others without the risk of physically sending the field log book. Field log books that are full should be archived with the project files, and readily retrievable.

IX. Quality Assurance

Be mindful that the field log book may be produced in court. All entries should be legible (as discussed above). Entries should also be in English, unless working in a country where English is not the predominant language or you are directed otherwise by the project manager.

X. References

Not Applicable

Infrastructure, environment, facilities

Imagine the result

Drilling Procedures for Collecting and Screening of Soil Samples

Rev. #: 2

Rev Date: March 24, 2008

Approval Signatures

Prepared by: ______________________________ Date: ________________________

Reviewed by: ______________________________ Date: ________________________
(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the collection and field screening of soils samples using a truck- or track-mounted drill rig using the hollow-stem auger, drive and wash, or mud/water rotary drilling methods after completion of utility clearance procedures. Field screening of the soil samples upon collection may be conducted using a photoionization detector (PID) and/or a flame ionization detector (FID). These instruments are used to measure relative concentrations of volatile organic compounds (VOCs) for the selection of samples for further laboratory or field analysis.

II. Personnel Qualifications

The Project Manager (a qualified geologist, environmental scientist, or engineer) will identify the appropriate soil boring locations, depth and soil sample intervals in a written plan.

Personnel responsible for overseeing drilling operations must have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

III. Equipment List

- appropriate health and safety equipment;
- PID and FID;
- air-tight sample containers, 8-oz. glass Mason jars or driller's jars, and 40 mL headspace vials;
- aluminum foil;
- extra batteries for the PID;
- calibration gases and regulators;
- spare filter cartridges;
- field notebook and appropriate screening forms; and
- indelible ink pens.

IV. Cautions

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

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.

V. Health and Safety Considerations

To be completed by Preparer and reviewed by Technical Expert.

VI. Procedure

All soil samples will be field screened upon collection with a PID for a relative measure of the total VOCs. Initial PID readings will be recorded in the surface log or field notebook. The true soil sample will be separated from the wash material (if any) by using disposable gloves and a pre-cleaned stainless steel spoon. A representative portion of the sample will be placed in a pre-cleaned air-tight 8-ounce and 40 mL sampling container (as quickly as possible to avoid loss of VOCs), filling the containers half full to allow for the accumulation of vapors above the soil. For the glass 8-ounce jar, an aluminum foil seal will be placed between the glass and metal cap and the cap will be screwed on tightly. For the 40-mL vial, a Teflon septum cap will be placed between the glass and the plastic threaded lid. The sample containers will be stored in a cooler chilled to approximately 4ºC until screening.

Upon completion of sample collection, the headspace of the 8-ounce sample jars will be measured using a PID as follows:

1. Samples will be taken to a warm work space and allowed to equilibrate to room temperature for at least one hour.

2. Prior to measuring the soil vapor headspace concentration, the 8-ounce jar will be shaken.

3. The headspace of the sample will then be measured directly from the 8-ounce sample container with the PID by piercing the aluminum foil seal with the probe

of the PID and measuring the relative concentration of VOCs in the headspace of the soil sample. The initial (peak) reading must be recorded.

Upon completion of sample collection, the headspace of the 40 mL sample vial will be measured using an FID as follows:

1. The 40 mL vials will be placed in a hot water bath for an equal and pre-determined period of time (estimated at 15 minutes).

2. A gas-tight syringe will be used to pierce the teflon septum to extract a volume of headspace (.1 to .5 mL) from the vial.

3. The headspace sample will then be injected directly into the FID of an OVA with a GC attachment. The septum injection port of the OVA should be set on the total field mode. The reading will be recorded on the field screening forms and/or in the field notebook. If a peak is noted in total field mode, a duplicate sample will be injected with the OVA in GC mode and recorded on the strip chart recorder. The retention time will be noted on the GC strip chart, along with the date, time of injection, and the sample identification.

The PID will be calibrated to a benzene-related compound (isobutylene). The FID will be calibrated to methane. The FID/PID must be calibrated according to the manufacturer's specifications at a minimum frequency of once per day prior to collecting FID/PID readings. The time, date, and calibration procedure must be clearly documented in the field notebook and/or the calibration log book. If at any time the FID/PID results appear erratic or inconsistent with field observations, then the unit will be recalibrated. If calibration is difficult to achieve, then the PID's lamp should be checked for dirt or moisture and cleaned. During humid or wet conditions, the unit should be calibrated on a more frequent basis as determined by field personnel. In addition, a blank and a field duplicate will be performed every 10 samples. Maintenance and calibration records will be kept as part of the field quality assurance program.

Sampling for Laboratory Analysis Procedures

Samples will be selected for laboratory analysis based on:

1. Their position in relation to identified source areas;

2. The visual presence of source residues;

3. The relative levels of total VOCs based on field screening measurements; and/or

4. The judgment of the field coordinator.

Samples designated for laboratory analysis will be placed in the appropriate containers. Sample containers for VOC analysis will be filled first. Next, a sufficient amount of the remaining soil will be homogenized by mixing in a stainless steel tray with a clean stainless steel trowel. Then sample containers will be filled for SVOCs, metals, cyanide, and, lastly, for PCBs. For every 20 soil samples obtained, a duplicate soil sample will be obtained by splitting the sample into two sets of sample containers.

VII. Waste Management

Soil cuttings brought to the ground surface during the drilling activities will be handled based on the location of the boring, a visual assessment of the soil, and PID field screening. Soil cuttings from borings located on asphalt or landscaped ground surfaces will be contained in labeled and dated Department of Transportation (DOT)-approved 55-gallon drums. Soil cuttings from borings drilled within the SWMU/disposal areas will be examined and screened with a PID. Soil cuttings will be discarded at ground surface if the soil cuttings consist of cover material above the SWMU/disposal area and no relatively elevated PID readings are measured. If wastes are encountered in the SWMU/disposal area and/or relatively elevated PID readings are measured the soils will be contained in labeled and dated DOT-approved 55-gallon DOT drums.

VIII. Data Recording and Management

A field survey control program will be conducted by a qualified survey crew using standard instrument survey techniques to document boring locations.

IX. Quality Assurance

Equipment cleaning will occur prior to use on the site, between each drilling location, and upon completion of the drilling prior to leaving the site. 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 the soils will be cleaned with high-pressure steam cleaning equipment using a tap water source. The drilling equipment will be cleaned after each boring in an area designated by the field coordinator or supervising geologist. Cleaning water will be contained within a water-tight, lined cleaning area. The solids collected on the floor of the cleaning area will be stored in separate labeled and dated DOT-approved 55-gallon drums.

X. References

To be completed by Preparer and reviewed by Technical Expert.

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Soil Description

Rev. #: 0

Rev Date: May 20, 2008

Approval Signatures

Prepared by: ______________________ Date: 5/22/08

Reviewed by: ______________________ Date: 5/22/08
(Technical Expert)

I. Scope and Application

This ARCADIS standard operating procedure (SOP) describes proper soil description procedures. This SOP should be followed for all unconsolidated material unless there is an established client-required specific SOP or regulatory-required specific SOP. In cases where there is a required specific SOP, it should be followed and should be referenced and/or provided as an appendix to reports that include soil classifications and/or boring logs. When following a required non-ARCADIS SOP, additional information required by this SOP should be included in field notes with client approval.

This SOP has been developed to emphasize field observation and documentation of details required to:

- make hydrostratigraphic interpretations guided by depositional environment/geologic settings;
- provide information needed to understand the distribution of constituents of concern; properly design wells, piezometers, and/or additional field investigations; and develop appropriate remedial strategies.

This SOP incorporates elements from various standard systems such as ASTM D2488-06, Unified Soil Classification System, Burmister and Wentworth. However, none of these standard systems focus specifically on contaminant hydrogeology and remedial design. Therefore, although each of these systems contain valuable guidance and information related to correct descriptions, strict application of these systems can omit information critical to our clients and the projects that we perform.

This SOP does not address details of health and safety; drilling method selection; boring log preparation; sample collection; or laboratory analysis. Refer to other ARCADIS SOPS, the project work plans including the quality assurance project plan, sampling plan, and health and safety plan (HASP), as appropriate.

II. Personnel Qualifications

Soil descriptions will be completed only by persons who have been trained in ARCADIS soil description procedures. Field personnel will complete training on the ARCADIS soil description SOP in the office and/or in the field under the guidance of an experienced field geologist. For sites where soil descriptions have not previously been well documented, soil descriptions should be performed only by trained persons with a degree in geology or a geology-related discipline.

III. Equipment List

The following equipment should be taken to the field to facilitate soil descriptions:

- field book, field forms or PDA to record soil descriptions;
- field book for supplemental notes;
- this SOP for Soil Descriptions and any project-specific SOP (if required);
- field card showing Wentworth scale;
- Munsell® soil color chart;
- tape measure divided into tenths of a foot;
- stainless steel knife or spatula;
- hand lens;
- water squirt bottle;
- jar with lid;
- personal protective equipment (PPE), as required by the HASP; and
- digital camera.

IV. Cautions

Drilling and drilling-related hazards including subsurface utilities are discussed in other SOPs and site-specific HASPs and are not discussed herein.

Soil samples may contain hazardous substances that can result in exposure to persons describing soils. Routes for exposure may include dermal contact, inhalation and ingestion. Refer to the project specific HASP for guidance in these situations.

V. Health and Safety Considerations

Field activities associated with soil sampling and description will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities. Know what hazardous substances may be present in the soil and understand their hazards. Always avoid the temptation to touch soils with bare hands, detect odors by placing soils close to your nose, or tasting soils.

VI. Procedure

1. Select the appropriate sampling method to obtain representative samples in accordance with the selected sub-surface exploration method, e.g. split-spoon or Shelby sample for hollow-stem drilling, Lexan or acetate sleeves for dual-tube direct push, etc.

2. Proceed with field activities in required sequence. Although completion of soil descriptions is often not the first activity after opening sampler, identification of stratigraphic changes is often necessary to select appropriate intervals for field screening and/or selection of laboratory samples.

3. Examine all of each individual soil sample (this is different than examining each sample selected for laboratory analysis), and record the following for each stratum:

- depth interval;
- principal component with descriptors, as appropriate;
- amount and identification of minor component(s) with descriptors as appropriate;
- moisture;
- consistency/density;
- color; and
- additional description or comments (recorded as notes).

The above is described more fully below.

DEPTH

To measure and record the depth below ground level (bgl) of top and bottom of each stratum, the following information should be recorded.

1. Measured depth to the top and bottom of sampled interval. Use starting depth of sample based upon measured tool length information and the length of sample interval.

2. Length of sample recovered, not including slough (material that has fallen into hole from previous interval), expressed as fraction with length of recovered sample as numerator over length of sampled interval as denominator (e.g. 14/24 for 14 inches recovered from 24-inch sampling interval that had 2 inches of slough discarded).

3. Thickness of each stratum measured sequentially from the top of recovery to the bottom of recovery.

4. Any observations of sample condition or drilling activity that would help identify whether there was loss from the top of the sampling interval, loss from the bottom of the sampling interval, or compression of the sampling interval. Examples: 14/24, gravel in nose of spoon; or 10/18 bottom 6 inches of spoon empty.

DETERMINATION OF COMPONENTS

Obtain a representative sample of soil from a single stratum. If multiple strata are present in a single sample interval, each stratum should be described separately. More specifically, if the sample is from a 2-foot long split-spoon where strata of coarse sand, fine sand and clay are present, then the resultant description should be of the three individual strata unless a combined description can clearly describe the interbedded nature of the three strata. Example: Fine Sand with interbedded lenses of Silt and Clay, ranging between 1 and 3 inches thick.

Identify principal component and express volume estimates for minor components on logs using the following standard modifiers.

Modifier	Percent of Total Sample (by volume)
and	36 - 50
some	21 - 35
little	10 - 20
trace	<10

Determination of components is based on using the Udden-Wentworth particle size classification (see below) and measurement of the average grain size diameter. Each size grade or class differs from the next larger grade or class by a constant ratio of ½. Due to visual limitations, the finer classifications of Wentworth's scale cannot be distinguished in the field and the subgroups are not included. Visual determinations in the field should be made carefully by comparing the sample to the field gauge card that shows Udden-Wentworth scale or by measuring with a ruler. Use of field sieves s recommended to assist in estimating percentage of coarse grain sizes. Settling test or wash method (Appendix X4 of ASTM D2488) is recommended for determining presence and estimating percentage of clay and silt.

Udden-Wenworth Scale Modified ARCADIS, 2008			
Size Class	Millimeters	Inches	Standard Sieve #
Boulder	256 – 4096	10.08+	
Large cobble	128 - 256	5.04 -10.08	
Small cobble	64 - 128	2.52 – 5.04	
Very large pebble	32 – 64	0.16 - 2.52	
Large pebble	16 – 32	0.63 – 1.26	
Medium pebble	8 – 16	0.31 – 0.63	
Small pebble	4 – 8	0.16 – 0.31	No. 5 +
Granule	2 – 4	0.08 – 0.16	No.5 – No.10
Very coarse sand	1 -2	0.04 – 0.08	No.10 – No.18
Coarse sand	½ - 1	0.02 – 0.04	No.18 - No.35
Medium sand	¼ - ½	0.01 – 0.02	No.35 - No.60
Fine sand	1/8 -¼	0.005 – 0.1	No.60 - No.120
Very fine sand	1/16 – 1/8	0.002 – 0.005	No. 120 – No. 230
Silt (subgroups not included)	1/256 – 1/16	0.0002 – 0.002	Not applicable (analyze by pipette or hydrometer)
Clay (subgroups not included	1/2048 – 1/256	.00002 – 0.0002	

Identify components as follows. Remove particles greater than very large pebbles (64-mm diameter) from the soil sample. Record the volume estimate of the greater than very large pebbles. Examine the sample fraction of very large pebbles and smaller particles and estimate the volume percentage of the pebbles, granules, sand, silt and clay. Use the jar method, visual method, and/or wash method (Appendix X4 of ASTM D2488) to estimate the volume percentages of each category.

Determination of actual dry weight of each Udden-Wentworth fraction requires laboratory grain-size analysis using sieve sizes corresponding to Udden-Wentworth fractions and is highly recommended to determine grain-size distributions for each hydrostratigraphic unit.

Lab or field sieve analysis is advisable to characterize the variability and facies trends within each hydrostratigraphic unit. Field sieve-analysis can be performed on selected samples to estimate dry weight fraction of each category using ASTM D2488 Standard Practice for Classification of Soils for Engineering Purposes as guidance, but replace required sieve sizes with the following Udden-Wentworth set: U.S. Standard sieve mesh sizes 6; 12; 20; 40; 70; 140; and 270 to retain pebbles; granules; very coarse sand; coarse sand; medium sand; fine sand; and very fine sand, respectively.

PRINCIPAL COMPONENT

The principal component is the size fraction or range of size fractions containing the majority of the volume. Examples: the principal component in a sample that contained 55% pebbles would be “Pebbles”; or the principal component in a sample that was 20% fine sand, 30% medium sand and 25% coarse sand would be “Fine to coarse Sand” or for a sample that was 40% silt and 45% clay the principal component would be “Clay and Silt”.

Include appropriate descriptors with the principal component. These descriptors vary for different particle sizes as follows.

Angularity – Describe the angularity for very coarse sand and larger particles in accordance with the table below (ASTM D-2488-06). Figures showing examples of angularity are available in ASTM D-2488-06 and the ARCADIS Soil Description Field Guide.

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Plasticity – Describe the plasticity for silt and clay based on observations made during the following test method (ASTM D-2488-06).

- As in the dilatancy test below, select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

- Shape the test specimen into an elongated pat and roll by hand on a smooth surface or between the palms into a thread about 1/8 inch (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1/8 inch. The thread will crumble when the soil is near the plastic limit.

Description	Criteria
Nonplastic	A $^1/_8$ inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

Dilatancy – Describe the dilatancy for silt and silt-sand mixtures using the following field test method (ASTM D-2488-06).

- From the specimen select enough material to mold into a ball about ½ inch (12 mm) in diameter. Mold the material adding water if necessary, until it has a soft, but not sticky, consistency.
- Smooth the ball in the palm of one hand with a small spatula.
- Shake horizontally, striking the side of the hand vigorously with the other hand several times.
- Note the reaction of water appearing on the surface of the soil.
- Squeeze the sample by closing the hand or pinching the soil between the fingers, and not the reaction as none, slow, or rapid in accordance with the table below. The reaction is the speed with which water appears while shaking and disappears while squeezing.

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

MINOR COMPONENT(S)

The minor component(s) are the size fraction(s) containing less than 50% volume. Example: the identified components are estimated to be 60% medium sand to granules, 25 % silt and clay; 15 % pebbles – there are two identified minor components: silt and clay; and pebbles.

Include a standard modifier to indicate percentage of minor components (see Table on Page 5) and the same descriptors that would be used for a principal component. Plasticity should be provided as a descriptor for the silt and clay. Dilatancy should be provided for silt and silt-sand mixtures. Angularity should be provided as a descriptor for pebbles and coarse sand. For the example above, the minor constituents with modifiers could be: some silt and clay, low plasticity; little medium to large pebbles, sub-round.

