

June 23, 2011
File No. 05.0043654.00-C

Via E-Mail and U.S. Mail



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Ms. Barbara Morin
Rhode Island Department of Environmental Management
Office of Air Resources
235 Promenade Street
Providence, Rhode Island 02908

Re: Evaluation of Applicability of Air Pollution Control Regulation No. 9
Proposed Above Ground Former Processing Pipe Removal
Former Tidewater Facility
Pawtucket, Rhode Island
RIDEM Case No. 95-022

Dear Ms. Morin:

GZA GeoEnvironmental, Inc. (GZA) has prepared this letter on behalf of The Narragansett Electric Company d/b/a National Grid (National Grid) for the purpose of documenting our evaluation of the applicability of RIDEM's Air Pollution Control Permits (Regulation No. 9) to the upcoming activities related to the removal of a former process pipe at the Former Tidewater Facility in Pawtucket, Rhode Island ("the Site"). As described further herein, these activities will involve: (1) the removal and off-Site disposal of a section of above grade process piping; and (2) the removal and off-Site disposal of a limited volume of impacted soil located proximate to the process pipe. These proposed activities are further summarized in a *Short Term Response Action Plan* (STRAP) submitted to the Department in October 2010 (Revised January 2011).

Consistent with the analysis performed related to the natural gas regulator station upgrade project (see our submittal dated April 19, 2011), the applicability of Regulation No. 9 was evaluated based on potential volatile emission rate calculation/modeling performed consistent with published United States Environmental Protection Agency (EPA) guidance. This emission rate model was developed for the specific activities to be performed during this effort. As described further herein and in the attached, the results of this modeling indicates that these activities do not have the potential to increase emissions by greater than the minimum quantity as specified in Appendix A of APC Regulation No. 9 and therefore a minor source permit is not required for this activity.

BACKGROUND

The above ground former process pipe is located on the eastern portion of the Former Gas Plant Area (FGPA) of the Site, proximate to the Seekonk River, downgradient of former manufactured gas plant (MGP) features at the Site as shown in Figure 1 – *Site Plan*. Certain sections of this pipe were noted to be in disrepair and coal-tar like materials were observed on the ground surface and river embankment immediately beneath certain portions of the piping. The pipe is suspected of contributing to the observation of intermittent sheens to the Seekonk River. The residual material



encountered within the pipe was sampled and analyzed by GZA in September of 2010. The characteristics of the chromatogram for the sample, as summarized in Table 1A, indicated the presence of a petroleum product in the boiling range of coal tar oil with a total petroleum hydrocarbon (TPH) concentration of 1,200 mg/kg. Results of the analytical testing of the surface soils in this area, as summarized in Table 1B, indicate the presence of arsenic and certain PAHs at concentrations above the Industrial/Commercial Direct Exposure Criteria (I/CDEC). In addition, certain volatile organic compounds were detected at low levels. Groundwater and/or perched groundwater are unlikely to be encountered during the proposed surface soil removal given the limited depth of the removal efforts (± 2 to 4 feet below ground surface).

PROPOSED ACTIVITIES

As noted, a STRAP was prepared and submitted to the Office of Waste Management in October 2010 (later revised in January 2011) to address the above ground portion of the former steel process pipe on the FGPA. The following provides a summary of the planned response activities. For specific details regarding the proposed pipe removal and associated earthwork activities, please refer to the STRAP.

The above ground sections of pipe will be removed and disposed off-Site at a licensed disposal facility; the underground section of pipe on the southern end will be capped above grade with a blind flange. An approximately 5 square-foot area of coal tar-impacted surface material observed in the vicinity of the damaged pipe will be removed, as shown in Figure 2 *Proposed Removal Plan*. The depth of excavation is expected to be ± 2 to 4 feet below ground surface.

The excavated surface material will be containerized in drums and disposed off-Site at a licensed disposal facility. A non-woven geotextile will be placed over the removal area and the area will be backfilled to match surrounding grade with engineered material designed to stabilize the slope. In addition, residual, hardened coal tar-like material located on the river embankment will be manually removed and containerized in drums with the removed surface soil described above for off-Site transport to a licensed receiving facility for disposal. Mobilization, set-up of the erosion controls and clearing will take approximately 1 day to perform. The pipe removal and limited excavation work are expected to take approximately 2 to 3 days to complete. Restoration and demobilization activities will take another day to perform. It is estimated that the entire pipe removal project will take approximately 1 week to complete.

ESTIMATED AIR EMISSIONS

Average concentrations of VOCs in the six surface soil samples collected in the vicinity of the work area were used to calculate the estimated emissions for the proposed earthwork activities. These samples were collected proximate to the proposed soil removal area. As presented in Table 1B, the surface soil sample results indicate the presence of low levels of certain VOCs and PAHs. Naphthalene concentrations (reported as a VOC) ranged from non-detect to 1.40 mg/kg. Naphthalene results (as reported as a PAH) ranged from non-detect to 4.69 mg/kg. Detected benzene levels



ranged from non-detect to 0.460 mg/kg, with five of the six results below the detection limits. The average concentrations of this soil data set were used to calculate/model estimated volatile emissions for the soil removal portion of this activity. For naphthalene, an average concentration was calculated by taking the maximum detected value between EPA Method 8260B and EPA Method 8270C for each sample or the minimum reporting limit if neither were detected. Please note that the calculations attached assume that the excavated soil is stockpiled. This assumption is conservative for estimating emissions from excavations because containerizing the excavated material directly in drums generates fewer emissions.

To evaluate emissions from the removal and capping of the above ground pipe and its contents, the contents were assumed to be comparable to the observed DNAPL from nearby monitoring well MW-4 as compound-specific analytical testing was not available for the residual pipe material sample. The characteristics of the chromatogram for the sample of DNAPL from MW-4 indicated the presence of a petroleum product in the boiling range of coal tar oil. Analytical results of the DNAPL sample collected from this well, as presented in Table 1C, indicated concentrations of naphthalene and ethylbenzene as well as numerous PAHs.

Attachment 1 describes the emission calculations for the proposed pipe removal and associated earthwork activities which were based on the following EPA guidance document:

Eklund, *et al.* 1997. Air Emissions from the Treatment of Soils Contaminated with Petroleum Fuels and Other Substances. Prepared for U.S. Environmental Protection Agency Office of Air and Radiation and Office of Research and Development Washington, D.C. EPA-600/R-97-116. October.

The following presents a summary of the predicted total volatile emissions (expressed in pounds) for the soil and pipe removal activities compared to RIDEM's Minimum Quantities (expressed in pounds/year) published in Regulation No. 9, Appendix A. This list only includes those compounds for which there are minimal threshold quantities available.

Analyte	Total Emission (lb)	RIDEM Minimum Quantity (lb)
Naphthalene	7.72E-06	3
Benzene	5.96E-04	10
Carbon Tetrachloride	6.94E-04	8
Ethylbenzene	1.79E-04	9,000
Toluene	1.37E-04	3,000
m&p-Xylene	9.49E-05	1,000
o-Xylene	3.80E-05	

CONCLUSIONS

The results of this predictive modeling indicates that the pipe removal and associated earthwork activities do not have the potential to increase emissions by greater than the minimum quantity as specified in Appendix A of RIDEM APC Regulation No. 9 and



therefore a minor source permit is not required for this activity. Air monitoring will be completed during the proposed pipe removal and earthwork activities consistent with the April 2011 *Air Quality Monitoring Plan* (AQMP) previously submitted to and reviewed by the Department. We respectfully request that RIDEM respond in writing confirming that Regulation No. 9 does not apply to the upcoming work and that the April 2011 AQMP is appropriate for such work. The intent would be to complete the proposed work in Summer 2011. It is anticipated that the work would take approximately 2-3 days to complete.

We would be pleased to discuss this matter with you, if you would like, at your convenience.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

A handwritten signature in blue ink, appearing to read 'Margaret S. Kilpatrick'.

Margaret S. Kilpatrick, P.E.
Senior Project Manager

A handwritten signature in blue ink, appearing to read 'John P. Hartley'.

John P. Hartley
Consultant/Reviewer

A handwritten signature in blue ink, appearing to read 'James J. Clark'.

James J. Clark, P.E.
Principal

MSK/JJC:tja

Attachments: Table 1A – Summary of Pipe Residual TPH Fingerprinting
Table 1B – Summary of Detected Surface Soil Constituents Analytical Results
Table 1C – Summary of MW-4 DNAPL Analytical Results
Figure 1 – Site Plan
Figure 2 – Proposed Excavation Plan
Attachment 1 – Emissions Calculations
Attachment 2 – Air Quality Monitoring Plan

cc: Joe Martella, RIDEM
Michele Leone, National Grid

TABLES

TABLE 1A
PIPE RESIDUAL MATERIAL ANALYTICAL DATA
Former Tidewater Facility
Pawtucket, Rhode Island

File No. 05.0043654.00
6/23/2011

		Units	Riverside-Pipe-090110	
			1009-00022-001	
			09/01/2010	
			Result	RL
Mod. EPA 8100	TOTAL PETROLEUM HYDROCARBON			
	Hydrocarbon Content	µg/g	1,200,000	250,000

Notes:

-The characteristics of the chromatogram for sample Riverside-Pipe-090110 (1009-00022-001) indicate the presence of a petroleum product in the boiling range of coal tar oil.