SORTING

Sorting is the opposite of grading, which is a commonly used term in the USCS or ASTM methods to describe the uniformity of the particle size distribution in a sample. Well-sorted samples are poorly graded and poorly sorted samples are well graded. ARCADIS prefers the use of sorting for particle size distributions and grading to describe particle size distribution trends in the vertical profile of a sample or hydrostratigraphic unit because of the relationship between sorting and the energy of the depositional process. For soils with sand-sized or larger particles, sorting should be determined as follows:

- Well sorted – the range of particle sizes is limited (e.g. the sample is comprised of predominantly one or two grain sizes)

- Poorly sorted – a wide range of particle sizes are present

You can also use sieve analysis to estimate sorting from a sedimentological perspective; sorting is the statistical equivalent of standard deviation. Smaller standard deviations correspond to higher degree of sorting (see Remediation Hydraulics, 2008).

MOISTURE

Moisture content should be described for every sample since increases or decreases in water content is critical information. Moisture should be described in accordance with the table below (percentages should not be used unless determined in the laboratory).

Description	Criteria
Dry	Absence of moisture, dry to touch, dusty.
Moist	Damp but no visible water.
Wet (Saturated)	Visible free water, soil is usually below the water table.

CONSISTENCY or DENSITY

This can be determined by standard penetration test (SPT) blow counts (ASTM D-1586) or field tests in accordance with the tables below. For SPT blow counts the N-value is used. The N-value is the blows per foot for the 6" to 18" interval. Example: for 24-inch spoon, recorded blows per 6-inch interval are: 4/6/9/22. Since the second interval is 6" to12", the third interval is 12" to 18", the N value is 6+9, or 15. Fifty blow counts for less than 6 inches is considered refusal.

Fine-grained soil – Consistency

Description	Criteria
Very soft	N-value < 2 or easily penetrated several inches by thumb.
Soft	N-value 2-4 or easily penetrated one inch by thumb.
Medium stiff	N-value 9-15 or indented about ¼ inch by thumb with great effort.
Very stiff	N-value 16-30 or readily indented by thumb nail.
Hard	N-value > than 30 or indented by thumbnail with difficulty

Coarse-grained soil – Density

Description	Criteria
Very loose	N-value 1- 4
Loose	N-value 5-10
Medium dense	N-value 11-30
Dense	N-value 31- 50
Very dense	N-value >50

COLOR

Color should be described using simple basic terminology and modifiers based on the Munsell system. Munsell alpha-numeric codes are required for all samples. If the sample contains layers or patches of varying colors this should be noted and all representative colors should be described. The colors should be described for moist samples. If the sample is dry it should be wetted prior to comparing the sample to the Munsell chart.

ADDITIONAL COMMENTS (NOTES)

Additional comments should be made where observed and should be presented as notes with reference to a specific depth interval(s) to which they apply. Some of the significant information that may be observed includes the following.

- **Odor -** You should not make an effort to smell samples by placing near your nose since this can result in unnecessary exposure to hazardous materials. However, odors should be noted if they are detected during the normal sampling procedures. Odors should be based upon descriptors such as those used in NIOSH "Pocket Guide to Chemical Hazards", e.g. "pungent" or "sweet" and should not indicate specific chemicals such as "phenol-like" odor or "BTEX" odor.
- Structure
- Bedding planes (laminated, banded, geologic contacts)
- Presence of roots, root holes, organic material, man-made materials, minerals, etc.
- Mineralogy
- Cementation
- NAPL presence/characteristics, including sheen (based on client-specific guidance)
- Reaction with HCl (typically used only for special soil conditions)
- Origin, if known (capital letters: LACUSTRINE; FILL; etc.)

EXAMPLE DESCRIPTIONS

51.4 to 54.0' Clay, some silt, medium to high plasticity; trace small to large pebbles, subround to subangular up to 2" diameter; moist; stiff; dark grayish brown (10YR 4/2) NOTE: Lacustrine; laminated 0.01 to 0.02 feet thick, laminations brownish yellow (10 YR 4/3).

32.5 to 38.0' Sand, medium to Pebbles, coarse; sub-round to sub-angular; trace silt; poorly sorted; wet; grayish brown (10YR5/2). NOTE: sedimentary, igneous and metamorphic particles.

Unlike the first example where a density of cohesive soils could be estimated, this rotosonic sand and pebble sample was disturbed during drilling (due to vibrations in a loose Sand and Pebble matrix) so no density description could be provided. Neither sample had noticeable odor so odor comments were not included.

The standard generic description order is presented below.

- Depth

- Principal Components
  - Angularity for very coarse sand and larger particles
  - Plasticity for silt and clay
  - Dilatancy for silt and silt-sand mixtures
- Minor Components
- Sorting
- Moisture
- Consistency or Density
- Color
- Additional Comments

VII. Waste Management

Project-specific requirements should be identified and followed. The following procedures, or similar waste management procedures are generally required.

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal. PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

VIII. Data Recording and Management

Upon collection of soil samples, the soil sample should be logged on a standard boring log and/or in the field log book depending on Data Quality Objectives (DQOs) for the task/project. Two examples of standard boring logs are presented below.

The general scheme for soil logging entries is presented above; however, depending on task/project DQOs, specific logging entries that are not applicable to task/project goals may be omitted at the project manager's discretion. In any case, use of a consistent logging procedure is required.

Completed logs and/or logbook will be maintained in the task/project field records file. Digital photographs of typical soil types observed at the site and any unusual features should be obtained whenever possible. All photographs should include a ruler or common object for scale. Photo location, depth and orientation must be recorded in the daily log or log book and a label showing this information in the photo is useful.

ARCADIS Page _____ of _____

Sample Log

Well/Boring __________ Project Name and No. __________

Site Location __________ Drilling Started __________ Drilling Completed __________

Total Depth Drilled __________ feet Hole Diameter __________ inches Sampling Interval __________ feet

Length and Diameter of Sampling Device __________ Type of Sampling Device __________

Drilling Method __________ Drilling Fluid Used __________

Drilling Contractor __________ Driller __________ Helper __________

Prepared By __________ Hammer Weight __________ Hammer Drop __________ inches

Sample Depth (feet below land surface)		Sample Recovery (feet)	Time/Hydraulic Pressure or Blows per 6 inches	Sample Description	PID (ppm)
From	To				

http://team/Sites/Offices/North/Northeast Area/Northeast Area Geoscience Forms/Sample Core Log.XLS - Sheet1

IX. Quality Assurance

Soil descriptions should be completed only by appropriately trained personnel. Descriptions should be reviewed by an experienced field geologist for content, format and consistency. Edited boring logs should be reviewed by the original author to assure that content has not changed.

X. References

ARCADIS Soil Description Field Guide, 2008 (in progress)

Munsell® Color Chart – available from Forestry Suppliers, Inc.- Item 77341 "Munsell® Color Soil Color Charts

Field Gauge Card that Shows Udden-Wentworth scale – available from Forestry Suppliers, Inc. – Item 77332 "Sand Grain Sizing Folder"

ASTM D-1586, Test Method for Penetration Test and Split-Barrel Sampling of Soils

ASTM D-2488-00, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)

United States Bureau of Reclamation. Engineering Geology Field Manual. United States Department of Interior, Bureau of Reclamation. http://www.usbr.gov/pmts/geology/fieldmap.htm

Petrology of Sedimentary Rocks, Robert L. Folk, 1980, p. 1-48

NIOSH Pocket Guide to Chemical Hazards

Remediation Hydraulics, Fred C. Payne, Joseph A. Quinnan, and Scott T. Potter, 2008, p 59-63

Infrastructure, environment, buildings

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Soil Drilling and Sample Collection

Rev. #: 2

Rev Date: March 8, 2011

Approval Signatures

Prepared by: ______________________ Date: 03/08/2011

Reviewed by: ______________________ Date: 03/08/2011
(Technical Expert)

I. Scope and Application

Overburden drilling is commonly performed using the hollow-stem auger drilling method. Other drilling methods suitable for overburden drilling, which are sometimes necessary due to site-specific geologic conditions, include: drive-and-wash, spun casing, Rotasonic, dual-rotary (Barber Rig), and fluid/mud rotary. Direct-push techniques (e.g., Geoprobe or cone penetrometer) may also be used. The drilling method to be used at a given site will be selected based on site-specific consideration of anticipated drilling depths, site or regional geologic knowledge, types of sampling to be conducted, required sample quality and volume, and cost.

No oils or grease will be used on equipment introduced into the boring (e.g., drill rod, casing, or sampling tools).

II. Personnel Qualifications

The Project Manager (a qualified geologist, environmental scientist, or engineer) will identify the appropriate soil boring locations, depth and soil sample intervals in a written plan.

Personnel responsible for overseeing drilling operations must have at least 16 hours of prior training overseeing drilling activities with an experienced geologist, environmental scientist, or engineer with at least 2 years of prior experience.

III. Equipment List

The following materials will be available during soil boring and sampling 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;
- drilling equipment required by the American Society for Testing and Materials (ASTM) D 1586, when performing split-spoon sampling;
- disposable plastic liners, when drilling with direct-push equipment;
- appropriate soil sampling equipment (e.g., stainless steel spatulas, knife);

- equipment cleaning materials;
- appropriate sample containers and labels;
- chain-of-custody forms;
- insulated coolers with ice, when collecting samples requiring preservation by chilling;
- photoionization detector (PID) or flame ionization detector (FID); and
- field notebook and/or personal digital assistant (PDA).

IV. Cautions

Prior to beginning field work, underground utilities in the vicinity of the drilling areas will be identified by one of the following three actions (lines of evidence):

- Contact the State One Call
- Obtain a detailed site utility plan drawn to scale, preferably an “as-built” plan
- Conduct a detailed visual site inspection

In the event that one or more of the above lines of evidence cannot be conducted, or if the accuracy of utility location is questionable, a minimum of one additional line of evidence will be utilized as appropriate or suitable to the conditions. Examples of additional lines of evidence include but are not limited to:

- Private utility locating service
- Research of state, county or municipal utility records and maps including computer drawn maps or geographical information systems (GIS)
- Contact with the utility provider to obtain their utility location records
- Hand augering or digging
- Hydro-knife
- Air-knife
- Radio Frequency Detector (RFD)

- Ground Penetrating Radar (GPR)

- Any other method that may give ample evidence of the presence or location of subgrade utilities.

Overhead power lines also present risks and the following safe clearance must be maintained from them.

Power Line Voltage Phase to Phase (kV)	**Minimum Safe Clearance (feet)**
50 or below	10
Above 50 to 200	15
Above 200 to 350	20
Above 350 to 500	25
Above 500 to 750	35
Above 750 to 1,000	35

ANSI Standard B30.5-1994, 5-3.4.5

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

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 borehole will be obtained, reviewed and approved to meet project quality objectives.

V. Health and Safety Considerations

Field activities associated with overburden drilling and soil sampling will be performed in accordance with a site-specific HASP, a copy of which will be present on site during such activities.

VI. Procedure

Drilling Procedures

The drilling contractor will be responsible for obtaining accurate and representative samples; informing the supervising geologist of changes in drilling pressure; and keeping a separate general log of soils encountered, including blow counts (i.e., the number of blows from a soil sampling drive weight [140 pounds] required to drive the split-barrel sampler in 6-inch increments). The term "samples" means soil materials from particular depth intervals, whether or not portions of these materials are submitted for laboratory analysis. Records will also be kept of occurrences of premature refusal due to boulders or construction materials that may have been used as fill. Where a boring cannot be advanced to the desired depth, the boring will be abandoned and an additional boring will be advanced at an adjacent location to obtain the required sample. Where it is desirable to avoid leaving vertical connections between depth intervals, the borehole will be sealed using cement and/or bentonite. Multiple refusals may lead to a decision by the supervising geologist to abandon that sampling location.

Soil Characterization Procedures

Soils encountered while drilling soil borings will be collected using one of the following methods:

- 2-inch split-barrel (split-spoon) sampler, if using the ASTM D 1586 - Standard Test Method for Penetration Test and Split-Barrel Sampling of Soils

- Plastic internal soil sample sleeves if using direct-push drilling.

Soils are typically field screened with an FID or PID at sites where volatile organic compounds are present in the subsurface. Field screening is performed using one of the following methods:

- Upon opening the sampler, the soil is split open and the PID or FID probe is placed in the opening and covered with a gloved hand. Such readings should be obtained at several locations along the length of the sample

- A portion of the collected soil is placed in a jar, which is covered with aluminum foil, sealed, and allowed to warm to room temperature. After warming, the cover is removed, the foil is pieced with the FID or PID probe, and a reading is obtained.

Samples selected for laboratory analysis will be handled, packed, and shipped in accordance with the procedures outlined in the Work Plan, FSP, or Chain-of-Custody, Handling, Packing, and Shipping SOP.

A geologist will be onsite during drilling and sampling operations to describe each soil interval on the soil boring log, including:

- percent recovery;
- structure and degree of sample disturbance;
- soil type;
- color;
- moisture condition;
- density;
- grain-size;
- consistency; and
- other observations, particularly relating to the presence of waste materials

Further details regarding geologic description of soils are presented in the Soil Description SOP.

Particular care will be taken to fully describe any sheens observed, oil saturation, staining, discoloration, evidence of chemical impacts, or unnatural materials.

VII. Waste Management

Water generated during cleaning procedures will be collected and contained onsite in appropriate containers for future analysis and appropriate disposal.

PPE (such as gloves, disposable clothing, and other disposable equipment) resulting from personnel cleaning procedures and soil sampling/handling activities will be placed in plastic bags. These bags will be transferred into appropriately labeled 55-gallon drums or a covered roll-off box for appropriate disposal.

Soil materials will be placed in sealed 55-gallon steel drums or covered roll-off boxes and stored in a secured area. Once full, the material will be analyzed to determine the appropriate disposal method.

VIII. Data Recording and Management

The supervising geologist or scientist will be responsible for documenting drilling events using a bound field notebook and/or PDA to record all relevant information in a clear and concise format. The record of drilling events will include:

- start and finish dates of drilling;
- name and location of project;
- project number, client, and site location;
- sample number and depths;
- blow counts and recovery;
- depth to water;
- type of drilling method;
- drilling equipment specifications, including the diameter of drilling tools;
- documentation of any elevated organic vapor readings;
- names of drillers, inspectors, or other people onsite; and
- weather conditions.

IX. Quality Assurance

Equipment will be cleaned prior to use onsite, between each drilling location, and prior to leaving the site. Drilling equipment and associated tools, including augers, drill rods, sampling equipment, wrenches, and other equipment or tools that may have come in contact with soils and/or waste materials will be cleaned with high-pressure steam-cleaning equipment using a potable water source. The drilling equipment will be cleaned in an area designated by the supervising engineer or geologist that is located outside of the work zone. More elaborate cleaning procedures may be required for reusable soil samplers (split-spoons) when soil samples are obtained for laboratory analysis of chemical constituents.

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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Surface and Subsurface Soil Sampling Using Manual Methods

Rev. #: 1

Rev Date: March 6, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/6/09

Reviewed by: ______________________ Date: 3/6/09
(Technical Expert)

I. Scope and Application

This document describes procedures for surface and subsurface soil sampling using hand tools.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading soil sampling activities should have a minimum of 2 years of previous environmental soil sampling experience. ARCADIS personnel providing assistance to soil sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences.

III. Equipment List

The following materials will be available, as required, during soil sampling activities:

- personal protective equipment (PPE), as specified by the site Health and Safety Plan (HASP);
- stainless steel bowls;
- stainless steel spoons;
- stainless steel spades;
- stainless steel hand augers;
- indelible ink pens;
- engineer's ruler or survey rod;
- sealable plastic bags (e.g., Ziploc®);
- equipment decontamination materials
- sample bottles and preservatives appropriate for the parameters to be sampled for laboratory analysis, if any;
- transport container with ice (if sampling for laboratory analysis);
- appropriate sample containers and forms; and

- field notebook and/or personal digital assistant (PDA).

Documentation forms and notebooks to have on hand include: soil sample log forms, chain-of-custody forms, sample labels and seals, field logbook/PDA.

IV. Cautions / Hazards

Task specific Job Safety Analysis (JSAs) must be developed to identify site hazards associated with the investigation and reviewed by all field crew members prior to the start of work. Safe Performance Self-Assessment (SPSA) to be performed by employees before performing a new task. Underground utilities will be cleared per the ARCADIS Utility Location Policy and Procedure.

V. Health and Safety Considerations

Soil sample collection will be performed in accordance with a site-specific Health and Safety Plan (HASP) and task specific JSA forms, copies of which will be present on site during such activities.

VI. Procedure

Soil samples may be collected at intervals from the ground surface to various depths. Sample locations will be identified using stakes, flagging, or other appropriate means, and will be noted in a field logbook, PDA, and/or soil sampling logs. Sample points will be located by surveying, use of a global positioning system (GPS), and/or measurements from other surveyed site features.

1. Equipment that will come in contact with the soil sample should be cleaned in accordance with the appropriate equipment decontamination SOP(s), or else new, disposable equipment should be used. Collect equipment blanks in accordance with the project Quality Assurance Project Plan (QAPP).

2. Clear the ground surface of brush, root mat, grass, leaves, or other debris.

3. Use a spade, spoon, scoop, or hand auger to collect a sample of the required depth interval.

4. Use an engineer's ruler to verify that the sample is collected to the correct depth and record the top and bottom depths from the ground surface.

5. To collect samples below the surface interval, remove the surface interval first; then collect the deeper interval. To prevent the hole from collapsing, it may be

necessary to remove a wider section from the surface or use cut polyvinyl chloride (PVC) tubing or pipe to maintain the opening.

6. Collect samples for volatile organic compounds (VOCs) as discrete samples using Encore® samplers or cut syringes (see Extraction/Preservation of Soil/Sediment Samples for VOCs SOP).

7. Homogenize samples for other analyses across the required interval or mix them with other discrete grab samples to form a composite sample (see Compositing or Homogenizing Samples SOP).

8. Place sample in clean sample container; label with sample identification number, date, and time of collection; and place on ice (if obtained for laboratory analysis). Prepare samples for packaging and shipping to the laboratory in accordance with the Chain-of-Custody Handling, Packing, and Shipping SOP.

9. Backfill sample holes to grade with native material or with clean builder's sand or other suitable material.

VII. Waste Management

Waste soils will be managed as specified in the FSP or Work Plan, and according to state and /or federal requirements. Personal Protective Equipment (PPE) and decontamination fluids will be contained separately and staged at the project site for appropriate disposal. Waste containers must be a sealed and labeled at the time of generation. Labels will indicate date, sample locations, site name, city, state, and description of the matrix (e.g., soil, PPE).

VIII. Data Recording and Management

Field documentation such as log book entries and chain-of –custody records will be transmitted to the ARCADIS PM or Task Manager each day unless otherwise directed. The field team leader will retain all site documentation while in the field and add to project files when the field mobilization is complete.

IX. Quality Assurance

Quality assurance samples (rinse blanks, duplicates, and MS/MSDs) will be collected at the frequency specified in the FSP and/or QAPP and depending on the project quality objectives. Reusable soil sampling equipment will be cleaned prior to use following equipment cleaning SOP. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Any deviations from the SOP will be discussed with the project manager prior to changing any field procedures.

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Photoionization Detector Air Monitoring and Field Screening

Rev. #: 1

Rev Date: November 8, 2009

Approval Signatures

Prepared by: (the late) Maureen Geisser Date: July 28, 2003

Reviewed/revised by: Christopher C. Lutes Date: November 8, 2009
(Technical Expert)

I. Scope and Application

Field screening with a photoionization detector (PID), such as an HNu™, Photovac™, MicroTIP™, or MiniRAE™, is a procedure to measure relative concentrations of volatile organic compounds (VOCs) and other compounds. Characteristics of the PID are presented in Attachment 1 and the compounds a PID can detect are presented in Attachment 2. Field screening will frequently be conducted on the following:

- Work area air to assess exposure to on-site workers of air contaminants via the air pathway;
- Well headspaces as a precautionary measure each time the well cover is opened; and
- Headspace of soil samples to assess the relative concentration of volatile organics in the sample or to select particular intervals for off-site analysis for VOCs.

II. Personnel Qualifications

Personnel performing this method should be familiar with the basic principles of quantiative analytical chemistry (such as calibration) and familiar with the particular operation of the instrument to be used.

III. Equipment List

The following materials, as required, shall be available while performing PID field screening:

- personal protective equipment (PPE), as required by the site Health and Safety Plan (HASP);
- PID and operating manual;
- PID extra battery pack and battery charger;
- calibration canisters for the PID;
- sample jars;
- Q-tips;

- aluminum foil;
- field calibration log (attached); and
- field notebook.

IV. Cautions

PIDs are sensitive to moisture and may not function under high humidity. PIDs cannot be used to indicate oxygen deficiency or combustible gases.

V. Health and Safety Considerations

Since the PIDs cannot detect all of the chemicals that may be present at a sample location, a zero reading on either instrument does not necessarily signify the absence of air contaminants. PIDs cannot be used as an indicator for oxygen deficiency.

VI. Procedure (*Note these procedures were written particular to one specific instrument model, therefore please also refer to your owners manual.Hhowever the general principles – such as always measuring both a zero and span gas after an instrument adjustment/at the beginning of the analytical day, after four hours of testing and again at the end of an analytical day can be applied to all instruments.)*

PID Calibration

PID field instruments will be calibrated and operated to yield "total organic vapor" in parts per million (ppm) (v/v) relative to benzene or isobutylene (or equivalent). Operation, maintenance, and calibration shall be performed in accordance with the manufacturer's instructions and entered on the PID calibration and maintenance log (Attachment 3).

1. Don PPE, as required by the HASP.

2. Perform a BATTERY CHECK. Turn the FUNCTION switch to the BATTERY CHECK position. Check that the indicator is within or beyond the green battery arc. If battery is low, the battery must be charged before calibration.

3. Allow the instrument to warm up, then calibrate the PID. If equipped, turn the FUNCTION switch to the STANDBY position and rotate the ZERO

POTENTIOMETER until the meter reads zero with the instrument sampling clean air. Wait 15 to 20 seconds to confirm the adjustment. If unstable, readjust. If equipped, check to see that the SPAN POTENTIOMETER is adjusted for the probe being used (e.g., 9.8 for 10.2 electron volts [eV]). Set the FUNCTION switch to the desired ppm range (0-20, 0-200, or 0-2,000). A violet glow from the ultraviolet (UV) source should be visible at the sample inlet of the probe/sensor unit.

4. Listen for the fan operation to verify fan function.

5. Connect one end of the sampling hose to the calibration canister regulator outlet and the other end to the sampling probe of the PID. Crack the regulator valve and take a reading after 5 to 10 seconds. Adjust the span potentiometer to produce the concentration listed on the span gas cylinder. Record appropriate information on a PID Calibration and Maintenance Log (Attachment 3, or equivalent).

6. If so equipped, set the alarm at desired level.

7. Recheck the zero with fresh/clean air

8. Always recheck both zero and span after making any instrment adjustment, after four hours of screenign work and again after sample analysis.

Work Area Air Monitoring

1. Measure and record the background PID reading.

2. Measure and record the breathing space reading.

Well Headspace Screening

1. Measure and record the background PID reading.

2. Unlock and open the well cover while standing upwind of the well.

3. Remove the well cap.

4. Place the PID probe approximately 6 inches above the top of the casing.

5. Record all PID readings and proceed in accordance with the HASP.

Field Screening Procedures

Soil samples will be field screened upon collection with the PID for a relative measure of the total volatile organic concentration. The following steps define the PID field screening procedures.

1. Half-fill two clean glass jars with the sample (if sufficient quantities of soil are available) to be analyzed. Quickly cover each open top with one or two sheets of clean aluminum foil and subsequently apply screw caps to tightly seal the jars. Sixteen-ounce (approximately 500 mL) soil or "mason" type jars are preferred; jars less than 8 ounces (approximately 250 mL) total capacity may not be used.

2. Allow headspace development for at least 10 minutes. Vigorously shake jars for 15 seconds at both the beginning and end of the headspace development period. Where ambient temperatures are below 32°F (0°C), headspace development should be within a heated building.

3. Subsequent to headspace development, remove screw lid to expose the foil seal. Quickly puncture foil seal with instrument sampling probe, to a point about one-half of the headspace depth. Exercise care to avoid contact with water droplets or soil particulates.

4. Following probe insertion through foil seal, record the highest meter response for each sample as the jar headspace concentration. Using the foil seal/probe insertion method, maximum response should occur between 2 and 5 seconds. Erratic meter response may occur at high organic vapor concentrations or conditions of elevated headspace moisture, in which case headspace data should be recorded and erratic meter response noted.

5. The headspace screening data from both jar samples should be recorded and compared; generally, replicate values should be consistent to plus or minus 20%. It should be noted that in some cases (e.g., 6-inch increment soil borings), sufficient sample quantities may not be available to perform duplicate screenings. One screening will be considered sufficient for this case.

6. PID field instruments will be operated and calibrated to yield "total organic vapors" in ppm (v/v) as benzene. PID instruments must be operated with at least a 10.0 eV (+) lamp source. Operation, maintenance, and calibration will be performed in accordance with the manufacturer's specifications presented in Attachment 12-1. For jar headspace analysis, instrument calibration will be checked/adjusted at least twice per day, at the beginning and end of each day

of use. Calibration will exceed twice per day if conditions and/or manufacturer's specifications dictate.

7. Instrumentation with digital (LED/LCD) displays may not be able to discern maximum headspace response unless equipped with a "maximum hold" feature or strip-chart recorder.

VII. Waste Management

Do not dispose canisters of compressed gas, if there is still compressed gas in the canister. Return the canister to the manufactuer for proper disposal.

VIII. Data Recording and Management

Measurements will be record in the field notebook or boring logs at the time of measurement with notation of date, time, location, depth (if applicable), and item monitored. If a data memory is available, readings will be downloaded from the unit upon access to a computer with software to retrieve the data.

IX. Quality Assurance

After each use, the readout unit should be wiped down with a clean cloth or paper towel.

For a HNu, the UV light source window and ionization chamber should be cleaned once a month in the following manner:

1. With the PID off, disconnect the sensor/probe from the unit.

2. Remove the exhaust screw, grasp the end cap in one hand and the probe shell in the other, and pull apart.

3. Loosen the screws on top of the end cap and separate the end cap and ion chamber from the lamp and lamp housing.

4. Tilt the lamp housing with one hand over the opening so that the lamp slides out into your hand.

5. Clean the lamp with lens paper and HNu cleaning compound (except 11.7 eV). For the 11.7 eV lamp, use a chlorinated organic solvent.

6. Clean the ion chamber using methanol on a Q-tip and then dry gently at 50ºC to 60ºC for 30 minutes.

7. Following cleaning, reassemble by first sliding the lamp back into the lamp housing. Place ion chamber on top of the housing, making sure the contacts are properly aligned.

8. Place the end cap on top of the ion chamber and replace the two screws (tighten the screws only enough to seal the o-ring).

9. Line up the pins on the base of the lamp housing with pins inside the probe shell and slide the housing assembly into the shell.

X. References

Denahan, S.A. et. all "Relationships Between Chemical Screening Methodologies for Petroleum Contaminated Soils: Theory and Pracice" *Chapter 5 In Principles and Practices for Petroleum Contaminated Soils,* E.J. Calabrese and P.T. Kostecki Eds., Lewis Publishers 1993.

Fitzgerald, J. "Onsite Analytical Screening of Gasoline Contaminated Media Using a Jar Headspace Procedure" Chapter 4 *in Principles and Practices for Petroleum Contaminated Soils,* E.J. Calabrese and P.T. Kostecki Eds., Lewis Publishers 1993.

ATTACHMENT 1

Characteristics of the Photoionization Detector (PID)

I. Introduction

PIDs are used in the field to detect a variety of compounds in air. PIDs can be used to detect leaks of volatile substances in drums and tanks, to determine the presence of volatile compounds in soil and water, and to make ambient air surveys. If personnel are thoroughly trained to operate the instrument and interpret the data, these PID instruments can be a valuable tool. Its use can help in deciding the level of protection to be worn, assist in determining the implementation of other safety procedures, and in determining subsequent monitoring or sampling locations.

Portable PIDs detect the concentration of organic gases, as well as a few inorganic gases. The basis for detection is the ionization of gaseous species. The incoming gas molecules are subjected to UV radiation, which ionizes molecules that have an ionization potential (IP) less than or equal to that rated for the UV source. Every molecule has a characteristic IP, which is the energy required to remove an electron from the molecule, thus yielding a positively charged ion and the free electron. These ions are attracted to an oppositely charged electrode, causing a current and an electric signal to the LED display. Compounds are measured on a ppm volume basis.

II. HNu PI-101 / MiniRAE or Equivalent PID

The PIDs detect the concentration of organic gases, as well as a few inorganic gases. The basis for detection is the ionization of gaseous species. The incoming gas molecules are subjected to UV radiation, which is energetic enough to ionize many gaseous compounds. Each molecule is transformed into charged ion pairs, creating a current between two electrodes. Every molecule has a characteristic IP, which is the energy required to remove an electron from the molecule, yielding a positively charged ion and the free electron.

Three probes, each containing a different UV light source, are available for use with the PID. Probe energies are typically 9.5, 10.2, and 11.7 eV, respectively. All three probes detect many aromatic and large-molecule hydrocarbons. In addition, the 10.2 eV and 11.7 eV probes detect some smaller organic molecules and some halogenated hydrocarbons. The 10.2 eV probe is the most useful for environmental response work, as it is more durable than the 11.7 eV probe and detects more compounds than the 9.5 eV probe. A listing of molecules and compounds that the HNu can detect is presented in Attachment 2.

The primary PID calibration gas is either benzene or isobutylene. The span potentiometer knob is turned to 9.8 for benzene calibration. A knob setting of zero increases the sensitivity to benzene approximately 10-fold. Its lower detection limit is in the low ppm range. Additionally, response time is rapid; the dot matrix liquid crystal displays 90% of the indicated concentration within 3 seconds.

III. Limitations

The PID instrument can monitor several vapors and gases in air. Many non-volatile liquids, toxic solids, particulates, and other toxic gases and vapors, however, cannot be detected with PIDs (such as methane). Since the PIDs cannot detect all of the chemicals that may be present at a sample location, a zero reading on either instrument does not necessarily signify the absence of air contaminants.

The PID instrument is generally not specific and their response to different compounds is relative to the calibration gases. Instrument readings may be higher or lower than the true concentration. This effect can be observed when monitoring total contaminant concentrations if several different compounds are being detected at once. In addition, the response of these instruments is not linear over the entire detection range. Therefore, care must be taken when interpreting the data. Concentrations should be reported in terms of the calibration gas and probe type.

PIDs are small, portable instruments and may not yield results as accurate as laboratory instruments. PIDs were originally designed for specific industrial applications. They are relatively easy to use and interpret when detecting total concentrations of known contaminants in air, but interpretation becomes more difficult when trying to identify the individual components of a mixture. PIDs cannot be used as an indicator for combustible gases or oxygen deficiency.

ATTACHMENT 2

Molecules and Compounds Detected by a PID

Some Atoms and Simple Molecules

	IP(eV)		IP(eV)
H	13.595	I_2	9.28
C	11.264	HF	15.77
N	14.54	HCl	12.74
O	13.614	HBr	11.62
Si	8.149	HI	10.38
S	10.357	SO_2	12.34
F	17.42	CO_2	13.79
Cl	13.01	COS	11.18
Br	11.84	CS_2	10.08
I	10.48	N_2O	12.90
H_2	15.426	NO_2	9.78
N_2	15.580	O_3	12.80
O_2	12.075	H_2O	12.59
CO	14.01	H_2S	10.46
CN	15.13	H_2Se	9.88
NO	9.25	H_2Te	9.14
CH	11.1	HCN	3.91
OH	13.18	C_2N_2	13.8
F_2	15.7	NH_3	10.15
Cl_2	11.48	CH_3	9.840
Br_2	10.55	CH_4	12.98

Paraffins and Cycloparaffins

Molecule	IP(eV)
methane	12.98
ethane	11.65
propane	11.07
n-butane	10.63
i-butane	10.57
n-pentane	10.35
i-pentane	10.32
2,2-dimethylpropane	10.35
n-hexane	10.18
2-methlypentane	10.12
3-methlypentane	10.08
2,2-dimethlybutane	10.06
2,3-dimethlybutane	10.02
n-heptane	10.08
2,2,4-trimethlypentane	9.86
cyclopropane	10.06
cyclopentane	10.53
cyclohexane	9.88
methlycyclohexane	9.8

Alkyl Halides

IP(eV)	IP(eV)
HCl	12.74
Cl_2	11.48
CH_4	12.98
methyl chloride	11.28
dichloroemethane	11.35
trichloromethane	11.42
tetrachloromethane	11.47
ethyl chloride	10.98
1,2-dichloroethane	11.12
1-chloropropane	10.82
2-chloropropane	10.78
1,2-dichloropropane	10.87
1,3-dichloropropane	10.85
1-chlorobutane	10.67
2-chlorobutane	10.65
1-chloro-2-methylpropane	10.66
2-chloro-2-methylpropane	10.61
HBr	11.62
Br_2	10.55
methyl bromide	10.53
dibromomethane	10.49
tribromomethane	10.51
CH_2BrCl	10.77
$CHBr_2Cl$	10.59
ethyl bromide	10.29
1,1-dibromoethane	10.19
1-bromo-2-chloroethane	10.63
1-bromopropane	10.18
2-bromopropane	10.075
1,3-dibromopropane	10.07
1-bromobutane	10.13
2-bromobutane	9.98
1-bromo-2-methylpropane	10.09
2-bromo-2-methylpropane	9.89
1-bromopentane	10.10
HI	10.38
I_2	9.28