**TABLE 1B
SUMMARY OF DETECTED SURFACE SOIL CONSISTUENTS ANALYTICAL RESULTS**

Former Tidewater Facility
Pawtucket, Rhode Island

		Units	RIDEM GB Leachability Criteria	RIDEM Industrial/ Commercial DEC	RIDEM UCL	TP-366 (0-2ft.)		TP-365 (0-2ft.)		TP-326 (0-2ft.)		TP-366 (4-6ft.)		TB-12/MW-3 (0-2ft.)		TP-15 (3-4ft.)		
						FGPA		FGPA		FGPA		FGPA		FGPA		FGPA		
						1006-00042-005 06/04/2010		1006-00041-009 06/03/2010		1006-00042-002 06/04/2010		1006-00042-006 06/04/2010		1996		1996		
						Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	Result	RL	
EPA 8260	VOLATILE ORGANICS																	
	Benzene	µg/kg	4,300	200,000	10,000,000	<	95	<	80	<	140	<	50	NA	NA	460	NR	
	Carbon Tetrachloride	µg/kg	5,000	44,000	10,000,000	130	95	<	80	<	140	<	50	NA	NA	NA	NA	
	Ethylbenzene	µg/kg	62,000	10,000,000	10,000,000	<	95	<	80	<	140	<	50	NA	NA	260	NR	
	Toluene	µg/kg	54,000	10,000,000	10,000,000	110	95	<	80	560	140	<	50	NA	NA	670	NR	
	m&p-Xylene	µg/kg	NE	10,000,000	10,000,000	210	190	<	160	870	280	<	100	NA	NA	830	NR	
	o-Xylene	µg/kg	NE	10,000,000	10,000,000	130	95	<	80	530	140	<	50	NA	NA	670	NR	
	1,3,5-Trimethylbenzene	µg/kg	NE	NE	10,000,000	<	95	<	80	160	140	<	50	NA	NA	NA	NA	
	1,2,4-Trimethylbenzene	µg/kg	NE	NE	10,000,000	<	95	<	80	480	140	<	50	NA	NA	NA	NA	
	Naphthalene	µg/kg	NE	10,000,000	10,000,000	630	190	1,400	160	1,300	280	<	100	NA	NA	NA	NA	
Mod. EPA 8100	TOTAL PETROLEUM HYDROCARBON																	
	Hydrocarbon Content	mg/kg	2,500	2,500	30,000	1,300	62	300	11	730	58	75	54	NA	NA	NA	NA	
EPA 6010B	METALS																	
	Beryllium	mg/kg	NE	1.3	10,000	1.1	0.33	0.57	0.33	0.46	0.29	0.30	0.25	0.65	NR	0.63	NR	
	Arsenic	mg/kg	NE	7	10,000	6.3	0.82	12	0.84	2.8	0.73	1.6	0.62	7	NR	2	NR	
	Chromium	mg/kg	NE	10,000	10,000	11	0.41	19	0.42	5.0	0.37	6.0	0.31	11	NR	13	NR	
	Copper	mg/kg	NE	10,000	10,000	35	1.2	65	1.3	35	1.1	11	0.93	41	NR	43	NR	
EPA 7471A	Mercury	mg/kg	NE	610	10,000	0.028	0.013	0.14	0.0085	0.076	0.013	<	0.012	<	0.1	0.98	NR	
	Nickel	mg/kg	NE	10,000	10,000	28	0.82	54	0.84	9.0	0.73	7.2	0.62	25	NR	26	NR	
	Lead	mg/kg	NE	500	10,000	42	0.82	120	0.84	34	0.73	7.0	0.62	97	NR	69	NR	
	Antimony	mg/kg	NE	820	10,000	<	2.7	2.3	1.6	<	2.3	<	2.2	<	9.7	<	9	
	Zinc	mg/kg	NE	10,000	10,000	33	0.82	130	0.84	38	0.73	28	0.62	130	NR	88	NR	
EPA 8270	PAHS BY GCMS																	
	Naphthalene	µg/kg	NE	10,000,000	10,000,000	3,400	820	<	330	2,400	330	<	330	2,450	NR	4,690	NR	
	2-Methylnaphthalene	µg/kg	NE	10,000,000	10,000,000	3,500	820	<	330	2,900	330	<	330	3,340	NR	3,880	NR	
	Acenaphthylene	µg/kg	NE	10,000,000	10,000,000	3,900	820	780	330	1,800	330	<	330	1,510	NR	4,720	NR	
	Phenanthrene	µg/kg	NE	10,000,000	10,000,000	19,000	820	1,500	330	5,700	330	780	330	15,900	NR	16,100	NR	
	Anthracene	µg/kg	NE	10,000,000	10,000,000	3,000	820	560	330	1,300	330	<	330	2,950	NR	4,760	NR	
	Fluoranthene	µg/kg	NE	10,000,000	10,000,000	24,000	820	2,800	330	4,700	330	890	330	13,700	NR	17,400	NR	
	Pyrene	µg/kg	NE	10,000,000	10,000,000	22,000	820	3,200	330	5,100	330	720	330	15,200	NR	33,700	NR	
	Benzo [a] Anthracene	µg/kg	NE	7,800	10,000,000	12,000	820	2,000	330	3,000	330	460	330	9,220	NR	15,800	NR	
	Chrysene	µg/kg	NE	780,000	10,000,000	15,000	820	1,900	330	4,400	330	<	330	9,410	NR	12,100	NR	
	Benzo [b] Fluoranthene	µg/kg	NE	7,800	10,000,000	15,000	820	2,000	330	4,100	330	540	330	7,400	NR	7,500	NR	
	Benzo [k] Fluoranthene	µg/kg	NE	78,000	10,000,000	4,100	820	770	330	1,300	330	<	330	6,390	NR	10,400	NR	
	Benzo [a] Pyrene	µg/kg	NE	800	10,000,000	6,700	820	1,600	330	2,400	330	380	330	8,850	NR	15,100	NR	
	Indeno [1,2,3-cd] Pyrene	µg/kg	NE	7,800	10,000,000	6,700	820	1,100	330	1,800	330	<	330	5,000	NR	7,030	NR	
	Dibenzo [a,h] Anthracene	µg/kg	NE	800	10,000,000	1,800	820	<	330	340	330	<	330	980	NR	1,790	NR	
	Benzo [g,h,i] Perylene	µg/kg	NE	10,000,000	10,000,000	6,900	820	1,000	330	1,700	330	<	330	6,060	NR	7,910	NR	
SW-846 9010A	SUBCONTRACTED ANALYTES																	
	Total Cyanide	mg/kg	NE	10,000	10,000	<	11	63	9.7	<	11	<	9.1	12	NR	1	NR	

TABLE 1C
SUMMARY OF MW-4 DNAPL ANALYTICAL RESULTS
Former Tidewater Facility
Pawtucket, Rhode Island

File No. 005.0043654.00
6/23/2011

		Units	MW-4 DNAPL	
			Result	RL
EPA 8260	VOLATILE ORGANICS			
	Dichlorodifluoromethane	µg/kg	<	1,700,000
	Chloromethane	µg/kg	<	1,700,000
	Vinyl chloride	µg/kg	<	850,000
	Bromomethane	µg/kg	<	1,700,000
	Chloroethane	µg/kg	<	850,000
	Trichlorofluoromethane	µg/kg	<	1,700,000
	Diethylether	µg/kg	<	1,700,000
	Acetone	µg/kg	<	22,000,000
	1,1-Dichloroethene	µg/kg	<	850,000
	Dichloromethane	µg/kg	<	1,700,000
	Methyl tert-butyl ether	µg/kg	<	850,000
	trans-1,2-Dichloroethene	µg/kg	<	850,000
	1,1-Dichloroethane	µg/kg	<	850,000
	2-Butanone (MEK)	µg/kg	<	22,000,000
	2,2-Dichloropropane	µg/kg	<	850,000
	cis-1,2-Dichloroethene	µg/kg	<	850,000
	Chloroform	µg/kg	<	850,000
	Bromochloromethane	µg/kg	<	850,000
	Tetrahydrofuran	µg/kg	<	8,500,000
	1,1,1-Trichloroethane	µg/kg	<	850,000
	1,1-Dichloropropene	µg/kg	<	850,000
	Carbon tetrachloride	µg/kg	<	850,000
	1,2-Dichloroethane	µg/kg	<	850,000
	Benzene	µg/kg	<	850,000
	Trichloroethene	µg/kg	<	850,000
	1,2-Dichloropropane	µg/kg	<	850,000
	Bromodichloromethane	µg/kg	<	850,000
	Dibromomethane	µg/kg	<	850,000
	4-Methyl-2-pentanone (MIBK)	µg/kg	<	22,000,000
	cis-1,3-Dichloropropene	µg/kg	<	850,000
	Toluene	µg/kg	<	850,000
	trans-1,3-Dichloropropene	µg/kg	<	1,700,000
	1,1,2-Trichloroethane	µg/kg	<	850,000
	2-Hexanone	µg/kg	<	22,000,000
	1,3-Dichloropropane	µg/kg	<	850,000
	Tetrachloroethene	µg/kg	<	850,000
	Dibromochloromethane	µg/kg	<	850,000
	1,2-Dibromoethane (EDB)	µg/kg	<	1,700,000
	Chlorobenzene	µg/kg	<	850,000
	1,1,1,2-Tetrachloroethane	µg/kg	<	850,000
	Ethylbenzene	µg/kg	1,300,000	850,000
	m&p-Xylene	µg/kg	<	1,700,000
	o-Xylene	µg/kg	<	850,000
	Styrene	µg/kg	<	850,000
	Bromoform	µg/kg	<	1,700,000
	Isopropylbenzene	µg/kg	<	850,000
	1,1,2,2-Tetrachloroethane	µg/kg	<	850,000
	1,2,3-Trichloropropane	µg/kg	<	850,000
	Bromobenzene	µg/kg	<	850,000