Alkyl Halides

Molecule	IP(eV)
methyl iodide	9.54
diiodomethane	9.34
ethyl iodide	9.33
1-iodopropane	9.26
2-iodopropane	9.17
1-iodobutane	9.21
2-iodobutane	9.09
1-iodo-2-methylpropane	9.18
2-iodo-2-methylpropane	9.02
1-iodopentane	9.19
F_2	15.7
HF	15.77
$CFCl_3$ (Freon 11)	11.77
CF_2Cl_2 (Freon 12)	12.31
CF_3Cl (Freon 13)	12.91
$CHClF_2$ (Freon 22)	12.45
$CFBR_3$	10.67
CF_2Br_2	11.07
CH_3CF_2Cl (Genetron 101)	11.98
$CFCl_2CF_2Cl$	11.99
CF_3CCl_3 (Freon 113)	11.78
$CFHBrCH_2Cr$	10.75
CF_2BrCH_2Br	10.83
CF_3CH_2I	10.00
n-C_3F_7I	10.36
n-$C_3F_7CH_2Cl$	11.84
n-$C_3F_7CH_2I$	9.96

Aliphatic Alcohol, Ether, Thiol, and Sulfides

Molecule	IP(eV)
H_2O	12.59
methyl alcohol	10.85
ethyl alcohol	10.48
n-propyl alcohol	10.20
i-propyl alcohol	10.16
n-butyl alcohol	10.04
dimethyl ether	10.00
diethyl ether	9.53
n-propyl ether	9.27
i-propyl ether	9.20
H_2S	10.46
methanethiol	9.440
ethanethiol	9.285
1-propanethiol	9.195
1-butanethiol	9.14
dimethyl sulfide	8.685
ethyl methyl sulfide	8.55
diethyl sulfide	8.430
di-n-propyl sulfide	8.30

Aliphatic Aldehydes and Ketones

Molecule	IP(eV)
CO_2	13.79
formaldehyde	10.87
acetaldehyde	10.21
propionaldehyde	9.98
n-butyraldehyde	9.86
isobutyraldehyde	9.74
n-valeraldehyde	9.82
isovaleraldehyde	9.71
acrolein	10.10
crotonaldehyde	9.73
benzaldehyde	9.53
acetone	9.69
methyl ethyl ketone	9.53
methyl n-propyl ketone	9.39
methyl i-propyl ketone	9.32
diethyl ketone	9.32
methyl n-butyl ketone	9.34
methyl i-butyl ketone	9.30
3,3-dimethyl butanone	9.17
2-heptanone	9.33
cyclopentanone	9.26
cyclohexanone	9.14
2,3-butanedione	9.23
2,4-pentanedione	8.87

Aliphatic Acids and Esters

Molecule	IP(eV)
CO_2	13.79
formic acid	11.05
acetic acid	10.37
propionic acid	10.24
n-butyric acid	10.16
isobutyric acid	10.02
n-valeric acid	10.12
methyl formate	10.815
ethyl formate	10.61
n-propyl formate	10.54
n-butyl formate	10.50
isobutyl formate	10.46
methyl acetate	10.27
ethyl acetate	10.11
n-propyl acetate	10.04
isopropyl acetate	9.99
n-butyl acetate	10.01
isobutyl acetate	9.97
sec-butyl acetate	9.91
methyl propionate	10.15
ethyl propionate	10.00
methyl n-butyrate	10.07
methyl isobutyrate	9.98

Aliphatic Amines and Amides

Molecule	IP(eV)
NH_3	10.15
methyl amine	8.97
ethyl amine	8.86
n-propyl amine	8.78
i-propyl amine	8.72
n-butyl amine	8.71
i-butyl amine	8.70
s-butyl amine	8.70
t-butyl amine	8.64
dimethyl amine	8.24
diethyl amine	8.01
di-n-propyl amine	7.84
di-i-propyl amine	7.73
di-n-butyl amine	7.69
trimethyl amine	7.82
triethyl amine	7.50
tri-n-propyl amine	7.23
formamide	10.25
acetamide	9.77
N-methyl acetamide	8.90
N,N-dimethyl formamide	9.12
N,N-dimethyl acetamide	8.81
N,N-diethyl formamide	8.89
N,N-diethyl acetamide	8.60

Other Aliphatic Molecules with N Atom

Molecule	IP(eV)
nitromethane	11.08
nitroethane	10.88
1-nitropropane	10.81
2-nitropropane	10.71
HCN	13.91
acetonitrile	12.22
propionitrile	11.84
n-butyronitrile	11.67
acrylonitrile	10.91
3-butene-nitrile	10.39
ethyl nitrate	11.22
n-propyl nitrate	
methyl thiocyanate	10.065
ethyl thiocyanate	9.89
methyl isothiocyanate	9.25
ethyl isothiocyanate	9.14

Olefins, Cyclo-ofefins, Acetylenes

Molecule	IP(eV)
ethylene	10.515
propylene	9.73
1-butene	9.58
2-methylpropene	9.23
trans-2-butene	9.13
cis-2-butene	9.13
1-pentene	9.50
2-methyl-1-butene	9.12
3-methyl-1-butene	9.51
3-methyl-2-butene	8.67
1-hexene	9.46
1,3-butadiene	9.07
isoprene	8.845
cyclopentene	9.01
cyclohexene	8.945
4-methylcyclohexene	8.91
4-cinylcylohexene	8.93
cyclo-octatetraene	7.99
acetylene	11.41
propyne	10.36
1-butyne	10.18

Some Derivatives of Olefins

Molecule	IP(eV)
vinyl chloride	9.995
cis-dichloroethylene	9.65
trans-dichloroethylene	9.66
trichloroethylene	9.45
tetrachloroethylene	9.32
vinyl bromide	9.80
1,2-dibromoethylene	9.45
tribromoethylene	9.27
3-chloropropene	10.04
2,3-dichloropropene	9.82
1-bromopropene	9.30
3-bromopropene	9.7
$CF_3CCl{=}CClCF_3$	10.36
n-$C_5F_{11}CF{=}CF_2$	10.48
acrolein	10.10
crotonaldehyde	9.73
mesityl oxide	9.08
vinyl methyl ether	8.93
allyl alcohol	9.67
vinyl acetate	9.19

Aromatic Compounds

Molecule	IP(eV)
benzene	9.245
toluene	8.82
ethyl benzene	8.76
n-propyl benzene	8.72
i-propyl benzene	8.69
n-butyl benzene	8.69
s-butyl benzene	8.68
t-butyl benzene	8.68
o-xylene	8.56
m-xylene	8.56
p-xylene	8.445
mesitylene	8.40
durene	8.025
styrene	8.47
alpha-methyl styrene	8.35
ethynylbenzene	8.815
naphthalene	8.12
1-methylnapthalene	7.69
2-methylnapthalene	7.955
biphenyl	8.27
phenol	8.50
anisole	8.22
phenetole	8.13
benzaldehyde	9.53
acetophenone	9.27
benzenethiol	8.33
phenyl isocyanate	8.77

Aromatic Compounds

Molecule	IP(eV)
phenyl isothiocyanate	8.520
benzonitrile	9.705
nitrobenzene	9.92
aniline	7.70
fluoro-benzene	9.195
chloro-benzene	9.07
bromo-benzene	8.98
iodo-benzene	8.73
o-dichlorobenzene	9.07
m-dichlorobenzene	9.12
p-dichlorobenzene	8.94
1-chloro-2-fluorobenzene	9.155
1-chloro-3-fluorobenzene	9.21
1-chloro-4-fluorobenzene	8.99
o-fluorotoluene	8.915
m-fluorotoluene	8.915
p-fluorotoluene	8.785
o-chlorotoluene	8.83
m-chlorotoluene	8.83
p-chlorotoluene	8.70
o-bromotoluene	8.79
m-bromotoluene	8.81
p-bromotoluene	8.67
o-iodotoluene	8.62
m-iodotoluene	8.61
p-iodotoluene	8.50
benzotrifluoride	9.68
o-fluorophenol	8.66

Heterocyclic Molecules

Molecule	IP(eV)
furan	8.89
2-methyl furan	8.39
2-furaldehyde	9.21
tetrahydrofuran	9.54
dihydropyran	8.34
tetrahydropyran	9.26
thiophene	8.860
2-chlorothiophene	8.68
2-bromothiophene	8.63
pyrrole	8.20
pyridine	9.32
2-picoline	9.02
3-picoline	9.04
4-picoline	9.04
2,3-lutidine	8.85
2,4-lutidine	8.85
2,6-lutidine	8.85

Miscellaneous Molecules

Molecule	IP(eV)
ethylene oxide	10.565
propylene oxide	10.22
p-dioxane	9.13
dimethoxymethane	10.00
diethoxymethane	9.70
1,1-dimethoxyethane	9.65
propiolactone	9.70
methyl disulfide	8.46
ethyl disulfide	8.27
diethyl sulfite	9.68
thiolacetic acid	10.00
acetyl chloride	11.02
acetyl bromide	10.55
cyclo-$C_6H_{11}CF_3$	10.46
$(n\text{-}C_3F_7)(CH_3)C{=}O$	10.58
trichlorovinylsilane	10.79
$(C_2F_5)_3N$	11.7
isoprene	9.08
phosgene	11.77

Notes:

Reference: HNu Systems, Inc., 1985
IP = Ionization Potential

ATTACHMENT 3

PID CALIBRATION AND MAINTENANCE LOG						
Instrument Model Number						
Instrument Serial Number						
Calibration Gas					**ppm**	
Date/Time	**Initials**	**Battery Check**	**Calibration**			
			Background Value	**True Gas Value**	**Measured Gas Value**	**Adjust**
COMMENTS:						

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Field Equipment Decontamination

Rev. #: 3

Rev Date: April 26, 2010

Approval Signatures

Prepared by: ______________________ Date: 4/26/2010
Keith Shepherd

Reviewed by: ______________________ Date: 4/26/2010
Richard Murphy (Technical Expert)

I. Scope and Application

Equipment decontamination is performed to ensure that sampling equipment that contacts a sample, or monitoring equipment that is brought into contact with environmental media to be sampled, is free from analytes of interest and/or constituents that would interfere with laboratory analysis for analytes of interest. Equipment must be cleaned prior to use for sampling or contact with environmental media to be sampled, and prior to shipment or storage. The effectiveness of the decontamination procedure should be verified by collecting and analyzing equipment blank samples.

The equipment cleaning procedures described herein includes pre-field, in the field, and post-field cleaning of sampling tools which will be conducted at an established equipment decontamination area (EDA) on site (as appropriate). Equipment that may require decontamination at a given site includes: soil sampling tools; groundwater, sediment, and surface-water sampling devices; water testing instruments; down-hole instruments; and other activity-specific sampling equipment. Non-disposable equipment will be cleaned before collecting each sample, between sampling events, and prior to leaving the site. Cleaning procedures for sampling equipment will be monitored by collecting equipment blank samples as specified in the applicable work plan or field sampling plan. Dedicated and/or disposable (not to be re-used) sampling equipment will not require decontamination.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired fieldwork. The project HASP and other documents will identify any other training requirements such as site specific safety training or access control requirements.

III. Equipment List

- health and safety equipment, as required in the site Health and Safety Plan (HASP)
- distilled water

- Non-phosphate detergent such as Alconox or, if sampling for phosphorus phosphorus-containing compounds, Luminox (or equivalent).
- tap water
- rinsate collection plastic containers
- DOT-approved waste shipping container(s), as specified in the work plan or field sampling plan (if decontamination waste is to be shipped for disposal)
- brushes
- large heavy-duty garbage bags
- spray bottles
- (Optional) – Isoprophyl alcohol (free of ketones) or methanol
- Ziploc-type bags
- plastic sheeting

IV. Cautions

Rinse equipment thoroughly and allow the equipment to dry before re-use or storage to prevent introducing solvent into sample medium. If manual drying of equipment is required, use clean lint-free material to wipe the equipment dry.

Store decontaminated equipment in a clean, dry environment. Do not store near combustion engine exhausts.

If equipment is damaged to the extent that decontamination is uncertain due to cracks or dents, the equipment should not be used and should be discarded or submitted for repair prior to use for sample collection.

A proper shipping determination will be performed by a DOT-trained individual for cleaning materials shipped by ARCADIS.

V. Health and Safety Considerations

Review the material safety data sheets (MSDS) for the cleaning materials used in decontamination. If solvent is used during decontamination, work in a well-ventilated area and stand upwind while applying solvent to equipment. Apply solvent in a manner that minimizes potential for exposure to workers. Follow health and safety procedures outlined in the HASP.

VI. Procedure

A designated area will be established to clean sampling equipment in the field prior to sample collection. Equipment cleaning areas will be set up within or adjacent to the specific work area, but not at a location exposed to combustion engine exhaust. Detergent solutions will be prepared in clean containers for use in equipment decontamination.

Cleaning Sampling Equipment

1. Wash the equipment/pump with potable water.

2. Wash with detergent solution (Alconox, Liquinox or equivalent) to remove all visible particulate matter and any residual oils or grease.

3. If equipment is very dirty, precleaning with a brush and tap water may be necessary.

4. (Optional) – Flush with isopropyl alcohol (free of ketones) or with methanol. This step is optional but should be considered when sampling in highly impacted media such as non-aqueous phase liquids or if equipment blanks from previous sampling events showed the potential for cross contamination of organics.

5. Rinse with distilled/deionized water.

Decontaminating Submersible Pumps

Submersible pumps may be used during well development, groundwater sampling, or other investigative activities. The pumps will be cleaned and flushed before and between uses. This cleaning process will consist of an external detergent solution wash and tap water rinse, a flush of detergent solution through the pump, followed by a flush of potable water through the pump. Flushing will be accomplished by using an appropriate container filled with detergent solution and another contained filled with potable water. The pump will run long enough to effectively flush the pump housing and hose (unless new, disposable hose is used). Caution should be exercised to avoid contact with the pump casing and water in the container while the pump is running (do not use metal drums or garbage cans) to avoid electric shock. Disconnect the pump from the power source before handling. The pump and hose should be placed on or in clean polyethylene sheeting to avoid contact with the ground surface.

VII. Waste Management

Equipment decontamination rinsate will be managed in conjunction with all other waste produced during the field sampling effort. Waste management procedures are outlined in the work plan or Waste Management Plan (WMP).

VIII. Data Recording and Management

Equipment cleaning and decontamination will be noted in the field notebook. Information will include the type of equipment cleaned, the decontamination location and any deviations from this SOP. Specific factors that should be noted include solvent used (if any), and source of water.

Any unusual field conditions should be noted if there is potential to impact the efficiency of the decontamination or subsequent sample collection.

An inventory of the solvents brought on site and used and removed from the site will be maintained in the files. Records will be maintained for any solvents used in decontamination, including lot number and expiration date.

Containers with decontamination fluids will be labeled.

IX. Quality Assurance

Equipment blanks should be collected to verify that the decontamination procedures are effective in minimizing potential for cross contamination. The equipment blank is prepared by pouring deionized water over the clean and dry tools and collecting the deionized water into appropriate sample containers. Equipment blanks should be analyzed for the same set of parameters that are performed on the field samples collected with the equipment that was cleaned. Equipment blanks are collected per equipment set, which represents all of the tools needed to collect a specific sample.

X. References

USEPA Region 9, Field Sampling Guidance #1230, Sampling Equipment Decontamination.

USEPA Region 1, Low Stress (low flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells.

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Chain-of-Custody, Handling, Packing and Shipping

Rev. #: 2

Rev Date: March 6, 2009

Approval Signatures

Prepared by: ______________________ Date: 3/6/09
Caron Koll

Reviewed by: ______________________ Date: 3/6/09
Jane Kennedy(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the chain-of-custody, handling, packing, and shipping procedures for the management of samples to decrease the potential for cross-contamination, tampering, mis-identification, and breakage, and to insure that samples are maintained in a controlled environment from the time of collection until receipt by the analytical laboratory.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training, including 40-hour HAZWOPER training, Department of Transportation (DOT) training, site supervisor training, and site-specific training, as needed. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and possess the skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following list provides materials that may be required for each project. Project documents and sample collection requirements should be reviewed prior to initiating field operations:

- indelible ink pens (black or blue);
- polyethylene bags (resealable-type);
- clear packing tape, strapping tape, duct tape;
- chain of custody
- DOT shipping forms, as applicable
- custody seals or tape;
- appropriate sample containers and labels,;
- insulated coolers of adequate size for samples and sufficient ice to maintain 4°C during collection and transfer of samples;
- wet ice;
- cushioning and absorbent material (i.e., bubble wrap or bags);

- temperature blank
- sample return shipping papers and addresses; and
- field notebook.

IV. Cautions

Review project requirements and select appropriate supplies prior to field mobilization.

Insure that appropriate sample containers with applicable preservatives, coolers, and packing material have been supplied by the laboratory.

Understand the offsite transfer requirements for the facility at which samples are collected.

If overnight courier service is required schedule pick-up or know where the drop-off service center is located and the hours of operation. Prior to using air transportation, confirm air shipment is acceptable under DOT and International Air Transport Association (IATA) regulation

Schedule pick-up time for laboratory courier or know location of laboratory/service center and hours of operation.

Understand DOT and IATA shipping requirements and evaluate dangerous goods shipping regulations relative to the samples being collected (i.e. complete an ARCADIS shipping determination). Review the ARCADIS SOPs for shipping, packaging and labeling of dangerous goods. Potential samples requiring compliance with this DOT regulation include:

- Methanol preservation for Volatile Organic Compounds in soil samples
- Non-aqueous phase liquids (NAPL)

V. Health and Safety Considerations

Follow health and safety procedures outlined in the project/site Health and Safety Plan (HASP).

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

Some sample containers contain preservatives.

- The preservatives must be retained in the sample container and should in no instance be rinsed out.
- Preservatives may be corrosive and standard care should be exercised to reduce potential contact to personnel skin or clothing. Follow project safety procedures if spillage is observed.
- If sample container caps are broken discard the bottle. Do not use for sample collection.

VI. Procedure

Chain-of-Custody Procedures

1. Prior to collecting samples, complete the chain-of-custody record header information by filling in the project number, project name, and the name(s) of the sampling technician(s) and other relevant project information. Attachment 1 provides an example chain-o- custody record

2. Chain-of-custody information MUST be printed legibly using indelible ink (black or blue).

3. After sample collection, enter the individual sample information on the chain-of-custody:

   a. Sample Identification indicates the well number or soil location that the sample was collected from. Appropriate values for this field include well locations, grid points, or soil boring identification numbers (e.g., MW-3, X-20, SB-30). When the depth interval is included, the complete sample ID would be "SB-30 (0.5-1.0) where the depth interval is in feet. Please note it is very important that the use of hyphens in sample names and depth units (i.e., feet or inches) remain consistent for all samples entered on the chain-of-custody form. DO NOT use the apostrophe or quotes in the sample ID. Sample names may also use the abbreviations "FB," "TB," and "DUP" as prefixes or suffixes to indicate that the sample is a field blank, trip blank, or field duplicate, respectively. NOTE: The sample nomenclature may be dictated by the project database and require unique identification for each sample collected for the project. Consult the project data management plan for additional information regarding sample identification.

b. List the date of sample collection. The date format to be followed should be mm/dd/yy (e.g., 03/07/09) or mm/dd/yyyy (e.g. 03/07/2009).

c. List the time that the sample was collected. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

d. The composite field should be checked if the sample is a composite over a period of time or from several different locations and mixed prior to placing in sample containers.

e. The “Grab”. field should be marked with an “X” if the sample was collected as an individual grab sample. (e.g. monitoring well sample or soil interval).

f. Any sample preservation should be noted.

g. The analytical parameters that the samples are being analyzed for should be written legibly on the diagonal lines. As much detail as possible should be presented to allow the analytical laboratory to properly analyze the samples. For example, polychlorinated biphenyl (PCB) analyses may be represented by entering “PCBs” or “Method 8082.” Multiple methods and/or analytical parameters may be combined for each column (e.g., PCBs/VOCs/SVOCs or 8082/8260/8270). These columns should also be used to present project-specific parameter lists (e.g., Appendix IX+3 target analyte list. Each sample that requires a particular parameter analysis will be identified by placing the number of containers in the appropriate analytical parameter column. For metals in particular, indicate which metals are required.

h. Number of containers for each method requested. This information may be included under the parameter or as a total for the sample based on the chain of custody form used.

i. Note which samples should be used for site specific matrix spikes.

j. Indicate any special project requirements.

k. Indicate turnaround time required.

l. Provide contact name and phone number in the event that problems are encountered when samples are received at the laboratory.

m. If available attach the Laboratory Task Order or Work Authorization forms

n. The remarks field should be used to communicate special analytical requirements to the laboratory. These requirements may be on a per sample basis such as "extract and hold sample until notified," or may be used to inform the laboratory of special reporting requirements for the entire sample delivery group (SDG). Reporting requirements that should be specified in the remarks column include: 1) turnaround time; 2) contact and address where data reports should be sent; 3) name of laboratory project manager; and 4) type of sample preservation used.

o. The "Relinquished By" field should contain the signature of the sampling technician who relinquished custody of the samples to the shipping courier or the analytical laboratory.

p. The "Date" field following the signature block indicates the date the samples were relinquished. The date format should be mm/dd/yyyy (e.g., 03/07/2005).

q. The "Time" field following the signature block indicates the time that the samples were relinquished. The time value should be presented using military format. For example, 3:15 P.M. should be entered as 15:15.

r. The "Received By" section is signed by sample courier or laboratory representative who received the samples from the sampling technician or it is signed upon laboratory receipt from the overnight courier service.

3. Complete as many chain-of-custody forms as necessary to properly document the collection and transfer of the samples to the analytical laboratory.

4. Upon completing the chain-of-custody forms, forward two copies to the analytical laboratory and retain one copy for the field records.

5. If electronic chain-of-custody forms are utilized, sign the form and make 1 copy for ARCADIS internal records and forward the original with the samples to the laboratory.

Handling Procedures

1. After completing the sample collection procedures, record the following information in the field notebook with indelible ink:

    - project number and site name;
    - sample identification code and other sample identification information, if appropriate;
    - sampling method;
    - date;
    - name of sampler(s);
    - time;
    - location (project reference);
    - location of field duplicates and both sample identifications;
    - locations that field QC samples were collected including equipment blanks, field blanks and additional sample volume for matrix spikes; and
    - any comments.

2. Complete the sample label with the following information in indelible ink:

    - sample type (e.g., surface water);
    - sample identification code and other sample identification information, if applicable;
    - analysis required;
    - date;
    - time sampled; and
    - initials of sampling personnel;

- sample matrix; and
- preservative added, if applicable.

3. Cover the label with clear packing tape to secure the label onto the container and to protect the label from liquid.

4. Confirm that all caps on the sample containers are secure and tightly closed.

5. In some instances it may be necessary to wrap the sample container cap with clear packing tape to prevent it from becoming loose.

6. For some projects individual custody seals may be required. Custody seal evidence tape may be placed on the shipping container or they may be placed on each sample container such that the cooler or cap cannot be opened without breaking the custody seal. The custody seal should be initialed and dated prior to relinquishing the samples.

Packing Procedures

Following collection, samples must be placed on wet ice to initiate cooling to 4°C immediately. Retain samples on ice until ready to pack for shipment to the laboratory.

1. Secure the outside and inside of the drain plug at the bottom of the cooler being used for sample transport with “Duct” tape.

2. Place a new large heavy duty plastic garbage bag inside each cooler

3. Place each sample bottle wrapped in bubble wrap inside the garbage bag. VOC vials may be grouped by sample in individual resealable plastic bags). If a cooler temperature blank is supplied by the laboratory, it should be packaged following the same procedures as the samples. If the laboratory did not include a temperature blank, do not add one. Place 1 to 2 inches of cushioning material (i.e., vermiculite) at the bottom of the cooler.

4. Place the sealed sample containers upright in the cooler.

5. Package ice in large resealable plastic bags and place inside the large garbage bag in the cooler. Samples placed on ice will be cooled to and maintained at a temperature of approximately 4°C.

6. Fill the remaining space in the cooler with cushioning material such as bubble wrap. The cooler must be securely packed and cushioned in an upright position and be surrounded (Note: to comply with 49 CFR 173.4, filled cooler must not exceed 64 pounds).

7. Place the completed chain-of-custody record(s) in a large resealable bag and tape the bag to the inside of the cooler lid.

8. Close the lid of the cooler and fasten with packing tape.

9. Wrap strapping tape around both ends of the cooler.

10. Mark the cooler on the outside with the following information: shipping address, return address, “Fragile, Handle with Care” labels on the top and on one side, and arrows indicating “This Side Up” on two adjacent sides.

11. Place custody seal evidence tape over front right and back left of the cooler lid, initial and date, then cover with clear plastic tape.

Note: Procedure numbers 2, 3, 5, and 6 may be modified in cases where laboratories provide customized shipping coolers. These cooler types are designed so the sample bottles and ice packs fit snugly within preformed styrofoam cushioning and insulating packing material.

Shipping Procedures

1. All samples will be delivered by an express carrier within 48 hours of sample collection. Alternatively, samples may be delivered directly to the laboratory or laboratory service center or a laboratory courier may be used for sample pickup.

2. If parameters with short holding times are required (e.g., VOCs [EnCore™ Sampler], nitrate, nitrite, ortho-phosphate and BOD), sampling personnel will take precautions to ship or deliver samples to the laboratory so that the holding times will not be exceeded.

3. Samples must be maintained at 4°C±2°C until shipment and through receipt at the laboratory

4. All shipments must be in accordance with DOT regulations and ARCADIS dangerous goods shipping SOPs.

5. When the samples are received by the laboratory, laboratory personnel will complete the chain-of-custody by recording the date and time of receipt of samples, measuring and recording the internal temperature of the shipping container, and checking the sample identification numbers on the containers to ensure they correspond with the chain-of-custody forms.

Any deviations between the chain-of-custody and the sample containers, broken containers, or temperature excursions will be communicated to ARCADIS immediately by the laboratory.

VII. Waste Management

Not applicable

VIII. Data Recording and Management

Chain-of-custody records will be transmitted to the ARCADIS PM or designee at the end of each day unless otherwise directed by the ARCADIS PM. The sampling team leader retains copies of the chain-of-custody forms for filing in . the project file. Record retention shall be in accordance with project requirements.

IX. Quality Assurance

Chain-of-custody forms will be legibly completed in accordance with the applicable project documents such as Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), Work Plan, or other project guidance documents. A copy of the completed chain-of-custody form will be sent to the ARCADIS Project Manager or designee for review.

X. References

Not Applicable

Attachment 1

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ID#:

CHAIN OF CUSTODY & LABORATORY ANALYSIS REQUEST FORM

Page ___ of ___

Lab Work Order #

Send Results to:	
Contact & Company Name:	Telephone:
Address:	Fax:
City State Zip	E-mail Address:
Project Name/Location (City, State):	Project #:
Sampler's Printed Name:	Sampler's Signature:

Preservative								
Filtered (✓)								
# of Containers								
Container Information								

PARAMETER ANALYSIS & METHOD

Keys

Preservation Key:
A. H_2SO_4
B. HCL
C. HNO_3
D. NaOH
E. None
F. Other: ________
G. Other: ________
H. Other: ________

Container Information Key:
1. 40 ml Vial
2. 1 L Amber
3. 250 ml Plastic
4. 500 ml Plastic
5. Encore
6. 2 oz. Glass
7. 4 oz. Glass
8. 8 oz. Glass
9. Other: ________
10. Other: ________

Matrix Key:
SO - Soil; SE - Sediment; NL - NAPL/Oil
W - Water; SL - Sludge; SW - Sample Wipe
T - Tissue; A - Air; Other: ________

Sample ID	Collection Date	Collection Time	Type (✓) Comp	Type (✓) Grab	Matrix								REMARKS

Special Instructions/Comments:

☐ **Special QA/QC Instructions(✓):**

Laboratory Information and Receipt		Relinquished By	Received By	Relinquished By	Laboratory Received By
Lab Name:	Cooler Custody Seal (✓)	Printed Name:	Printed Name:	Printed Name:	Printed Name:
☐ Cooler packed with ice (✓)	☐ Intact ☐ Not Intact	Signature:	Signature:	Signature:	Signature:
Specify Turnaround Requirements:	Sample Receipt:	Firm:	Firm/Courier:	Firm/Courier:	Firm:
Shipping Tracking #:	Condition/Cooler Temp: ________	Date/Time:	Date/Time:	Date/Time:	Date/Time:

20730826 CofC AR Form 01.12.2007 **Distribution:** **WHITE – Laboratory returns with results** **YELLOW – Lab copy** **PINK – Retained by BBL**

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Standard Groundwater Sampling for Monitoring Wells

Rev. #: 1

Rev Date: July 16, 2008

Approval Signatures

Prepared by: ______________________ Date: 7/16/08

Reviewed by: ______________________ Date: 7/16/08
(Technical Expert)

I. Scope and Application

This Standard Operating Procedure (SOP) describes the procedures to be used to collect groundwater samples using traditional purging and sampling techniques. For low-flow purging techniques, please refer to the Low Flow Purging SOP. Monitoring wells must be developed after installation at least 1 week prior to groundwater sample collection. Monitoring wells will not be sampled until the well has been developed. During precipitation events, groundwater sampling will be discontinued until precipitation ceases or a cover has been erected over the sampling area and monitoring well.

Both filtered and unfiltered groundwater samples may be collected using this SOP. Filtered samples may be obtained using a 1.0-, 0.45-, or 0.1-micron disposable filter.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 2 years of previous groundwater sampling experience. Field employees with less than 6 months of experience should be accompanied by a supervisor (as described above) to ensure that proper sample collection techniques are employed.

III. Equipment List

The following materials shall be available, as required, during groundwater sampling:

- site plan of monitoring well locations and site Field Sampling Plan (FSP);
- appropriate health and safety equipment, as specified in the site Health and Safety Plan (HASP);
- photoionization detector (PID) or flame ionization detector (FID), as needed, in accordance with the HASP;
- monitoring well construction logs or tables and historical water level information, if available;
- dedicated plastic sheeting or other clean surface to prevent sample contact with the ground;
- if bailers are to be used in sampling:

  - appropriate dedicated bottom-loading, bottom-emptying bailers (i.e., polyvinyl chloride [PVC], Teflon, or stainless steel);
  - polypropylene rope;
- if submersible pumps are to be used in sampling:
  - dedicated tubing and other equipment necessary for purging;
  - generator or battery for operation of pumps, if required;
  - a pump selected in accordance with the FSP or Work Plan (parameter-specific [e.g., submersible, bladder, peristaltic]);
- graduated buckets to measure purge water;
- water-level or oil/water interface probe, in accordance with the FSP or Work Plan;
- conductivity/temperature/pH meter;
- down-hole dissolved oxygen meter, oxidation reduction potential meter, and/or turbidity meter, if specified in the FSP;
- water sample containers appropriate for the analytical method(s) with preservative, as needed (parameter-specific);
- filter, as needed, in accordance with the analytical method and parameter;
- appropriate blanks (trip blank supplied by the laboratory), as specified in the FSP;
- Ziploc-type freezer bags for use as ice containers;
- appropriate transport containers (coolers) with ice and appropriate labeling, packing, and shipping materials;
- appropriate groundwater sampling log (example attached);
- chain-of-custody forms;
- site map with well locations and groundwater contour maps;

- keys to wells and contingent bolt cutters for rusted locks and replacement keyed-alike locks; and

- drums or other containers for purge water, as specified by the site investigation derived waste (IDW) management plan.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Remember that field logs and some forms are considered to be legal documents. All field logs and forms should therefore be filled out in indelible ink.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Check monitoring well logs for use of bentonite pellets. Make note of potential use of bentonite pellets on the groundwater sampling log. Coated bentonite pellets have been found to contaminate monitoring wells with elevated levels of acetone.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to more impacted based on previous analytical data. If no analytical data are available, samples are to be collected in the following order:

1. First sample the upgradient well(s).

2. Next, sample the well located furthest downgradient of the interpreted or known source.

3. The remaining wells should be progressively sampled in order from downgradient to upgradient, such that the wells closest to the interpreted or known source are sampled last.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can impair the integrity of the seal.

V. Health and Safety Considerations

If thunder or lighting is present, discontinue sampling until 30 minutes have passed after the last occurrence of thunder or lighting.

VI. Procedure

The procedures to sample monitoring wells will be as follows:

1. Don safety equipment, as required in the HASP. Depending on site-specific security and safety considerations, this often must be done prior to entering the work area.

2. Review equipment list (Section III above) to confirm that the appropriate equipment has been acquired.

3. Record site and monitoring well identification on the groundwater sampling log, along with date, arrival time, and weather conditions. Also identify the personnel present, equipment utilized, and other relevant data requested on the log.

4. Label all sample containers with indelible ink.

5. Place plastic sheeting adjacent to the well for use as a clean work area, if conditions allow. Otherwise, prevent sampling equipment from contacting the ground or other surface that could compromise sample integrity.

6. Remove lock from well and if rusted or broken, replace with a new brass keyed-alike lock.

7. Unlock and open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting.

8. Set the sampling device,meters, and other sampling equipment on the plastic sheeting. If a dedicated sampling device stored in the well is to be used, this may also be set temporarily on the plastic sheeting, for convenience. However, if a dedicated sampling device is stored below the water table, removing it may compromise water-level data, so water level measurements should be taken prior to removing the device.

9. Obtain a water-level depth and bottom-of-well depth using an electric well probe and record on the groundwater sampling log using indelible ink. Clean the probe(s) after each use in accord with the FSP or the equipment

decontamination SOP.

Note: Water levels may be measured at all wells prior to initiating any sampling activities, depending on FSP requirements.

10. Calculate the number of gallons of water in the well using the length of water column (in feet). Record the well volume on the groundwater sampling log using indelible ink.