TABLE 1C
SUMMARY OF MW-4 DNAPL ANALYTICAL RESULTS

File No. 005.0043654.00

6/23/2011

Former Tidewater Facility
Pawtucket, Rhode Island

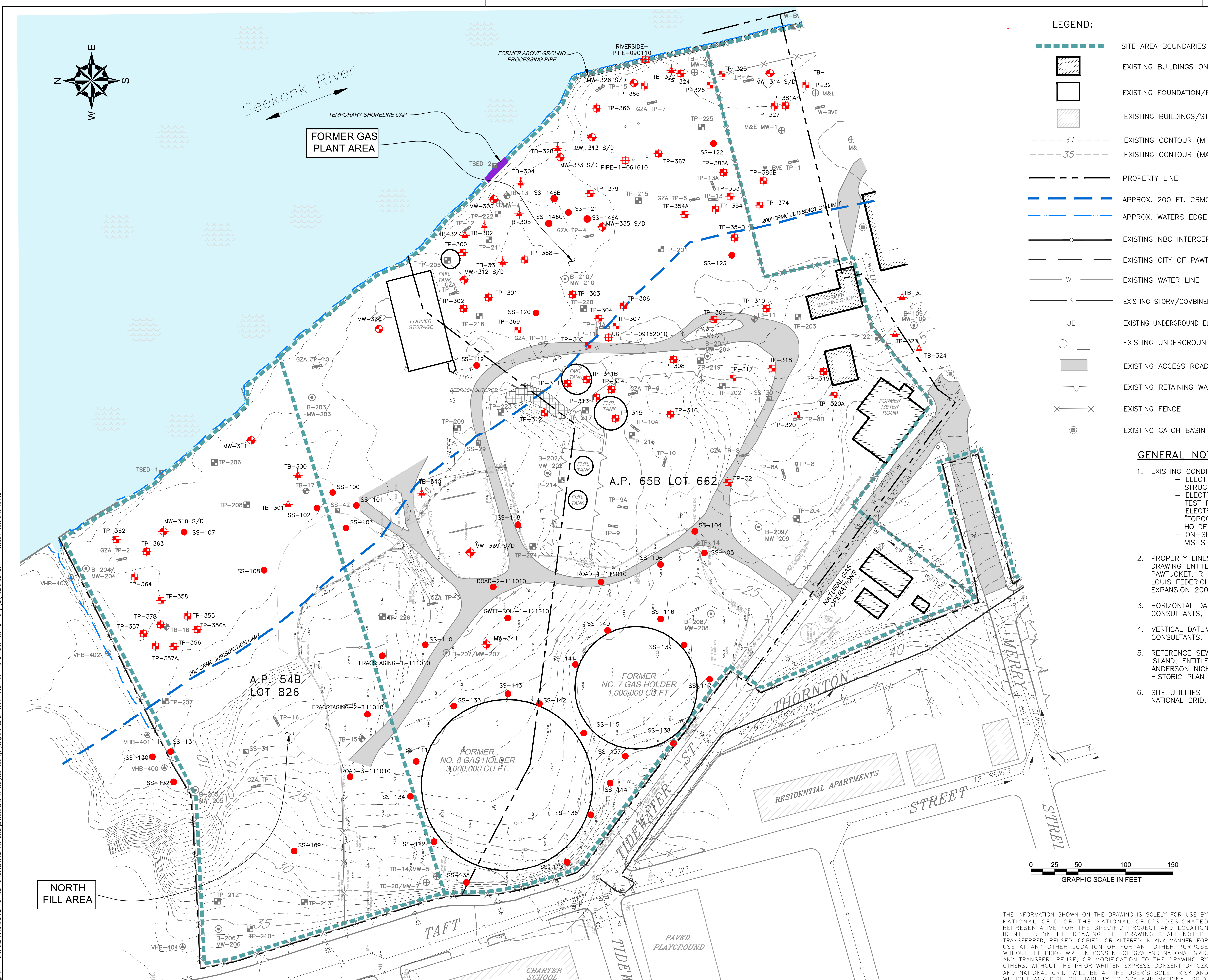
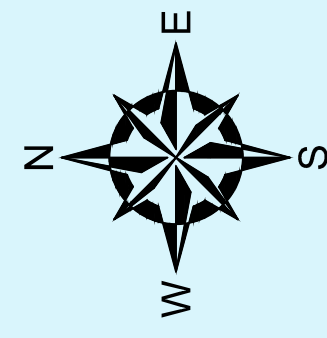
		Units	MW-4 DNAPL	
			Result	RL
EPA 8260	VOLATILE ORGANICS			
	n-Propylbenzene	µg/kg	<	850,000
	2-Chlorotoluene	µg/kg	<	850,000
	1,3,5-Trimethylbenzene	µg/kg	<	850,000
	4-Chlorotoluene	µg/kg	<	850,000
	tert-Butylbenzene	µg/kg	<	850,000
	1,2,4-Trimethylbenzene	µg/kg	1,300,000	850,000
	sec-Butylbenzene	µg/kg	<	850,000
	p-Isopropyltoluene	µg/kg	<	850,000
	1,3-Dichlorobenzene	µg/kg	<	850,000
	1,4-Dichlorobenzene	µg/kg	<	850,000
	n-Butylbenzene	µg/kg	<	850,000
	1,2-Dichlorobenzene	µg/kg	<	850,000
	1,2-Dibromo-3-chloropropane	µg/kg	<	1,700,000
	1,2,4-Trichlorobenzene	µg/kg	<	850,000
	Hexachlorobutadiene	µg/kg	<	850,000
	Naphthalene	µg/kg	40,000,000	1,700,000
	1,2,3-Trichlorobenzene	µg/kg	<	850,000
EPA 8100	TOTAL PETROLEUM HYDROCARBON			
	Hydrocarbon Content	µg/g	720,000	38,000
EPA 8270	PAHS BY GCMS			
	Naphthalene	µg/kg	35,000,000	1,300,000
	2-Methylnaphthalene	µg/kg	20,000,000	1,300,000
	Acenaphthylene	µg/kg	1,600,000	1,300,000
	Acenaphthene	µg/kg	12,000,000	1,300,000
	Fluorene	µg/kg	1,400,000	1,300,000
	Phenanthrene	µg/kg	19,000,000	1,300,000
	Anthracene	µg/kg	5,600,000	1,300,000
	Fluoranthene	µg/kg	7,200,000	1,300,000
	Pyrene	µg/kg	8,700,000	1,300,000
	Benzo [a] Anthracene	µg/kg	3,600,000	1,300,000
	Chrysene	µg/kg	3,000,000	1,300,000
	Benzo [b] Fluoranthene	µg/kg	2,200,000	1,300,000
	Benzo [k] Fluoranthene	µg/kg	<	1,300,000
	Benzo [a] Pyrene	µg/kg	2,400,000	1,300,000
	Indeno [1,2,3-cd] Pyrene	µg/kg	<	1,300,000
	Dibenzo [a,h] Anthracene	µg/kg	<	1,300,000
	Benzo [g,h,i] Perylene	µg/kg	<	1,300,000

Notes

Hydrocarbon Fingerprint:

MW-4 DNAPL: The characteristics of the chromatogram indicates the presence of a petroleum product in the boiling range of coal tar oil.