11. Remove the required purge volume of water from the well (measure purge water volume in measuring buckets). The required purge volume will be three to five well volumes (the water column in the well screen and casing) unless the well runs dry, in which case, the water that comes into the well will be sampled (USEPA, 1996). In any case, the pumping rate will be decreased during sampling to limit the potential for volatilization of organics potentially present in the groundwater.

12. Field parameter measurements will be periodically collected in accord with FSP specifications. The typical time intervals of field parameter measurement are (1) after each well volume removed, and (2) before sampling. If the field parameters are being measured above-ground (rather than with a downhole probe), then the final pre-sampling parameter measurement should be collected at the reduced flow rate to be used during sampling. The physical appearance of the purged water should be noted on the groundwater sampling log. In addition, water level measurements should be collected and recorded to verify that the well purging is in accord with the guidelines set forth in the previous step.

13. Unless otherwise specified by the applicable regulatory agencies, all purge water will be contained. Contained purge water will be managed in accordance with the FSP or Work Plan. If historical concentrations in the well are less than federal or state regulated concentrations appropriate for current land use, *and permission has been granted by the oversight regulatory agency* to dispose of clean purge water on the ground next to the well(s), then purge water will be allowed to infiltrate into the ground surface downgradient from the monitoring well after the well is sampled.

14. After the appropriate purge volume of groundwater in the well has been removed, or if the well has been bailed dry and allowed to recover, obtain the groundwater sample needed for analysis with the dedicated bailer or from the dedicated sampling tubing, pour the groundwater directly from the sampling device into the appropriate container in the order of volatilization sensitivity of

the parameters sampled, and tightly screw on the cap (snug, but not too tight). The suggested order for sample parameter collection, based on volatilization sensitivity, is presented below:

a. volatile organic compounds (VOCs);

b. semi-volatile organic compounds (SVOCs);

c. polychlorinated biphenyls (PCBs)/pesticides;

d. metals; and

e. wet chemistry.

15. When sampling for volatiles, water samples will be collected directly from the bailer or dedicated tubing into 40 mL vials with Teflon-lined septa.

16. For other analytical samples, sample containers for each analyte type should be filled in the order specified by the FSP. If a bailer is used, then the sample for dissolved metals and/or filtered PCBs should either be placed directly from the bailer into a pressure filter apparatus or pumped directly from the bailer with a peristaltic pump, through an in-line filter, into the pre-preserved sample bottle. If dedicated sample tubing is used, then the filter should be installed in-line just prior to filtered sample collection.

17. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Sample filtration for the filtered sample will be performed in the field utilizing a pump prior to preservation. Attach (clamp) a new 1.0-, 0.45-, or 0.1-micron filter to the discharge tubing of the pump (note the filter flow direction). Turn the pump on and allow 100 mL (or manufacturer recommended amount) of fluid through the filter before sample collection. Dispense the filtered liquid directly into the laboratory sample bottles. If bailers are used for purging and sampling, a proper volume of purge water will be placed in a disposable or decontaminated polyethylene container and pumped through the filter and into the sample container using a peristaltic pump.

18. Place the custody seal around the cap and the sampler container, if required. Note the time on the sample label. Secure with packing material and maintain at approximately 4°C on wet ice contained in double Ziploc-type freezer bags during storage in an insulated, durable transport container.

19. Replace the well cap and lock well, or install a new lock if needed.

20. Record the time sampling procedures were completed on the appropriate field logs (using indelible ink).

21. Complete the procedures for chain-of-custody, handling, packing, and shipping. Chain-of-custody forms should be filled out and checked against the labels on the sample containers progressively after each sample is collected.

22. Place all disposable sampling materials (such as plastic sheeting, disposable tubing or bailers, and health and safety equipment) in appropriate containers.

23. If new locks were installed, forward copies of the keys to the client Project Manager (PM) and ARCADIS PM at the end of the sampling activities.

VII. Waste Management

Purge water will be managed as specified in the FSP or Work Plan, and according to state and/or federal requirements. Personal protective equipment (PPE) and decontaminated fluids will be contained separately and staged at the sampling location. Containers must be labeled at the time of collection. Labels will include date, location(s), site name, city, state, and description of matrix contained (e.g., soil, groundwater, PPE). General guidelines for IDW management are set forth in a separate IDW management SOP.

VIII. Data Recording and Management

Initial field logs and chain-of-custody records will be transmitted to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling logs. All field data should be recorded in indelible ink.

IX. Quality Assurance

Field-derived quality assurance blanks will be collected as specified in the FSP, depending on the project quality objectives. Typically, field rinse blanks will be collected when non-dedicated equipment is used during groundwater sampling. Field rinse blanks will be used to confirm that decontamination procedures are sufficient and samples are representative of site conditions. Trip blanks for VOCs, which aid in the detection of contaminates from other media, sources, or the container itself, will be kept with the coolers and the sample containers throughout the sampling activities.

X. References

USEPA. 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA. 1991. Handbook Groundwater, Volume ii Methodology, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July, 1991).

U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

ARCADIS
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Low-Flow Groundwater Purging and Sampling Procedures for Monitoring Wells

Rev. #: 4

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

Groundwater samples will be collected from monitoring wells to evaluate groundwater quality. The protocol presented in this standard operating procedure (SOP) describes the procedures to be used to purge monitoring wells and collect groundwater samples. This protocol has been developed in accordance with the United States Environmental Protection Agency (USEPA) Region I Low Stress (Low Flow) Purging and Sampling Procedures for the Collection of Groundwater Samples from Monitoring Wells (USEPA SOP No. GW0001; July 30, 1996). Both filtered and unfiltered groundwater samples may be collected using this low-flow sampling method. Filtered samples will be obtained using a 0.45-micron disposable filter. No wells will be sampled until well development has been performed in accordance with the procedures presented in the SOP titled Monitoring Well Development, unless that well has been sampled or developed within the prior 1-year time period. Groundwater samples will not be collected within 1 week following well development.

II. Personnel Qualifications

ARCADIS personnel directing, supervising, or leading groundwater sample collection activities should have a minimum of 2 years of previous groundwater sampling experience. ARCADIS personnel providing assistance to groundwater sample collection and associated activities should have a minimum of 6 months of related experience or an advanced degree in environmental sciences, engineering, hydrogeology, or geology.

The supervisor of the groundwater sampling team will have at least 1 year of previous supervised groundwater sampling experience.

Prior to mobilizing to the field, the groundwater sampling team should review and be thoroughly familiar with relevant site-specific documents including but not limited to the site work plan, field sampling plan, QAPP, HASP, and historical information. Additionally, the groundwater sampling team should review and be thoroughly familiar with documentation provided by equipment manufacturers for all equipment that will be used in the field prior to mobilization.

III. Equipment List

Specific to this activity, the following materials (or equivalent) will be available:

- Health and safety equipment (as required in the site Health and Safety Plan [HASP]).

- Site Plan, well construction records, prior groundwater sampling records (if available).
- Sampling pump, which may consist of one or more of the following:
  - submersible pump (e.g., Grundfos Redi-Flo 2);
  - peristaltic pump (e.g., ISCO Model 150); and/or
  - bladder pump (e.g., Marschalk System 1, QED Well Wizard, Geotech, etc.).
- Appropriate controller and power source for pump:
  - Submersible and peristaltic pumps require electric power from either a generator or a deep cell battery.
  - Submersible pumps such as Grundfos require a pump controller to run the pump
  - Bladder pumps require a pump controller and a gas source (e.g., air compressor or compressed N_2 or CO_2 gas cylinders).
- Teflon® tubing or Teflon®-lined polyethylene tubing of an appropriate size for the pump being used. For peristaltic pumps, dedicated Tygon® tubing (or other type as specified by the manufacturer) will also be used through the pump apparatus.
- Water-level probe (e.g., Solinist Model 101).
- Water-quality (temperature/pH/specific conductivity/ORP/turbidity/dissolved oxygen) meter and flow-through measurement cell. Several brands may be used, including:
  - YSI 6-Series Multi-Parameter Instrument;
  - Hydrolab Series 3 or Series 4a Multiprobe and Display; and/or
  - Horiba U-10 or U-22 Water Quality Monitoring System.
- Supplemental turbidity meter (e.g., Horiba U-10, Hach 2100P, LaMotte 2020). Turbidity measurements collected with multi-parameter meters have been shown to sometimes be unreliable due to fouling of the optic lens of the

turbidity meter within the flow-through cell. A supplemental turbidity meter will be used to verify turbidity data during purging if such fouling is suspected. Note that industry improvements may eliminate the need for these supplemental measurements in the future.

- Appropriate water sample containers (supplied by the laboratory).
- Appropriate blanks (trip blank supplied by the laboratory).
- 0.45-micron disposable filters (if field filtering is required).
- Large glass mixing container (if sampling with a bailer).
- Teflon® stirring rod (if sampling with a bailer).
- Cleaning equipment.
- Groundwater sampling log (attached) or bound field logbook.

Note that in the future, the client may acquire different makes/models of some of this equipment if the listed makes/models are no longer available, or as a result of general upgrades or additional equipment acquisitions. In the event that the client uses a different make/model of the equipment listed, the client will use an equivalent type of equipment (e.g., pumps, flow-through analytical cells) and note the specific make/model of the equipment used during a sampling event on the groundwater sampling log. In addition, should the client desire to change to a markedly different sampling methodology (e.g., discrete interval samplers, passive diffusion bags, or a yet to be developed technique), the client will submit a proposed SOP for the new methodology for USEPA approval prior to implementing such a change.

The maintenance requirements for the above equipment generally involve decontamination or periodic cleaning, battery charging, and proper storage, as specified by the manufacturer. For operational difficulties, the equipment will be serviced by a qualified technician.

IV. Cautions

If heavy precipitation occurs and no cover over the sampling area and monitoring well can be erected, sampling must be discontinued until adequate cover is provided. Rain water could contaminate groundwater samples.

Do not use permanent marker or felt-tip pens for labels on sample container or sample coolers – use indelible ink. The permanent markers could introduce volatile constituents into the samples.

It may be necessary to field filter some parameters (e.g., metals) prior to collection, depending on preservation, analytical method, and project quality objectives.

Store and/or stage empty and full sample containers and coolers out of direct sunlight.

To mitigate potential cross-contamination, groundwater samples are to be collected in a pre-determined order from least impacted to impacted based on previous analytical data. If no analytical data are available, samples are collected in order of upgradient, then furthest downgradient to source area locations.

Be careful not to over-tighten lids with Teflon liners or septa (e.g., 40 mL vials). Over-tightening can cause the glass to shatter or impair the integrity of the Teflon seal.

V. Health and Safety Considerations

Use caution and appropriate cut resistant gloves when tightening lids to 40 mL vials. These vials can break while tightening and can lacerate hand. Amber vials (thinner glass) are more prone to breakage.

If thunder or lighting is present, discontinue sampling and take cover until 30 minutes have passed after the last occurrence of thunder or lighting.

Use caution when removing well caps as well may be under pressure, cap can dislodge forcefully and cause injury.

Use caution when opening protective casing on stickup wells as wasps frequently nest inside the tops of the covers. Also watch for fire ant mounds near well pads when sampling in the south or western U.S.

VI. Procedure

Groundwater will be purged from the wells using an appropriate pump. Peristaltic pumps will initially be used to purge and sample all wells when applicable. If the depth to water is below the sampling range of a peristaltic pump (approximately 25 feet), submersible pumps or bladder pumps will be used provided the well is constructed with a casing diameter greater than or equal to 2 inches (the minimum well diameter capable of accommodating such pumps). Bladder pumps are preferred over peristaltic and submersible pumps if sampling of VOCs is required to prevent volatilization. For smaller diameter wells where the depth to water is below the sampling range of a peristaltic pump, alternative sampling methods (i.e., bailing or small diameter bladder pumps) will be used to purge and sample the groundwater. Purge water will be collected and containerized.

1. Calibrate field instruments according to manufacturer procedures for calibration.

2. Measure initial depth to groundwater prior to placement of pumps.

3. Prepare and install pump in well: For submersible and non-dedicated bladder pumps, decontaminate pump according to site decontamination procedures. Non-dedicated bladder pumps will require a new Teflon® bladder and attachment of an air line, sample discharge line, and safety cable prior to placement in the well. Attach the air line tubing to the air port on the top of the bladder pump. Attach the sample discharge tubing to the water port on the top of the bladder pump. Care should be taken not to reverse the air and discharge tubing lines during bladder pump set-up as this could result in bladder failure or rupture. Attach and secure a safety cable to the eyebolt on the top of bladder pump (if present, depending on pump model used). Slowly lower pump, safety cable, tubing, and electrical lines into the well to a depth corresponding to the approximate center of the saturated screen section of the well. Take care to avoid twisting and tangling of safety cable, tubing, and electrical lines while lowering pump into well; twisted and tangled lines could result in the pump becoming stuck in the well casing. Also, make sure to keep tubing and lines from touching the ground or other surfaces while introducing them into the well as this could lead to well contamination. If a peristaltic pump is being used, slowly lower the sampling tubing into the well to a depth corresponding to the approximate center of the saturated screen section of the well. The pump intake or sampling tube must be kept at least 2 feet above the bottom of the well to prevent mobilization of any sediment present in the bottom of the well.

4. If using a bladder pump, connect the air line to the pump controller output port. The pump controller should then be connected to a supply line from an air compressor or compressed gas cylinder using an appropriate regulator and air hose. Take care to tighten the regulator connector onto the gas cylinder (if used) to prevent leaks. Teflon tape may be used on the threads of the cylinder to provide a tighter seal. Once the air compressor or gas cylinder is connected to the pump controller, turn on the compressor or open the valve on the cylinder to begin the gas flow. Turn on the pump controller if an on/off switch is present and verify that all batteries are charged and fully operating before beginning to pump.

5. Connect the pump discharge water line to the bottom inlet port on the flow-through cell connected to the water quality meter.

6. Measure the water level again with the pump in the well before starting the pump. Start pumping the well at 200 to 500 milliliters (mL) per minute (or at lower site-specific rate if specified). The pump rate should be adjusted to cause little or no water level drawdown in the well (less than 0.3 feet below the initial static depth to water measurement) and the water level should stabilize. The water level should be monitored every 3 to 5 minutes (or as appropriate, lower flow rates may require longer time between readings) during pumping if the well diameter is of sufficient size to allow such monitoring. Care should be taken not to break pump suction or cause entrainment of air in the sample. Record pumping rate adjustments and depths to water. If necessary, pumping rates should be reduced to the minimum capabilities of the pump to avoid pumping the well dry and/or to stabilize indicator parameters. A steady flow rate should be maintained to the extent practicable. Groundwater sampling records from previous sampling events (if available) should be reviewed prior to mobilization to estimate the optimum pumping rate and anticipated drawdown for the well in order to more efficiently reach a stabilized pumping condition.

   If the recharge rate of the well is very low, alternative purging techniques should be used, which will vary based on the well construction and screen position. For wells screened across the water table, the well should be pumped dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should be pumped until a stabilized level (which may be below the maximum displacement goal of 0.3 feet) can be maintained and monitoring for stabilization of field indicator parameters can commence. If a lower stabilization level cannot be maintained, the well should be pumped until the drawdown is at a level slightly higher than the bentonite seal above the well screen. Sampling should commence after one well volume has been removed and the well has recovered sufficiently to permit collection of samples.

   During purging, monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, pH, etc.) every 3 to 5 minutes (or as appropriate). Field indicator parameters will be measured using a flow-through analytical cell or a clean container such as a glass beaker. Record field indicator parameters on the groundwater sampling log. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain within 3%, ORP readings remain within ± 10 mV and pH remains within 0.1 units for three consecutive readings collected at 3- to 5-minute intervals (or other appropriate interval, alternate stabilization goals may exist in different geographic regions, consult the site-specific Work Plan for stabilization criteria). If the field indicator parameters do not stabilize within 1 hour of the start of purging, but the groundwater turbidity is below the goal of 50 NTU and the values for all other parameters are within 10%, the well can be sampled. If the parameters have stabilized but the turbidity is not in the range of the 50 NTU goal, the pump flow rate should be decreased to a minimum rate of 100 mL/min to reduce turbidity levels as low as possible. Dissolved oxygen is extremely susceptible to various external influences (including temperature or the presence of bubbles on the DO meter); care should be taken to minimize the agitation or other disturbance of water within the flow-through cell while collecting these measurements. If air bubbles are present on the DO probe or in the discharge tubing, remove them before taking a measurement. If dissolved oxygen values are not within acceptable range for the temperature of groundwater (Attachment 1), then again check for and remove air bubbles on probe before re-measuring. If the dissolved oxygen value is 0.00 or less, then the meter should be serviced and re-calibrated. If the dissolved oxygen values are above possible results, then the meter should be serviced and re-calibrated.

During extreme weather conditions, stabilization of field indicator parameters may be difficult to obtain. Modifications to the sampling procedures to alleviate these conditions (e.g., measuring the water temperature in the well adjacent to the pump intake) will be documented in the field notes. If other field conditions exist that preclude stabilization of certain parameters, an explanation of why the parameters did not stabilize will also be documented in the field logbook.