FIGURES



LEGEND:

- SITE AREA BOUNDARIES
- EXISTING BUILDINGS ON-SITE
- EXISTING FOUNDATION/PAD ON-SITE
- EXISTING BUILDINGS/STRUCTURES OFF-SITE
- EXISTING CONTOUR (MINOR 1 FOOT INTERVAL)
- EXISTING CONTOUR (MAJOR 5 FOOT INTERVAL)
- PROPERTY LINE
- APPROX. 200 FT. CRMC JURISDICTION LIMIT
- APPROX. WATERS EDGE
- EXISTING NBC INTERCEPTOR SANITARY SEWER
- EXISTING CITY OF PAWTUCKET STORM DRAIN
- EXISTING WATER LINE
- EXISTING STORM/COMBINED SAN. SEWER OVERFLOW
- EXISTING UNDERGROUND ELECTRIC CABLE IN CONDUIT
- EXISTING UNDERGROUND ELECTRIC MH/STRUCTURE
- EXISTING ACCESS ROAD
- EXISTING RETAINING WALLS
- EXISTING FENCE
- EXISTING CATCH BASIN LOCATIONS

SAMPLE LEGEND	
	ATLANTIC SURFACE SOIL SAMPLE LOCATION
	ATLANTIC SEDIMENT SAMPLE LOCATION
	WESTON/BLACKSTONE VALLEY ELECTRIC SEDIMENT SAMPLE LOCATION
	RIDEM SURFACE SOIL SAMPLE LOCATION
	MONITORING WELL/BORING (VHB) SURVEYED
	ATLANTIC TEST PIT LOCATION
	WESTON/BLACKSTONE VALLEY ELECTRIC TEST PIT LOCATION
	GZA/VALLEY GAS TEST PIT LOCATION
	ATLANTIC SOIL BORING LOCATION
	ATLANTIC MONITORING WELL LOCATION
	METCALF & EDDY MONITORING WELL LOCATION
	VHB SURFACE SOIL SAMPLE LOCATION NON-SURVEYED
	VHB TEST PIT (2006)
	GZA TEST PIT (2009)
	GZA TEST BORING LOCATION (2010)
	GZA TEST PIT LOCATION (2010)
	GZA SURFACE SOIL SAMPLE LOCATION (2010)
	ARCADIS SEDIMENT SAMPLE LOCATION (2008)
	GZA RESIDUAL MATERIAL SAMPLE (2010)

GENERAL NOTES:

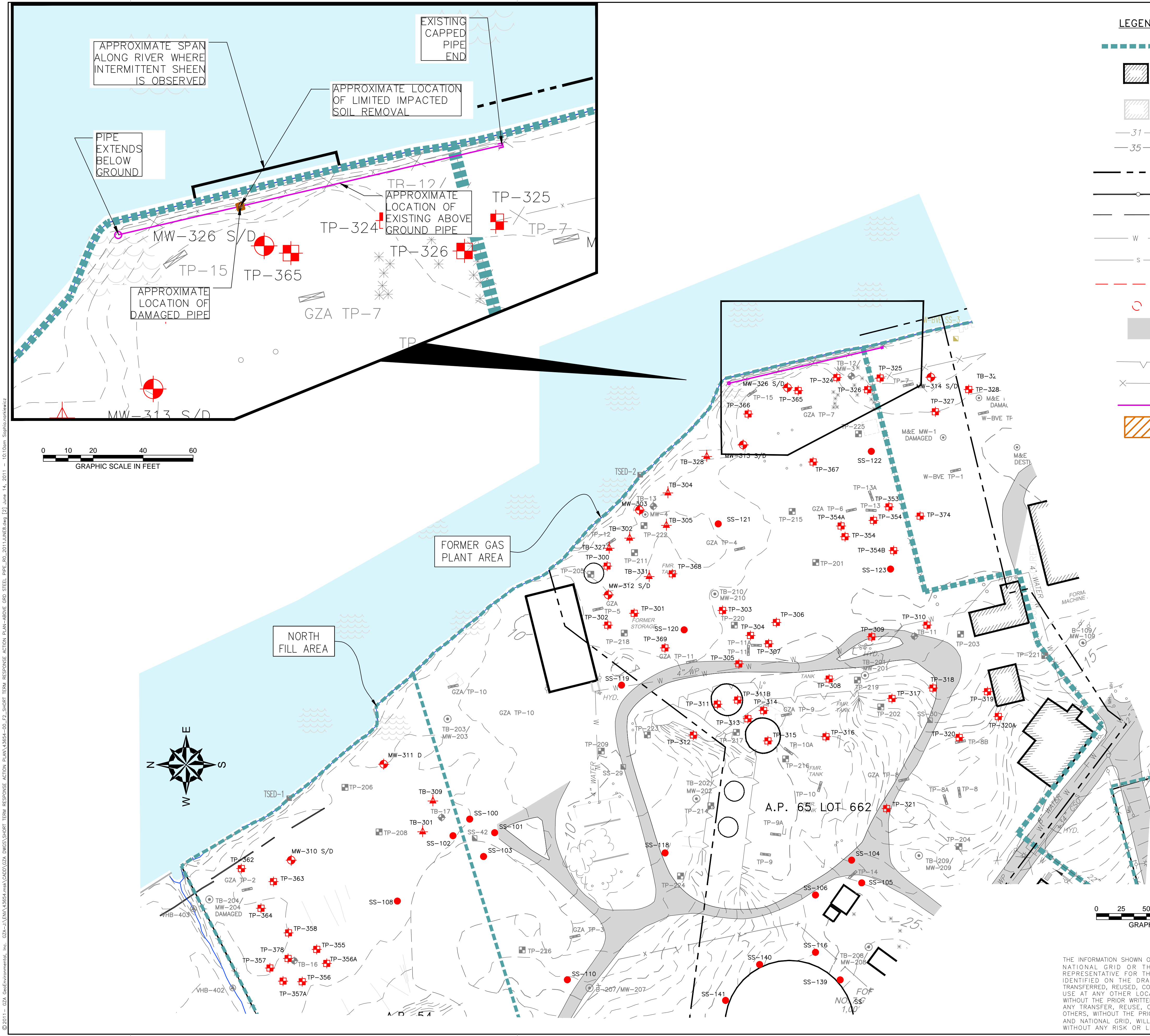
1. EXISTING CONDITIONS BASE MAP DEVELOPED FROM THE FOLLOWING:
 - ELECTRONIC FILES FROM GEI CONSULTANTS, INC. (FORMERLY AES) ENTITLED "HISTORIC STRUCTURES AND SAMPLE LOCATIONS", ORIGINAL SCALE 1"=80', DATED JULY 1999
 - ELECTRONIC FILES FROM VANASSE HANGEN BRUSTLIN, INC. ENTITLED "SOIL BORING, TEST PIT AND MONITOR WELL LOCATIONS", SCALE: 1"=60', UNDATED
 - ELECTRONIC FILES FROM WELSH ASSOCIATES LAND SURVEYORS, INC. ENTITLED "TOPOGRAPHIC SURVEY (AS-BUILT), FORMER TIDEWATER FACILITY, DEMOLITION OF GAS HOLDERS NOS. 7 & 8", DATED DECEMBER 17, 2010
 - ON-SITE INVESTIGATIONS AND SURVEYS BY GZA PERSONNEL DURING VARIOUS SITE VISITS DURING 2009 AND 2010.
2. PROPERTY LINES AND LOT INFORMATION ESTABLISHED FROM INFORMATION PROVIDED ON A DRAWING ENTITLED "PERIMETER SURVEY OF LAND AT THE TIDEWATER FORMER MGP SITE IN PAWTUCKET, RHODE ISLAND FOR ATLANTIC ENVIRONMENTAL SERVICES INC." DEVELOPED BY LOUIS FEDERICI AND ASSOCIATES AND AN AUTO CAD FILE ENTITLED "MAX READ FIELD TRACK EXPANSION 2007" PROVIDED BY THE CITY OF PAWTUCKET.
3. HORIZONTAL DATUM IS BASED ON NAD 1983 FROM BASE MAPPING PROVIDED BY GEI CONSULTANTS, INC.
4. VERTICAL DATUM IS BASED ON NGVD 1929 (MSL) FROM BASE MAPPING PROVIDED BY GEI CONSULTANTS, INC.
5. REFERENCE SEWER DATA FROM SCANNED IMAGES PROVIDED BY THE CITY OF PAWTUCKET, RHODE ISLAND, ENTITLED "STUDY OF SEWERAGE FACILITIES" BY WATERMAN ENGINEERING CO. & ANDERSON NICHOLS CO. DATED NOV. 1975, ORIGINAL SCALE 1"=400' & SCANNED IMAGES OF HISTORIC PLAN & PROFILE DRAWINGS PROVIDED BY THE CITY OF PAWTUCKET, RHODE ISLAND.
6. SITE UTILITIES TAKEN FROM 1984 SANBORN MAP AND HISTORIC FIGURES PROVIDED BY NATIONAL GRID. ALL UTILITY LOCATIONS ARE APPROXIMATE AND SHOWN FOR REFERENCE ONLY.



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NO.	ISSUE/DESCRIPTION	BY	DATE
FORMER TIDEWATER FACILITY			
PAWTUCKET, RHODE ISLAND			
SITE PLAN			
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists 530 BROADWAY PROVIDENCE, RHODE ISLAND 02909 (401) 421-4140		PREPARED FOR: NATIONAL GRID	
PROJ MGR: MSK	REVIEWED BY: MSK	CHECKED BY: MSK	FIGURE
DESIGNED BY: SDN	DRAWN BY: CRD	SCALE: 1"=50"	1
DATE: JUNE 2011	PROJECT NO. 43654.00	REVISION NO. 0	
			SHEET NO. 1 OF 2

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LEGEND:

- SITE AREA BOUNDARIES
- EXISTING STRUCTURES ON-SITE
- EXISTING BUILDINGS/STRUCTURES OFF-SITE
- EXISTING CONTOUR (MINOR 1 FOOT INTERVAL)
- EXISTING CONTOUR (MAJOR 5 FOOT INTERVAL)
- INTERIOR PROPERTY LINE
- EXISTING NBC INTERCEPTOR SANITARY SEWER
- EXISTING CITY OF PAWTUCKET STORM DRAIN
- EXISTING WATER LINE
- EXISTING STORM/COMBINED SAN. SEWER OVERFLOW
- EXISTING UNDERGROUND ELECTRIC CABLE IN CONDUIT
- EXISTING UNDERGROUND ELECTRIC MH/STRUCTURE
- EXISTING ACCESS ROAD
- EXISTING RETAINING WALLS
- EXISTING FENCE
- ABOVE GROUND PIPE RELATED TO FORMER FACILITY OPERATIONS
- PROPOSED EXCAVATION OF IMPACTED SOIL

- SAMPLE LEGEND**
- SS-9 ATLANTIC SURFACE SOIL SAMPLE LOCATION
 - TSSED-6 ATLANTIC SEDIMENT SAMPLE LOCATION
 - W-BVE SS-3 WESTON/BLACKSTONE VALLEY ELECTRIC SEDIMENT SAMPLE LOCATION
 - TP-109/MW-109 MONITORING WELL/BORING (VHB) SURVEYED
 - TP-3A ATLANTIC TEST PIT LOCATION
 - W-BVE TP-1 WESTON/BLACKSTONE VALLEY ELECTRIC TEST PIT AND SOIL SAMPLE LOCATION
 - GZA TP-8 GZA/VALLEY GAS TEST PIT AND SOIL SAMPLE LOCATION
 - TP-15 ATLANTIC SOIL BORING LOCATION
 - MW-3 ATLANTIC MONITORING WELL LOCATION
 - M&E MW-1 METCALF & EDDY MONITORING WELL LOCATION
 - VHB-400 VHB BORING NON-SURVEYED
 - TP-204 VHB TEST PIT (2006)
 - GZ-TP-101 GZA TEST PIT (2009)
 - TP-300 GZA TEST BORING LOCATION (2010)
 - MW-320 S/D GZA MONITORING WELL LOCATION (2010)
 - TP-306 GZA TEST PIT LOCATION (2010)
 - SS-100 GZA SOIL SAMPLE LOCATION (2010)

GENERAL NOTES:

1. BASE MAP DEVELOPED FROM ELECTRONIC FILES FROM GEI CONSULTANTS, INC. ENTITLED "HISTORIC STRUCTURES AND SAMPLE LOCATIONS", ORIGINAL SCALE 1"=80', DATED JULY 1999 AND ELECTRONIC FILES FROM VANASSE HANGEN BRUSTLIN, INC. ENTITLED "SOIL BORING, TEST PITS AND MONITOR WELL LOCATION", SCALE: 1"=60'.
2. PROPERTY LINES AND LOT INFORMATION ESTABLISHED FROM INFORMATION PROVIDED ON A DRAWING ENTITLED "PERIMETER SURVEY OF LAND AT THE TIDEWATER FORMER MGP SITE IN PAWTUCKET, RHODE ISLAND FOR ATLANTIC ENVIRONMENTAL SERVICES, INC." DEVELOPED BY LOUIS FEDERICI AND ASSOCIATES AND AN AUTO CAD FILE ENTITLED "MAX READ FIELD TRACK EXPANSION 2007" PROVIDED BY THE CITY OF PAWTUCKET.
3. HORIZONTAL DATUM IS BASED ON NAD 1983 FROM BASE MAPPING PROVIDED BY GEI CONSULTANTS, INC.
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5. REFERENCE SEWER DATA FROM SCANNED IMAGE PROVIDED BY THE CITY OF PAWTUCKET, RHODE ISLAND, ENTITLED "STUDY OF SEWERAGE FACILITIES" BY WATERMAN ENGINEERING CO. & ANDERSON NICHOLS CO. DATED NOV. 1975, ORIGINAL SCALE 1"=400' & SCANNED IMAGES OF HISTORIC PLAN & PROFILE DRAWINGS PROVIDED CITY OF PAWTUCKET, RHODE ISLAND.
6. SITE UTILITIES TAKEN FROM 1984 SANBORN MAP AND HISTORIC FIGURES PROVIDED BY NATIONAL GRID. ALL UTILITY LOCATIONS ARE APPROXIMATE AND SHOWN FOR REFERENCE ONLY.



NO.	ISSUE/DESCRIPTION	BY	DATE
FORMER TIDEWATER FACILITY			
PAWTUCKET, RHODE ISLAND			
PROPOSED REMOVAL PLAN			
FORMER ABOVE GROUND PROCESS PIPE			
PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists 530 BROADWAY PROVIDENCE, RHODE ISLAND 02909 (401) 421-4140		PREPARED FOR: NATIONAL GRID	
PROJ MGR: MSK	REVIEWED BY: SDN	CHECKED BY: MSK	FIGURE 2
DESIGNED BY: SDN	DRAWN BY: CRD	SCALE: AS NOTED	
DATE: JUNE 2011	PROJECT NO: 43654.00	REVISION NO: 0	SHEET NO. 2 OF 2

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ATTACHMENT 1
EMISSIONS CALCULATIONS

Pipe Removal and Excavation Emissions Modeling

Assumptions	
Assumed Average MW of NAPL	250 (g/mol)
Assumed NAPL Temperature	15 (°C)
Assumed Time to Remove Pipe	4 (hr)
Assumed Pipe % Filled with NAPL	10%
Assumed Volume of Pipe Headspace	0.74 (m ³)
Assumed Time to Excavate Volume of Soil	20 (hr)

Site-Specific	
Pipe Diameter	0.5 (ft)
Pipe Length	150 (ft)
Cut Length (ft)	15 (ft)
Bottom of Excavation Surface Area	5 (ft ²)
Pile Surface Area (Assume 2.5'x2.5'x4')	4 (m ²)
Time to Excavate Volume of Soil	360 (s)
Emitting Surface Area (6-minute Segment)	0.11 (m ²)
Excavation Depth	4 (ft)
Excavation Depth	1.2 (m)
Volume of Soil Moved	0.50 (ft ³)
Volume of Soil Moved	0.0032 (m ³)

Constants	
Typical Bulk Density	1.5 (g/cm ³)
R	8.21E-05 (m ³ *atm/K/mol)
R	8.31E-03 (kJ/K/mol)
R	62,361 (mm Hg*cm ³ /mol/K)
Soil Gas to Atmosphere Exchange Constant (Wet Soils)	0.1 (%/100)
Air-Filled Porosity (Wet or Compacted Soils)	0.35
Total Porosity	0.625 Eklund 1997 Default
Gas-Phase Mass Transfer Coefficient	0.15 cm/s Eklund 1997 Default
Time since Start of Excavation of Soil of Interest	60 s Eklund 1997 Default

Site-Specific	
TOC of Soil	0.006 (g OC/g soil)
Excavation Rate	8.85E-06 (m ³ /s)

Analyte	Average Measured Concentration in NAPL (mg/kg)	Average Measured Concentration in Soil (ug/g)	Partial Pressure in the Pipe ² (atm)	Calculated Concentration in Pipe Headspace (mg/m ³)	Total Emissions from Pipe (lb)	Partial Pressure in Soil ² (atm)	Equilibrium Coefficient	Effective Diffusivity in Air (cm ² /s)	Total Excavation Emissions Potential (lb)	Excavation Emissions ³ (lb)	Total Emission (lb)	RIDEM Annual Minimum Quantity (lb)
Naphthalene	40,000	0.85	8.76E-07	4.7	7.72E-06	3.20E-09	4.79E-06	4.58E-03	8.90E-06	1.83E-09	7.72E-06	3
Benzene	<850	0.13	1.11E-04	366	5.95E-04	5.79E-06	3.47E-02	7.23E-03	1.35E-06	1.77E-07	5.96E-04	10
Carbon Tetrachloride	<850	0.07	6.56E-05	427	6.94E-04	1.77E-06	4.05E-02	4.91E-03	6.98E-07	8.32E-08	6.94E-04	8
Ethylbenzene	1,300	0.09	2.45E-05	110	1.79E-04	2.88E-07	3.41E-03	5.82E-03	9.32E-07	2.97E-08	1.79E-04	9,000
Toluene	<850	0.28	2.16E-05	84	1.37E-04	2.47E-06	8.01E-03	6.75E-03	2.96E-06	1.65E-07	1.37E-04	3,000
m&p-Xylene ¹	<1,700	0.41	1.30E-05	58	9.48E-05	1.08E-06	2.77E-03	2.72E-03	4.30E-06	8.84E-08	9.49E-05	1,000
o-Xylene	<850	0.28	5.19E-06	23.3	3.79E-05	5.89E-07	2.21E-03	6.75E-03	2.94E-06	7.64E-08	3.80E-05	

- Notes:
- All constants for m&p-xylene are the average of the individual constants for m-xylene and p-xylene.
 - The Partial Pressure in the Pipe was calculated using Raoult's Law and the Average Measured Concentration in NAPL. The Partial Pressure in Soil was calculated using Raoult's Law and the concentration in NAPL calculated by dividing the Average Measured Concentration in Soil by the TOC of Soil.
 - If the calculated Excavation Emissions exceeds the Total Excavation Emissions Potential, the Total Excavation Emissions Potential was used to calculate the Total Emission.
 - Only detected analytes with RIDEM minimum quantity values are shown. If an analyte was not detected in the soil, but was detected in the NAPL, half the reporting limit was used to calculate the emissions associated with the pipe removal.
 - Concentration units are in mg/kg and ug/g, both of which are equal to ppm.
 - MW = molecular weight; atm = atmosphere; kJ = kilojoules; mol = moles; NAPL = non-aqueous phase liquid; ppm = parts per million; mm Hg = millimeter mercury; cm = centimeter; m = meter; g = gram; ug = microgram; ft = feet, lb = pound; s = second; yr = year; hr = hour; < = less than the reporting limit; TOC = total organic carbon.
 - Yellow Highlighting indicates model inputs.
 - Blue Highlighting indicates the calculated Excavation Emissions Rate exceeds the Total Excavation Emissions Rate Potential.
 - Red Highlighting indicates the Emissions Rate exceeds the Rhode Island Department of Environmental Management (RIDEM) Minimum Quantity.