7. Complete the sample label(s) and cover the label(s) with clear packing tape to secure the label onto the container.

8. After the indicator parameters have stabilized, collect groundwater samples by diverting flow out of the unfiltered discharge tubing into the appropriate labeled sample container. If a flow-through analytical cell is being used to measure field parameters, the flow-through cell should be disconnected after stabilization of the field indicator parameters and prior to groundwater sample collection. Under no circumstances should analytical samples be collected from the discharge of the flow-through cell. When the container is full, tightly screw on the cap. Samples should be collected in the following order: VOCs, TOC, SVOCs, metals and cyanide, and others (or other order as defined in the site-specific Work Plan).

9. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Install an in-line, disposable 0.45-micron particle filter on the discharge tubing after the appropriate unfiltered groundwater sample has been collected. Continue to run the pump until an initial volume of “flush” water has been run through the filter in accordance with the manufacturer’s directions (generally 100 to 300 mL). Collect filtered groundwater sample by diverting flow

out of the filter into the appropriately labeled sample container. When the container is full, tightly screw on the cap.

10. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

11. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the stabilized field indicator parameters as measured during the final reading during purging (Attachment 2 – Example Sampling Log).

12. Turn off the pump and air compressor or close the gas cylinder valve if using a bladder pump set-up. Slowly remove the pump, tubing, lines, and safety cable from the well. Do not allow the tubing or lines to touch the ground or any other surfaces which could contaminate them. .

13. If tubing is to be dedicated to a well, it should be folded to a length that will allow the well to be capped and also facilitate retrieval of the tubing during later sampling events. A length of rope or string should be used to tie the tubing to the well cap. Alternatively, if tubing and safety line are to be saved and reused for sampling the well at a later date they may be coiled neatly and placed in a clean plastic bag that is clearly labeled with the well ID. Make sure the bag is tightly sealed before placing it in storage.

14. Secure the well and properly dispose of personal protective equipment (PPE) and disposable equipment.

15. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

16. Complete decontamination procedures for flow-through analytical cell and submersible or bladder pump, as appropriate.

17. At the end of the day, perform calibration check of field instruments.

If it is not technically feasible to use the low-flow sampling method, purging and sampling of monitoring wells may be conducted using the bailer method as outlined below:

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

2. Place plastic sheeting around the well.

3. Clean sampling equipment.

4. Open the well cover while standing upwind of the well. Remove well cap and place on the plastic sheeting. 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 log. 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 breathing zone reading is less than 5 PID units, proceed. If the PID reading in the breathing zone 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 appropriate respiratory protection in accordance with the requirements of the HASP. Record all PID readings. For wells that are part of the regular weekly monitoring program and prior PID measurements have not resulted in a breathing zone reading above 5 PID units, PID measurements will be taken monthly.

5. Measure the depth to water and determine depth of well by examining drilling log data or by direct measurement. Calculate the volume of water in the well (in gallons) by using the length of the water column (in feet), multiplying by 0.163 for a 2-inch well or by 0.653 for a 4-inch well. For other well diameters, use the formula:

   Volume (in gallons) = π TIMES well radius (in feet) squared TIMES length of water column (in feet) TIMES 7.481 (gallons per cubic foot)

6. Measure a length of rope or twine at least 10 feet greater than the total depth of the well. Secure one end of the rope to the well casing and secure the other end to the bailer. Test the knots and make sure the rope will not loosen. Check bailers so that all parts are intact and will not be lost in the well.

7. Lower bailer into well and remove one well volume of water. Contain all water in appropriate containers.

8. Monitor the field indicator parameters (e.g., turbidity, temperature, specific conductance, and pH). Measure field indicator parameters using a clean container such as a glass beaker or sampling cups provided with the instrument. Record field indicator parameters on the groundwater sampling log.

9. Repeat Steps 7 and 8 until three or four well volumes have been removed. Examine the field indicator parameter data to determine if the parameters have stabilized. The well is considered stabilized and ready for sample collection when turbidity values remain within 10% (or within 1 NTU if the turbidity reading is less than 10 NTU), the specific conductance and temperature values remain

within 3%, and pH remains within 0.1 units for three consecutive readings collected once per well volume removed.

10. If the field indicator parameters have not stabilized, remove a maximum of five well volumes prior to sample collection. Alternatively, five well volumes may be removed without measuring the field indicator parameters.

11. If the recharge rate of the well is very low, wells screened across the water table may be bailed dry and sampling should commence as soon as the volume in the well has recovered sufficiently to permit collection of samples. For wells screened entirely below the water table, the well should only be bailed down to a level slightly higher than the bentonite seal above the well screen. The well should not be bailed completely dry, to maintain the integrity of the seal. Sampling should commence as soon as the well volume has recovered sufficiently to permit sample collection.

12. Following purging, allow water level in well to recharge to a sufficient level to permit sample collection.

13. Complete the sample label and cover the label with clear packing tape to secure the label onto the container.

14. Slowly lower the bailer into the screened portion of the well and carefully retrieve a filled bailer from the well causing minimal disturbance to the water and any sediment in the well.

15. The sample collection order (as appropriate) will be as follows:

    a. VOCs;

    b TOC;

    c. SVOCs;

    d. metals and cyanide; and

    e. others.

16. When sampling for volatiles, collect water samples directly from the bailer into 40-mL vials with Teflon®-lined septa.

17. For other analytical samples, remove the cap from the large glass mixing container and slowly empty the bailer into the large glass mixing container. The

sample for dissolved metals and/or filtered PCBs should either be placed directly from the bailer into a pressure filter apparatus or pumped directly from the bailer with a peristaltic pump, through an in-line filter, into the pre-preserved sample bottle.

18. Continue collecting samples until the mixing container contains a sufficient volume for all laboratory samples.

19. Mix the entire sample volume with the Teflon® stirring rod and transfer the appropriate volume into the laboratory jar(s). Secure the sample jar cap(s) tightly.

20. If sampling for total and filtered metals and/or PCBs, a filtered and unfiltered sample will be collected. Sample filtration for the filtered sample will be performed in the field using a peristaltic pump prior to preservation. Install new medical-grade silicone tubing in the pump head. Place new Teflon® tubing into the sample mixing container and attach to the intake side of pump tubing. Attach (clamp) a new 0.45-micron filter (note the filter flow direction). Turn the pump on and dispense the filtered liquid directly into the laboratory sample bottles.

21. Secure with packing material and store at 4°C in an insulated transport container provided by the laboratory.

22. After sample containers have been filled, remove one additional volume of groundwater. Measure the pH, temperature, turbidity, and conductivity. Record on the groundwater sampling log or bound field logbook the time sampling procedures were completed, any pertinent observations of the sample (e.g., physical appearance, and the presence or lack of odors or sheens), and the values of the field indicator parameters.

23. Remove bailer from well, secure well, and properly dispose of PPE and disposable equipment.

24. If a bailer is to be dedicated to a well, it should be secured inside the well above the water table, if possible. Dedicated bailers should be tied to the well cap so that inadvertent loss of the bailer will not occur when the well is opened.

25. Complete the procedures for packaging, shipping, and handling with associated chain-of-custody.

VII. Waste Management

Materials generated during groundwater sampling activities, including disposable equipment, will be placed in appropriate containers. Containerized waste will be disposed of by the client consistent with the procedures identified in the HASP.

VIII. Data Recording and Management

Initial field logs and chain-of-custody records will be transmitted to the ARCADIS PM at the end of each day unless otherwise directed by the PM. The groundwater team leader retains copies of the groundwater sampling logs.

IX. Quality Assurance

In addition to the quality control samples to be collected in accordance with this SOP, the following quality control procedures should be observed in the field:

- Collect samples from monitoring wells in order of increasing concentration, to the extent known based on review of historical site information if available.
- Equipment blanks should include the pump and tubing (if using disposable tubing) or the pump only (if using tubing dedicated to each well).
- Collect equipment blanks after wells with higher concentrations (if known) have been sampled.
- Operate all monitoring instrumentation in accordance with manufacturer's instructions and calibration procedures. Calibrate instruments at the beginning of each day and verify the calibration at the end of each day. Record all calibration activities in the field notebook.
- Clean all groundwater sampling equipment prior to use in the first well and after each subsequent well using procedures for equipment decontamination.

X. References

United States Environmental Protection Agency (USEPA). 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (September 1986).

USEPA Region II. 1998. *Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling*.

USEPA. 1991. Handbook Groundwater, Volume II Methodology, Office of Research and Development, Washington, DC. USEPN62S, /6-90/016b (July, 1991).

U.S. Geological Survey (USGS). 1977. National Handbook of Recommended Methods for Water-Data Acquisition: USGS Office of Water Data Coordination. Reston, Virginia.

Attachment 1

Groundwater Sampling Log

Attachment 2

Oxygen Solubility in Fresh Water

Temperature (degrees C)	**Dissolved Oxygen** (mg/L)
0	14.6
1	14.19
2	13.81
3	13.44
4	13.09
5	12.75
6	12.43
7	12.12
8	11.83
9	11.55
10	11.27
11	11.01
12	10.76
13	10.52
14	10.29
15	10.07
16	9.85
17	9.65
18	9.45
19	9.26
20	9.07
21	8.9
22	8.72
23	8.56
24	8.4
25	8.24
26	8.09
27	7.95
28	7.81
29	7.67
30	7.54
31	7.41
32	7.28
33	7.16
34	7.05
35	6.93

Reference: Vesilind, P.A., *Introduction to Environmental Engineering*, PWS Publishing Company, Boston, 468 pages (1996).

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Investigation-Derived Waste Handling and Storage

Rev. #: 2

Rev Date: March 6, 2009

Approval Signatures

Prepared by: Andrew Kamik Date: 3/6/09

Reviewed by: Liz Marsh Date: 3/6/09
(Technical Expert)

I. Scope and Application

The objective of this Standard Operating Procedure (SOP) is to describe the procedures to manage investigation-derived wastes (IDW), both hazardous and non-hazardous, generated during site activities, which may include, but are not limited to - drilling, trenching/excavation, construction, demolition, monitoring well sampling, soil sampling, decontamination and remediation. Please note that this SOP is intended for materials that have been deemed a solid waste as defined by 40 CFR § 261.2 (which may includes liquids, solids, and sludges). In some cases, field determinations will be made based on field screening or previous data that materials are not considered a solid waste. IDW may include soil, groundwater, drilling fluids, decontamination liquids, personal protective equipment (PPE), sorbent materials, construction and demolition debris, and disposable sampling materials that may have come in contact with potentially impacted materials. IDW will be collected and staged at the point of generation. Quantities small enough to be containerized in 55-gallon drums will be taken to a designated temporary storage area (discussed in further detail under Drum Storage) onsite pending characterization and disposal. Waste materials will be analyzed for constituents of concern to evaluate proper disposal methods. PPE and disposable sampling equipment will be placed in DOT-approved drums prior to disposal and typically does not require laboratory analysis. This SOP describes the necessary equipment, field procedures, materials, regulatory references, and documentation procedures necessary for proper handling and storage of IDW up to the time it is properly disposed. The procedures for handling IDW are based on the United States Environmental Protection Agency's Guide to Management of Investigation Derived Wastes (USEPA, 1992). IDW is assumed to be contaminated with the site constituents of concern (COCs) until analytical evidence indicates otherwise. IDW will be managed to ensure the protection of human health and the environment and will comply with all applicable or relevant and appropriate requirements (ARAR). The following Laws and Regulations on Hazardous Waste Management are potential ARAR for this site.

State Laws and Regulations

- To Be Determined Based on Location of Site and Location of Treatment, Storage, and/or Disposal Facility (TSDF) to be utilized

Federal Laws and Regulations

- Resource Conservation and Recovery Act (RCRA) 42 USC § 6901-6987

- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) 42 USC § 9601-9675

- Superfund Amendments and Reauthorization Act (SARA)
- Department of Transportation (DOT) Hazardous Materials Transportation

Pending characterization, IDW will be stored appropriately within each area of contamination (AOC). Under RCRA, "storage" is defined as the holding of hazardous waste for a temporary period, at the end of which the hazardous waste is treated, disposed of, or stored elsewhere" (40 CFR § 260.10). The onsite waste staging area will be in a secure and controlled area. Waste characterization can either be based on generator knowledge, such as using materials safety data sheets (MSDS'), or can be based upon analytical results. The laboratory used for waste characterization analysis must have the appropriate state and federal certifications and be approved by ARCADIS and Client. IDW will be classified as RCRA hazardous or non-regulated under RCRA based on the waste characterization.

If IDW is characterized as RCRA hazardous waste, RCRA and DOT requirements must be followed for packaging, labeling, transporting, storing, and record keeping as described in 40 CFR § 262 and 49 CFR § 171-178. Wastes judged to potentially meet the criteria for hazardous wastes shall be stored in DOT approved packaging. Waste material classified as RCRA non-hazardous may be handled and disposed of as an industrial waste.

Liquid wastes judged to potentially meet the criteria for hazardous wastes shall be stored in DOT approved 55 gallon drums or other approved containers that are compatible with the type of material stored therein. Solid materials deemed to potentially meet hazardous criteria will be drummed where practicable. Large quantities of potentially hazardous solid materials must be containerized (such as in a roll-off box) for up to a maximum of 90 or 180 days as described in the Excavated Solids Section. Waste material classified as non-hazardous may be handled and disposed of as an industrial waste and is not subject to the 90-day or 180-day on-site storage limitation.

This is a standard (i.e., typically applicable) operating procedure which may be varied or changed as required, dependent upon site conditions, equipment limitations, or limitations imposed by the procedure. The ultimate procedure employed will be documented in the project work plans or reports. If changes to the sampling procedures are required due to unanticipated field conditions, the changes will be discussed with the Project Manager and Client as soon as practicable and documented in the report.

II. Personnel Qualifications

ARCADIS field sampling personnel will have current health and safety training including 40-hour HAZWOPER training, site supervisor training, site-specific training, first aid, and CPR, as needed. ARCADIS personnel may sign manifests on a case-to-case basis for clients, provided the appropriate agreement is in place between ARCADIS and the client documenting that ARCADIS is not the generator, but is acting as authorized representative for the generator. ARCADIS personnel who sign hazardous waste manifests will have the current DOT hazardous materials transportation training according to 49 CFR § 172.704. ARCADIS field personnel will also comply with client-specific training such as LPS. In addition, ARCADIS field sampling personnel will be versed in the relevant SOPs and posses the required skills and experience necessary to successfully complete the desired field work.

III. Equipment List

The following materials, as required, shall be available for IDW handling and storage:

Appropriate personal protective equipment as specified in the Site Health and Safety Plan

- 55-gallon steel drums, DOT 1A2 or equivalent
- ¾ -inch socket wrench
- Hammer
- Leather gloves
- Drum dolly
- Appropriate drum labels (outdoor waterproof self adhesive)
- Polyethylene storage tank
- Appropriate labeling, packing, chain-of-custody forms, and shipping materials as specified in the *Chain-of-Custody* SOP and *Field Sampling Handling, Packing, and Shipping* SOP.
- Indelible ink and/or permanent marking pens
- Plastic sheeting

- Appropriate sample containers, labels, and forms
- Stainless-steel bucket auger
- Stainless steel spatula or knife
- Stainless steel hand spade
- Stainless steel scoop
- Digital camera
- Field logbook.

IV. Cautions

- Filled drums can be very heavy, always use appropriate moving techniques and equipment.
- Similar media will be stored in the same drums to aid in sample analysis and disposal.
- Drum lids must be secured to prevent rainwater from entering the drums.
- Drums containing solid material may not contain any free liquids.
- Waste containers stored for extended periods of time may be subject to deterioration. Drum over packs may be used as secondary containment.
- All drums must be in good condition to prevent potential leakage and facilitate subsequent disposal. Inspect the drums for dents and rust, and verify the drum has a secure lid prior to use.

V. Health and Safety Considerations

- Appropriate personal protective equipment must be worn by all field personnel within the designated work area.
- Air monitoring may be required during certain field activities as required in the Site Health and Safety Plan.

- If excavating in potentially hazardous areas is possible, contingency plans should be developed to address the potential for encountering gross contamination or non-aqueous phase liquids.

- ARCADIS field personnel will be familiar and compliant with Client-specific health and safety requirements such as Chevron's hand safety policy including the prohibition of fixed and/or folding blade knives.

VI. Procedure

Waste storage and handling procedures to be used depend upon the type of generated waste. For this reason, IDW should be stored in a secure location onsite in separate 55-gallon storage drums, solids can be stockpiled onsite (if non-hazardous), and purge water may be stored in polyethylene tanks. Waste materials such as broken sample bottles or equipment containers and wrappings will be stored in 55-gallon drums unless they were not in contact with sample media.

Management of IDW

Minimization of IDW should be considered by the Project Manager during all phases of the project. Site managers may want to consider techniques such as replacing solvent-based cleaners with aqueous-based cleaners for decontamination of equipment, reuse of equipment (where it can be decontaminated), limitation of traffic between exclusion and support zones, and drilling methods and sampling techniques that generate little waste. Alternative drilling and subsurface sampling methods may include the use of small diameter boreholes, as well as borehole testing methods such as a core penetrometer or direct push technique instead of coring (EPA, 1993).