EXCAVATION EMISSIONS CALCULATIONS

Former Tidewater Facility
Pawtucket, Rhode Island

To estimate the emissions from excavation activities at the Former Tidewater Facility (“the Site”), GZA GeoEnvironmental, Inc. (GZA) used the following modified versions of the equations given in Appendix D of “Air Emissions from the Treatment of Soils Contaminated with Petroleum Fuels and Other Substances” (Eklund 1997):

First the total excavation emissions potential is calculated as a benchmark:

Total Excavation Emissions Potential:

$$E_{Potential} = C_{i,Soil} \times S_v \times \beta$$

Where,

$E_{Potential}$ = Total Mass of Component i in a given volume of soil in grams (g);

$C_{i,Soil}$ = Concentration of Component i in the Soil in micrograms of Component i per gram of Mixture (ug/g);

β = Typical Bulk Density in grams per cubic centimeter (g/cm³) (assumed to be 1.5 g/cm³); and

S_v = Volume of Soil Moved in cubic meters (m³).

Average Total Emissions (detailed model):

If the Average Total Emissions calculated by this detailed model (Eklund 1997) exceeds the calculated Total Excavation Emissions Potential, the Total Excavation Emissions Potential will be used.

$$E = E_{PS} + E_{DIFF}$$

$$E_{PS} = \frac{P_i MW 10^6 E_a S_v ExC}{R T}$$

$$E_{DIFF} = \frac{(C)(10,000)(SA)(t_v)}{\left(\frac{E_a}{K_{eq} k_g}\right) + \left(\frac{\pi t}{D_e K_{eq}}\right)^{1/2}}$$

Where,

E = Total Emissions from Excavation of Soil in g;

E_{PS} = Total Emissions due to Soil Pore Space Gas in g;

E_{DIFF} = Total Emissions due to Diffusion in g;

P_i = Partial Pressure of Component i in millimeters of mercury (mm Hg)¹;

MW = Molecular Weight in grams per mole (g/mol);

10^6 = Conversion Factor of cm³/m³;

E_a = Air-Filled Porosity (0.35 for wet, or compacted soil);

S_v = Volume of Soil Moved in m³;

ExC = Soil-Gas to Atmosphere Exchange Constant (0.10 for wet soils);

R = Universal Gas Constant in mm-Hg*cm³/mol/K (62,361 mm-Hg*cm³/mol/K);

T = Temperatures in K (assumed to be 15°C);

¹ Note that because the impacts at the Site are not pure-phase, we have used the partial pressure as opposed to the vapor pressure of the pure component.

C = Mass Loading of Component i in soil in g/cm^3 ;

10,000 = Conversion Factor of square centimeters per square meter (cm^2/m^2);

SA = Emitting Surface Area in square meters (m^2);

D_e = Effective Diffusivity in Air in square centimeter per second (cm^2/s);

K_{eq} = Equilibrium Coefficient;

t_v = Time to excavate Volume of Soil Moved in seconds (s);

k_g = Gas-Phase Mass Transfer Coefficient in centimeter per second (cm/s) (Default of 0.15 cm/s); and

t = Time that the Instantaneous Emission Rate approximates the Average Emission Rate over the 360 second period that Emissions from Freshly Excavated Soil are assumed to be Significant in s (60 s as per Eklund).

P_i is calculated by:

For this scenario, the partial pressure was estimated using Raoult's Law assuming the constituents are in a mixture with the other organic matter in the soil.

Raoult's Law:

$$P_i = P_i^* x_i$$

Where,

P_i = Partial Pressure of the Component i in the Mixture;

P_i^* = Vapor Pressure of the pure Component i ; and

x_i = Mole Fraction of the Component i in the Mixture (moles component/total moles).

$$x_i = \frac{10^{-6} C_{i,Mixture} MW_{Mixture}}{MW_i}$$

Where,

10^{-6} = Conversion Factor of kilogram per milligram (kg/mg);

$MW_{Mixture}$ = Molecular Weight of Mixture in g/mol (assumed to be 250 g/mol);

MW_i = Molecular Weight of Component i in g/mol ; and

$C_{i,Mixture}$ = Concentration of Component i in the Mixture in milligrams of Component i per kilogram of Mixture (mg/kg).

$$C_{i,Mixture} = \frac{C_{i,Soil}}{TOC}$$

Where,

$C_{i,Mixture}$ = Concentration of Component i in the Mixture in milligrams of Component i per kilogram of Mixture (mg/kg);

$C_{i,Soil}$ = Concentration of Component i in the Soil in micrograms of Component i per gram of Mixture (ug/g); and

TOC = Fraction of Total Organic Carbon in the Soil (mg/kg).

We've assumed a soil temperature of 15°C in our calculations. We have therefore utilized the Clausius-Clapeyron equation to calculate vapor pressures at 15°C from those in the literature (typically 25°C):

Clausius-Clapeyron Equation:

$$\ln\left(\frac{P_1}{P_2}\right) = \left(\frac{\Delta H_{vap}}{R}\right)\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Where,

P_1 = Vapor Pressure at a Known Point;
 P_2 = Vapor Pressure at a Given Point;
 T_1 = Temperature at a Known Point in Kelvin (K);
 T_2 = Temperature at a Given Point in K;
 ΔH_{vap} = Enthalpy of Vaporization of Component i in kilojoules per mole (kJ/mol); and
 R = Universal Gas Constant in kilojoules per Kelvin per mole (8.314E-03 kJ/K/mol).

C is calculated by:

$$C = 10^{-6} C_{i,soil} \beta$$

Where,
 10^{-6} = Conversion Factor of gram per microgram (g/ug);
 $C_{i,soil}$ = Concentration of Component i in the Soil in micrograms of Component i per gram of Mixture (ug/g); and
 β = Typical Bulk Density in g/m^3 ; (assumed to be $1.5 g/m^3$).

SA is calculated by:

$$SA = SA_{Open\ Excavation\ 6-minute\ Segment} + SA_{Pile\ 6-minute\ Segment}$$

$$= 2 * SA_{Open\ Excavation\ 6-minute\ Segment} + 4 * d * \sqrt{SA_{Open\ Excavation\ 6-minute\ Segment}}$$

Where,
 $SA_{Open\ Excavation\ 6-minute\ Segment}$ = Open Surface Area of 6-Minute Segment Excavation in m^2 ;
 $SA_{Pile\ 6-minute\ Segment}$ = Open Surface Area of the 6-Minute Segment Pile in m^2 ;
 d = Depth of 6-Minute Segment Excavation in m.

This calculation assumes the excavation and pile are shaped like prisms. According to Eklund (1997), "It is assumed that emissions from freshly excavated soil are significant for a period of 360 seconds, after which the soil is covered by subsequent layers of excavated material." Therefore, dimensions of the pile and excavation were dividing into six minute segments. The areas of these 6-minute segments were estimated assuming a square 6-minute segment pile with the surface area of the top of the 6-minute segment pile being equal to the surface area of the bottom of the 6-minute segment excavation and the height of the 6-minute segment pile being equal to the depth of the 6-minute segment excavation.

K_{eq} is calculated by::

$$K_{eq} = \frac{P_i MW E_a}{R T C}$$

Where,
 P_i = Partial Pressure of the Component i in the Mixture in mm Hg;
 MW = Molecular Weight in g/mol;
 E_a = Air-Filled Porosity (0.35 for wet, or compacted soil);
 R = Universal Gas Constant in mm-Hg* cm^3 /mol/K (62,361 mm-Hg* cm^3 /mol/K);
 T = Temperatures in K (assumed to be 15°C);
 C = Mass Loading of Component i in soil in g/m^3 ;

D_e is calculated by:

$$D_e = \frac{D_a (E_a)^{3.33}}{(E_T)^2}$$

Where,

D_a = Diffusivity in Air of Component i in cm^2/s (Default of 0.1 was used when chemical-specific values could not be found);

E_a = Air-Filled Porosity (0.35 for wet, or compacted soil); and

E_T = Total Porosity (Default of 0.625).

References:

Eklund, et al. 1997. Air Emissions from the Treatment of Soils Contaminated with Petroleum Fuels and Other Substances. Prepared for U.S. Environmental Protection Agency Office of Air and Radiation and Office of Research and Development Washington, D.C. EPA-600/R-97-116. October.

RIDEM. 2009. Air Pollution Control Regulation No. 9: Air Pollution Control Permits. December.

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PIPE EMISSIONS CALCULATIONS

Former Tidewater Facility
Pawtucket, Rhode Island

To estimate the emissions from the pipe during its removal at the Former Tidewater Facility (“the Site”), GZA GeoEnvironmental, Inc. (GZA) assumed that the air in the pipe was in equilibrium with the non-aqueous phase liquid (NAPL) in the pipe and that all of the air would be released from the pipe once removal began. These emissions were calculated using the following equations:

Total Pipe Emissions:

$$E = m_{i, \text{Pipe Headspace}} = C_{i, \text{headspace}} * V_{\text{Pipe Headspace}}$$

Where,

E = Total mass emitted from the Pipe in grams (g);

$V_{\text{Pipe Headspace}}$ = Volume of the Pipe’s Headspace in cubic meters (m^3) (assumed to be 90% of 6-inch diameter pipe);

$m_{i, \text{Pipe Headspace}}$ = Amount of the Component i in the Pipe’s Headspace in g;

$C_{i, \text{headspace}}$ = Concentration of Constituent i in Pipe’s Headspace (g/m^3)

Ideal Gas Law:

$$\frac{n}{V_{\text{Pipe Headspace}}} = \frac{P_i}{R T}$$

$$C_{i, \text{headspace}} = \frac{n}{V_{\text{Pipe Headspace}}} * MW_i = \frac{P_i}{R T} MW_i$$

Where,

P_i = Partial Pressure of Component i in atmospheres (atm)¹;

n = Amount of the Component i in the Pipe’s Headspace in moles (mol);

MW_i = Molecular Weight of the Component i in grams per mole (g/mol);

T = Temperature of Mixture in Kelvin (K); and

R = Universal Gas Constant in atmospheres cubic meters per Kelvin per mole ($8.314E-03 \text{ atm} \cdot m^3/K/\text{mol}$).

P_i is calculated by:

For this scenario, the partial pressure was estimated using Raoult’s Law using the constituent’s concentration in NAPL.

Raoult’s Law:

$$P_i = P_i^* x_i$$

Where,

P_i = Partial Pressure of the Component i in the Mixture;

P_i^* = Vapor Pressure of the pure Component i ; and

x_i = Mole Fraction of the Component i in the Mixture (moles component/total moles).

¹ Note that because the impacts at the Site are not pure-phase, we have used the partial pressure as opposed to the vapor pressure of the pure component.

$$x_i = \frac{10^{-6} C_{i,Mixture} MW_{Mixture}}{MW_i}$$

Where,

10^{-6} = Conversion Factor of kilogram per milligram (kg/mg);

$MW_{Mixture}$ = Molecular Weight of Mixture in g/mol (assumed to be 250 g/mol); and

$C_{i,Mixture}$ = Concentration of Component i in the Mixture in milligrams of Component i per kilogram of Mixture (mg/kg) (the average measured constituent concentrations in NAPL located in wells on-Site was used).

We've assumed a NAPL temperature of 15°C in our calculations. We have therefore utilized the Clausius-Clapeyron equation to calculate vapor pressures at 15°C from those in the literature (typically 25°C):

Clausius-Clapeyron Equation:

$$\ln\left(\frac{P_1}{P_2}\right) = \left(\frac{\Delta H_{vap}}{R}\right)\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Where,

P_1 = Vapor Pressure at a Known Point;

P_2 = Vapor Pressure at a Given Point;

T_1 = Temperature at a Known Point in Kelvin (K);

T_2 = Temperature at a Given Point in K;

ΔH_{vap} = Enthalpy of Vaporization of Component i in kilojoules per mole (kJ/mol); and

R = Universal Gas Constant in kilojoules per Kelvin per mole (8.314E-03 kJ/K/mol).

ATTACHMENT 2

AIR QUALITY MONITORING PLAN

**NATIONAL GRID
AIR QUALITY MONITORING PLAN
PLANNED SHORT DURATION PROJECTS – FORMER TIDEWATER MGP**

INTRODUCTION

GZA GeoEnvironmental, Inc. (GZA), on behalf of The Narragansett Electric Company d/b/a National Grid (National Grid), has prepared this Air Quality Monitoring Plan (AQMP) for use on certain planned projects at the Tidewater Site located in Pawtucket, Rhode Island. Projects covered by this plan include: (1) the *Short Term Response Action Plan* associated with removal of a former process pipe (STRAP submitted to RIDEM in October 2010 and subsequently revised in January 2011); (2) the planned gas regulator station upgrade work; and short duration site investigation activities (test pits, borings). This AQMP is designed to provide for a consistent approach to air quality monitoring for these relatively short-duration remediation, construction, and/or maintenance activities.

While air monitoring requirements for more intrusive and longer duration projects may follow the same general procedures described herein, this AQMP is not intended to cover these more significant and intrusive efforts. Specific air monitoring requirements for these types of efforts will be evaluated on a case by case basis by National Grid as part of the planning, design, permitting and RIDEM-approval process. It is our intent to modify this air monitoring approach for future efforts at the Tidewater Site based on data collected during the activities listed above.

This AQMP for the Tidewater site was designed to achieve the following primary objectives:

- Estimate potential vapor emissions for these short duration efforts in accordance with United States Environmental Protection Agency (EPA) methodology and assess the applicability of RIDEM Air Pollution Control (APC) Regulation No. 9 on a case by case basis;
- Minimize exposure risks to both on-site workers and the surrounding community associated with airborne constituents during implementation of short term remediation, investigation, construction, and/or maintenance activities at the Tidewater site;
- Provide an early warning of site conditions allowing oversight personnel to proactively manage potential air quality issues via implementation of engineered controls and/or adjustments to work practices/procedures¹; and

¹ Please note, anticipated engineered controls and work practices are not described in this AQMP. These procedures are specific to each activity and will be described in the plans, workplans, STRAPs, etc. developed for each effort.

- Quantify air quality monitoring data and compare to applicable criteria to ensure compliance with this AQMP.

VAPOR EMISSION MODELING

Initial project planning activities for each of the short duration events currently anticipated at the Tidewater site will include an estimate of potential volatile air emissions for the proposed work using EPA methodology. Specifically, potential emissions from the proposed activities will be estimated and quantified using the general modeling approach and guidelines presented in the following published EPA guidance document:

- Eklund, et al. 1997. Air Emissions from the Treatment of Soils Contaminated with Petroleum Fuels and Other Substances. Prepared for U.S. Environmental Protection Agency Office of Air and Radiation and Office of Research and Development Washington, D.C. EPA-600/R-97-116. October.

An appropriate predictive air emission model will be developed based on these EPA guidelines for each effort. The results of the predictive modeling will be used to evaluate whether the activity has the potential to increase emissions by greater than the minimum quantity as specified in Appendix A of RIDEM APC Regulation No. 9 and whether a minor source permit is required. A summary of the predictive modeling and our evaluation of the results will be submitted to RIDEM prior to proceeding with on-site work.

AIR QUALITY MONITORING STRATEGY

The following monitoring program will be implemented for each of the short duration efforts anticipated at the Tidewater site regardless of the outcome of the above described predictive air modeling results². This air quality monitoring program has been designed to be protective by using a two tiered approach; real-time air monitoring, and time integrated sampling using US EPA approved sampling and analytical methods. The real time monitoring will involve the use of hand held instrumentation deployed upwind and directly downwind of the site work zone and at the nearest downwind location along the site property line. The first tier (real time monitoring) is designed to provide an early warning to site personnel of potential air quality issues and allow for the implementation of engineered controls and/or modifications to work practices. The second tier, time integrated, laboratory sampling, involves the deployment of stationary sampling equipment at the nearest property line directly downwind of the site work zone(s) and at an upwind perimeter location. This second tier is designed to assess and document perimeter air quality during these activities.

The means and methods associated with each tier of sampling are described in the last section of this plan.

² We understand that in instances where a Minor Source Permit is applicable, additional air monitoring requirements may be necessary.

SELECTION OF TARGET COMPOUNDS

The selection of target compounds for this monitoring plan is based on guidance presented in a document entitled “Health-based Guidelines for Air Management, Public Participation, and Risk Communication During the Excavation of Former Manufactured Gas Plants” prepared by Wisconsin Bureau of Environmental and Occupational Health, Department of Health and Family Services (DHFS) dated August 24, 2004. A copy of the Wisconsin Guideline document is included as Attachment A.

The target compounds selected for the real-time component of this air monitoring program include: Total Volatile Organic Compounds (TVOC) and respirable particulate matter (PM10). In addition, supplemental real-time monitoring will be conducted for benzene. Real time supplemental monitoring for naphthalene was also considered. However, since the instrument which is used to monitor naphthalene in real-time (zNose Model 4200/4300) is typically used as a screening tool and not a quantitative instrument for comparison to air quality standards, it is not considered appropriate for this application. Further, the zNose has a lower detection limit that is approximately ten times higher than the 24-hr RI Acceptable Ambient Level (AAL) for naphthalene, thus would be of limited value in quantifying ambient air quality. The time-integrated sampling and analyses described herein provides a more representative measure of air quality in comparison to the RIDEM AALs. As described further below, target compounds for the time integrated sampling component of this project will include benzene, toluene, ethylbenzene, xylenes, and naphthalene, which are a subset of the analytes contained within the USEPA Method TO-15 (VOCs).

ACTION LEVELS

This section presents the action levels for both tiers of sampling (real time and time integrated).