Drum Storage

Drums containing hazardous waste shall be stored in accordance with the requirements of 40 CFR 265 Subpart I (for containers) and 265 Subpart DD (for containment buildings). All 55-gallon drums will be stored at a secure, centralized on-site location that is readily accessible for vehicular pick-up. Drums confirmed as, or believed to contain hazardous waste will be stored over an impervious surface provided with secondary containment. The storage location will, for drums containing liquid, have a containment system that can contain at least the larger of 10% of the aggregate volume of staged materials or 100% of the volume of the largest container. Drums will be closed during storage and be in good condition in accordance with the Guide to Management of Investigation-Derived Wastes (USEPA, 1992).

Hazardous Waste Determination

Waste material must be characterized to determine if it meets any of the federal definitions of hazardous waste as required by 40 CFR § 262.11. If the waste does not meet any of the federal definitions, it must then be established if any state-specific hazardous waste criteria exist/apply.

Generator Status

Once hazardous waste determination has been made, the generator status will be determined. Large quantity generators (LQG) are generators who generate more than 1,000 kilograms of hazardous waste in a calendar month. Small quantity generators (SQG) of hazardous waste are generators who generate greater than 100 kilograms but less than 1,000 kilograms of hazardous waste in a calendar month. Conditionally exempt small quantity generators (CESQG) are generators who generate less than 100 kilograms of hazardous waste per month. Please note that a generator status may change from month to month and that a notice of this change is usually required by the generator's state agency.

Accumulation Time for Hazardous Waste

A LQG may accumulate hazardous waste on site for 90 days or less without a permit and without having interim status provided that such accumulation is in compliance with specifications in 40 CFR § 262.34. A SQG may accumulate hazardous waste on site for 180 days or less without a permit or without having interim status subject to the requirements of 40 CFR § 262.34(d). CESQG requirements are found in 40 CFR § 261.5. **NOTE**: The CESQG and SQG provisions of 40 CFR § 261.5, 262.20(e), 262.42(b) and 262.44 may not be recognized by some states (e.g. Rhode Island). **State-specific regulations must be reviewed and understood prior to the generation of hazardous waste.**

<u>Satellite Accumulation of Hazardous Waste</u>

Satellite accumulation (SAA) shall mean the accumulation of as much as fifty-five (55) gallons of hazardous waste, or the accumulation of as much as one quart of acutely hazardous waste, in containers at or near any point of generation where the waste initially accumulates, which is under the control of the operator of the process generating the waste, without a permit or interim status and without complying with the requirements of 40 CFR § 262.34(a) and without any storage time limit, provided that the generator complies with 40 CFR § 262.34(c)(1)(i).

Once more than 55 gallons of hazardous waste accumulates in SAA, the generator has three days to move this waste into storage.

Storage recommendations for hazardous waste include:

- Ignitable Hazardous wastes must be >50 feet from the property line per 40 CFR § 265.176 (LQG generators only).
- Hazardous waste must be stored on a concrete slab (asphalt is acceptable if there are no free liquids in the waste) per 40 CFR § 265.176.
- Drainage must be directed away from the accumulation area.
- Area must be properly vented.
- Area must be secure.

Drum/Container Labeling

Drums will be labeled on both the side and lid of the drum using a permanent marking pen. Old drum labels must be removed to the extent possible, descriptions crossed out should any information remain, and new labels affixed on top of the old labels. Other containers used to store various types of waste (polyethylene tanks, roll-off boxes, end-dump trailers, etc.) will be labeled with an appropriate "Waste Container" or “Testing in Progress” label pending characterization. Drums and containers will be labeled as follows:

- Appropriate waste characterization label (Testing In Progress, Hazardous, or Non-Hazardous)
- Waste generator's name (e.g., client name)
- Project name
- Name and telephone number of ARCADIS project manager
- Composition of contents (e.g., used oil, acetone 40%, toluene 60%)
- Media (e.g., solid, liquid)
- Accumulation start date

- Drum number of total drums as reconciled with the Drum Inventory maintained in the field log book.

IDW containers will remain closed except when adding or removing waste. Immediately upon beginning to place waste into the drum/container, a “Waste Container” or “Testing in Progress” label will be filled out to include the information specified above, and affixed to the container. Once the contents of the container are identified as either non-hazardous or hazardous, the following additional labels will be applied. Containers with waste determined to be non-hazardous will be labeled with a green and white "Non-Hazardous Waste" label over the "Waste Container" label. Containers with waste determined to be hazardous will be stored in an onsite storage area and will be labeled with the "Hazardous Waste" label and affixed over the "Waste Container" label. The ACCUMULATION DATE for the hazardous waste is the date the waste is first placed in the container and is the same date as the date on the "Waste Container" label. DOT hazardous class labels must be applied to all hazardous waste containers for shipment offsite to an approved disposal or recycling facility. In addition a DOT proper shipping name shall be included on the hazardous waste label. The transporter should be equipped with the appropriate DOT placards. However, placarding or offering placards to the initial transporter is the responsibility of the generator per 40 CFR § 262.33.

Inspections and Documentation

All IDW will be documented as generated on a Drum Inventory Log maintained in the field log book. The Drum Inventory will record the generation date, type, quantity, matrix and origin (e.g. Boring-1, Test Pit 3, etc) of materials in every drum, as well as a unique identification number for each drum. The drum inventory will be used during drum pickup to assist with labeling of drums. The drum storage area and any other areas of temporarily staged waste, such as soil/debris piles, will be inspected weekly. The weekly inspections will be recorded in the field notebook or on a Weekly Inspection Log. Digital photographs will be taken upon the initial generation and drumming/staging of waste, and final labeling after characterization to document compliance with labeling and storage protocols, and condition of the container. Evidence of damage, tampering or other discrepancy should be documented photographically.

Emergency Response and Notifications

Specific procedures for responding to site emergencies will be detailed in the HASP. If the generator is designated as a LQG, a Contingency Plan will need to be prepared to include emergency response and notification procedures per 40 CFR § 265 Subpart D. In the event of a fire, explosion, or other release which could threaten human health outside of the site or when Client or ARCADIS has knowledge of a spill that has reached surface water, Client or ARCADIS must immediately notify the National Response Center (800-424-8802) in accordance with 40 CFR § 262.34. Other notifications to state agencies may also be necessary.

Drilling Soil Cuttings and Muds

Soil cuttings are solid to semi-solid soils generated during trenching activities, subsurface soil sampling, or installation of monitoring wells. Depending on the drilling method, drilling fluids known as "muds" may be used to remove soil cuttings. Drilling fluids flushed from the borehole must be directed into a settling section of a mud pit. This allows reuse of the decanted fluids after removal of the settled sediments. Soil cuttings will be labeled and stored in 55-gallon drums with bolt-sealed lids.

Excavated Solids

Excavated solids may include, but are not limited to soil, fill and construction and demolition debris. Excavated solids may be temporarily stockpiled onsite as long as the material is a RCRA non-hazardous waste and the solids will be treated onsite pursuant to a certified, authorized, or permitted treatment method, or properly disposed off-site. Stockpiled materials characterized as hazardous must be immediately containerized and removed from the site within 90 days of generation (except for soils using satellite accumulation). Excavated solids should be stockpiled and maintained in a secure area onsite. At a minimum, the floor of the stockpile area will be covered with a 20-mil high density polyethylene liner that is supported by a foundation or at least a 60-mil high density polyethylene liner that is not supported by a foundation. The excavated material will not contain free liquids. The owner/operator will provide controls for windblown dispersion, run-on control, and precipitation runoff. The run-on control system will prevent flow onto the active portion of the pile during peak discharge from at least a 25-year storm and the run-off management system will collect and control at least the water volume resulting from a 24-hour, 25-year storm (EPA, 1992). Additionally, the stockpile area will be inspected on a weekly basis and after storm events. Individual states may require that the stockpile be inspected/certified by a licensed professional engineer. Stockpiled material will be covered with a 6-mil polyvinyl chloride (PVC) liner. The stockpile cover will be secured in place with appropriate material (concrete blocks, weights, etc.) to prevent the movement of the cover. Excavated solids may also be placed in roll off containers and covered with a 6-mil PVC liner pending results for waste characterization.

Decontamination Solutions

Decontamination solutions are generated during the decontamination of personal protective equipment and sampling equipment. Decontamination solutions may range from detergents, organic solvents and acids used to decontaminate small field sampling equipment to steam cleaning rinsate used to wash heavy field equipment. These solutions are to be labeled and stored in 55-gallon drums with bolt-sealed lids.

Disposable Equipment

Disposable equipment includes personal protective equipment (tyvek coveralls, gloves, booties and APR cartridges) and disposable sampling equipment such as trowels or disposable bailers. If the media sampled exhibits hazardous characteristics per results of waste characterization sampling, disposable equipment will also be disposed of as a hazardous waste. These materials will be stored onsite in labeled 55-gallon drums pending analytical results for waste characterization.

Purge Water

Purge water includes groundwater generated during well development, groundwater sampling, or aquifer testing. The volume of groundwater generated will dictate the appropriate storage procedure. Monitoring well development and groundwater sampling may generate three well volumes of groundwater or more. This volume will be stored in labeled 55-gallon drums. Aquifer tests may generate significantly greater volumes of groundwater depending on the well yield and the duration of the test. Therefore, large-volume portable polyethylene tanks will be considered for temporary storage pending groundwater-waste characterization.

Purged Water Storage Tank Decontamination and Removal

The following procedures will be used for inspection, cleaning, and offsite removal of storage tanks used for temporary storage of purge water. These procedures are intended to be used for rented portable tanks such as Baker Tanks or Rain for Rent containers. Storage tanks will be made of inert polyethylene materials.

The major steps for preparing a rented tank for return to a vendor include characterizing the purge water, disposing of the purge water, decontaminating the tank, final tank inspection, and mobilization. Decontamination and inspection procedures are describe in further detail below.

- Tank Cleaning: Most vendors require that tanks be free of any sediment and water before returning, a professional cleaning service may be required. Each specific vendor should be consulted concerning specific requirements for returning tanks.

- Tank Inspection: After emptying the tank, purged water storage tanks should be inspected for debris, chemical staining, and physical damage. The vendors require that tanks be returned in the original condition (i.e., free of sediment, staining and no physical damage).

VII. Waste Characterization Sampling and Shipping

Soil/Solids Characterization

Waste characterization will be conducted in accordance with waste hauler, waste handling facility, and state/federal requirements. In general, RCRA hazardous wastes are those solid wastes determined by a Toxicity Characteristic Leaching Procedure (TCLP) test or to contain levels of certain toxic metals, pesticides, or other organic chemicals above specific federally regulated thresholds. If the one or more of 40 toxic compounds listed in Table I of 40 CFR § 261.24 are detected in the sample at levels above the maximum unregulated concentrations, the waste must be characterized as a toxic hazardous waste. Wastes can also be considered “listed” hazardous waste depending on site-specific processes.

Composite soil samples will be collected at a frequency of one sample per 10 cubic yard basis for stockpiled soil or one per 55-gallon drum for containerized. A four point composite sample will be collected per 10 cubic yards of stockpiled material and for each drum. Sample and composite frequencies may be adjusted in accordance with the waste handling facility’s requirements. Waste characterization samples may be analyzed for the TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis.

Wastewater Characterization

Waste characterization will be conducted in accordance with the requirements of the waste hauler, waste handling facility, and state/federal governments. In general, purge water should be analyzed by methods appropriate for the known contaminants, if any, that have been historically detected in the monitoring wells. Samples will be collected and analyzed in accordance with the requirements of the waste disposal facility.

Wastewater characterization samples may be analyzed for TCLP volatile organic compounds (VOCs), TCLP semi-volatile organic compounds (SVOCs), TCLP RCRA metals, and polychlorinated biphenyls, as well as corrosivity (pH), reactivity and flammability (flashpoint). Additional samples may be collected and analyzed by the laboratory on a contingency basis.

Sample Handling and Shipping

All samples will be appropriately labeled, packed, and shipped, and the chain-of-custody will be filled out in accordance with the Chain-of-Custody SOP and Field Sampling Handling, Packing, and Shipping SOP and Hazardous Materials Packaging and Shipping SOP.

It should be noted that additional training is required for packaging and shipping of hazardous and/or dangerous materials. Please reference the following ARCADIS intranet team page for more information: http://team/sites/hazmat/default.aspx.

Preparing Waste Shipment Documentation (Hazardous and Non-Hazardous)

Waste profiles will be prepared by the ARCADIS PM and forwarded, along with laboratory analytical data to the Client PM for approval/signature. The Client PM will then return the profile to ARCADIS who will then forward to the waste removal contractor for preparation of a manifest. The manifest will be reviewed by ARCADIS prior to forwarding to the Client PM for approval. Upon approval of the manifest, the Client PM will return the original signed manifest directly to the waste contractor or to the ARCADIS PM for forwarding to the waste contractor.

Final drum labeling and pickup will be supervised by an ARCADIS representative who is experienced with waste labeling procedures. The ARCADIS representative will have a copy of the drum inventory maintained in the field book and will reconcile the drum inventory with the profile numbers on the labels and on the manifest. Different profile numbers will be generated for different matrices or materials in the drums. For example, the profile number for drill cuttings will be different than the profile number for purge water. **When there are multiple profiles it is critical that the proper label, with the profile number appropriate to a specific material be affixed to the proper drums.** A copy of the ARCADIS drum inventory will be provided to the waste transporter during drum pickup and to the facility receiving the waste.

VIII. Data Recording and Management

Waste characterization sample handling, packing, and shipping procedures will be documented in accordance with the *Quality Assurance Project Plan*, if one exists. Copies of the chains-of-custody forms will be maintained in the project file.

Following waste characterization, IDW containers will be re-labeled with the appropriate waste hazardous or non-hazardous waste labels and the client will initiate disposal at the appropriate waste disposal facility.

IX. Quality Assurance

The chain-of-custody and sample labels for waste characterization samples will be filled out in accordance with the *Quality Assurance Project Plan*.

X. References

United States Environmental Protection Agency (USEPA). 1992. Guide to Management of Investigation-Derived Wastes. Office of Remedial and Emergency Response. Hazardous Site Control Division. January 1992.

USEPA. 1991. *Guide to Discharging CERCLA Aqueous Wastes to Publicly Owned Treatment Works (POTWs)*. Office of Remedial and Emergency Response. Hazardous Site Control Division 0S-220W. March 1991.

1. Location and Sample Nomenclature (Revision 1.0)

Location: A sample designation system will be used to identify samples for laboratory analyses. A list of identifiers used for each sample will be maintained in the project logbook by the ARCADIS Field Team Leader.

Each location will have a unique sample location name. Since soil borings and monitoring wells have previously been completed at the site, investigative locations completed by ARCADIS will start with A, followed by a one to two letter designation to describe the type of sample. A four digit number and up to two letter designation will then follow to provide a unique identifier for each sample location. The first set of two numbers will designate the Focus Area of the boring, and the second set of two numbers will give the sequential designation. For delineation locations, the letters represent the direction from the original boring location. The following are sample prefex designations that will be employed at TCAP to identify sample locations.

ASB — Soil Boring

AMW- Monitoring Well

AHA – Hand Auger Boring

ASD – Sediment Location

AS – Surface Soil Location

AWS -Wipe Sample Location

ST – Sheen Test

Samples: Each sample that is collected will be designated by a unique sample identification number. The first part of the identifier will correspond to the location and the second part of the sample by the sample depth (if applicable) and the sample date. For example, a soil sample collected within Focus Area 1 from soil boring 1 from 4-6' on July 25, 2013 would be labeled: ASB-0101_4-6 (20130725). A water sample collected from this location would be referenced by ASB-0101_7-12 (20130725). The screened interval of the temporary well will also be noted in the field book. Repetitive sampling points, such as samples collected from groundwater monitoring wells, will be suffixed by the date collected.

Equipment blanks and trip blanks will be unique and identified by their associated prefix numbered sequentially (to differentiate between multiple samples collected on the same date), and suffixed by the date. The ARCADIS sampler will note each equipment blank and its corresponding sampling equipment in the field book.

EB - Equipment Blank	Ex. EB (20130725)
TB- Trip Blank	Ex. TB (20130725)

In the event that one or more EB or TB samples are collected on the same date, a number will be suffixed after the sample name. Ex. EB-01 (20130725)

Field duplicates will be identified with a unique sample identification number; such that the laboratory will not be aware that the sample is a duplicate (duplicates will be numbered sequentially). The ARCADIS Field Team Leader will note in the logbook where the duplicate samples were collected so this information will be available when the laboratory data is reviewed

DUP – Duplicate Sample Ex. DUP-001

Unlike the other quality assurance samples, MS/MSD samples are not separate samples; therefore, they are not assigned unique sample numbers. The only difference between a MS/MSD sample and a standard sample is that additional sample volume is collected at the location where the MS/MSD sample is obtained. These samples will be identified by adding a "MS" and "MSD" to the identifier of the sample where the MS/MSD sample is collected.