The following real-time monitoring action levels for the work zone perimeter and property line were selected for use on these shorter duration efforts. These action levels were adopted from Table 3 of the attached Wisconsin Guidance document. The determination of a work zone action level exceedance will be based on the difference between the upwind (background) sampling results and the downwind sampling results. The property line real time monitoring will be conducted at the nearest location downwind from the activity. In addition, real time monitoring will also be conducted at the property line adjacent to the nearest sensitive receptors west of the site, including the apartment complex, the International Charter School and the Francis J. Varieur School independent of wind direction.

Table 1 Action Levels – Real Time Monitoring

Compound	Work Zone Perimeter	Property Line
Total Volatile Organic Compounds (TVOC)	1.0 ppm	0.5 ppm
Respirable Particulate (PM10)	1,000 ug/m ³	150 ug/m ³
Benzene	NA	0.35 ppm

In the event these real time action levels are exceeded GZA will immediately identify the likely cause, implement appropriate engineering controls, and/or modify work practices. In addition, on any day when the real time monitoring exceed these action levels, time integrated samples from upwind and downwind property line locations will be sent to the laboratory for analysis (see below).

The following action levels were selected for use during the time integrated sample monitoring for benzene, toluene, ethylbenzene and xylenes (BTEX), and naphthalene. This compound list was developed based on the DHFS document and our experience at other MGP sites. The approach for selecting representative “sentinel” compounds, as presented in the DHFS document, is based on the fact that there are many different VOCs potentially present in MGP wastes and that the selected compounds should “be based on both the risk imparted by a compound’s prevalence and toxicity, as well as the analytical ability to detect these compounds”. The action levels were obtained from Table 4 of the Wisconsin Guidance document and are based on the DHFS recommended maximum 24-hour average concentration.

Table 2 Action Levels – Time Integrated Samples (Property Line)

Compound	Wisconsin Action Level (24 hour average)	RIDEM AAL (24 hour)	Proposed Action Levels (24 hour average)³
Benzene	10 ppb	6.2 ppb	6.2 ppb
Toluene	94 ppb	80 ppb ⁴	80 ppb
Ethylbenzene	230 ppb	692 ppb	230 ppb
Xylenes	23 ppb	692 ppb	23 ppb
Naphthalene	20 ppb	0.6 ppb ⁵	20 ppb

In the event time integrated perimeter sampling results indicate levels in excess of these action levels, the on-going activities will be shutdown and engineered controls and work practices will be re-evaluated in consultation with RIDEM prior to re-initiating on-site work. As indicated below, these time integrated sampling results will be available 24-48 hours after collection.

³ Action levels represent the lower of the DHFS and RIDEM AAL with the exception of naphthalene. DHFS action level for naphthalene is based on a subchronic exposure which is more appropriate for these shorter duration efforts than the AAL for naphthalene which is based on chronic exposure assumptions.

⁴ RIDEM does not have a 24-hour AAL for toluene. This value based on RIDEM annual AAL for toluene.

⁵ The listed 24 hour AAL for naphthalene is based on chronic exposure assumptions.

MEANS AND METHODS FOR REAL-TIME AND TIME INTEGRATED MONITORING

Real-Time Monitoring

The real time air monitoring is designed to measure site-related airborne constituents, namely volatile organic compounds (VOCs) and respirable particulate (PM10). Real-time methods for monitoring particle bound PAHs do not exist, thus particle levels will be used as a surrogate for PAHs. The equipment associated with the real time air monitoring are field photoionization detectors (PIDs) for TVOCs and continuous respirable particle monitors.

Volatile Organic Compound (VOC) Air Monitoring

During the activities described herein, the real-time air monitoring equipment will be maintained at the site to monitor VOC concentrations associated with the site remedial/maintenance activities. During these activities, a PID will provide continuous air quality measurements from sampling locations upwind and directly downwind of the work zone and the Site perimeter. Perimeter locations will be selected based on wind direction and the location of the nearest potential sensitive receptors. The real time air quality measurements will be compared to the action levels presented in Table 1 (after subtracting background concentrations) in order to assess the need for implementation of engineering controls and/or modifications to work practices. If the total VOC action level is exceeded, the contractor will be informed, potential sources of the exceedance will be investigated and, if appropriate, mitigation activities will be initiated. In addition, an exceedance of the TVOC Action Level downwind of the work zone will trigger the analysis of a time integrated sample from the site perimeter (see Time Integrated Monitoring discussion below).

Volatile organic substance concentrations will be measured utilizing a portable photoionization detector (Photovac 2020 PID) or equivalent. The PIDs measure volatile organic compounds by passing the air sample past an analytical detector and electronically measuring the resulting response. The PIDs are configured to respond to total organic compounds without any differentiation as to individual compound concentrations. The limit of detection is 10 parts per billion by volume (ppbv). The PID will be operated in accordance with manufacturers specifications.

Respirable Particulate Matter (RPM10) Perimeter Air Monitoring

As described above, real-time monitors for PAHs do not exist. Therefore, respirable dust will be measured as an indirect measure of ambient PAH levels.

Direct-reading real-time particulate meters (DustTrak) will be used to monitor for particulate (or dust). The measurement of dust levels is accomplished using infrared electromagnetic radiation to sense airborne particles. The dust meter will be configured to respond only to dust particles < 10 micron in diameter (PM10). The limit of detection is 1 ug/m³ (microgram per cubic meter). The DustTrak will be operated in accordance with manufacturers specifications.

Gas Chromatographs (benzene) Supplemental Monitoring

Real time benzene concentrations will be measured utilizing a portable field gas chromatograph (Photovac Voyager GC). The GC measures volatile organic compounds by passing an air sample through a series of analytical columns to separate individual compounds and then by an analytical detector, which electronically measures the resulting response and compares it to a known concentration response of each compound of interest. The GC will be calibrated to a known concentration of benzene each day prior to monitoring activities. The detection limit for benzene is 10 parts per billion (ppb). The GC will be operated in accordance with manufacturers specifications.

Time Integrated Monitoring

Time integrated air quality samples will be collected at the perimeter, at an upwind and a downwind location in order to document ambient levels of target VOCs presented in Table 2 of this plan using US EPA approved sampling and analytical methods. Samples will be collected daily during intrusive activities. Samples will be submitted for analysis if the results of the first tier, real time air quality monitoring (at either the work zone or the perimeter location) indicates an exceedance of the established action level presented in Table 1. In addition, regardless of the results of the real-time monitoring, at least one set of time integrated samples will be collected during each activity. Analyses will be performed by an accredited off-site analytical laboratory demonstrating proficiency for the specific methods stated in this section. The laboratory results will be available 24 to 48 hours after collection.

Volatile Organic Compounds

At a minimum, two VOC samples, one upwind and one downwind, will be collected during each day when intrusive activities are being performed. One additional sample will be used as a field blank and will be submitted along with the field samples to the laboratory. The sampling locations will be chosen based on actual and predicted wind conditions for the sampling day. VOC samples will be collected using SUMMA stainless steel canisters in conjunction with US EPA Method TO-15 GC/MS Full Scan, as presented in “The Compendium of Methods for the Determination of Toxic Organic Compounds in the Ambient Air”. The VOC samples will be analyzed for the compounds presented in Table 2 by an off-

site certified laboratory. The SUMMA canister method consists of the collection of a whole air sample into an evacuated stainless steel canister. The canister is passively filled with sample air via a mass flow controller which allows for uniform filling of the canister over the eight hour sampling period.

Documentation and Reporting

The real time field data and any time integrated sampling results will be maintained by GZA on-site. In addition, this air monitoring data will be presented in completion reports submitted to RIDEM for each effort.

Attachment: Health-based Guidelines for Air Management, Public Participation, and Risk Communication During the Excavation of Former Manufactured Gas Plants” prepared by Wisconsin Bureau of Environmental and Occupational Health, Department of Health and Family Services (DHFS) dated August 24, 2004

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**Health-based Guidelines for
Air Management, Public Participation, and Risk Communication
During the Excavation of Former Manufactured Gas Plants**

**Wisconsin Bureau of Environmental and Occupational Health
Department of Health and Family Services
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August 24, 2004

Wisconsin DHFS: Manufactured Gas Plant Air Guidance

Health-based Guidelines for Air Management, Public Participation, and Risk Communication During the Excavation of Former Manufactured Gas Plants

Robert Thiboldeaux and Henry Nehls-Lowe, Wisconsin Bureau of Environmental and Occupational Health, Department of Health and Family Services

Introduction

Purpose and intended audience. The purpose of this guidance is to provide public health expectations and recommendations for managing air quality at the perimeter of manufactured gas plant (MGP) cleanup sites in order to minimize exposure to the public.

This guidance is intended for project managers, representing both environmental regulatory agencies and private consultants, who are working with MGP remediations. Environmental consultants and contractors having a range of experience with MGP work have undertaken MGP projects in Wisconsin. This experience ranges from MGP remediation specialists using state-of-the-art techniques to more generalized environmental consultants and contractors working on small MGP sites, perhaps as one component of a much larger construction project. Similarly, DNR project managers have a range of experiences. Most work on a variety of remediation projects, but because there are relatively few MGP sites in the state, may be involved in a MGP project for the first time.

This guidance is also intended to complement information on MGP remediation already available to the Energy and Environmental industries. *Management of Manufactured Gas Plant Sites* (GRI 1996), in limited circulation from the Gas Research Institute, is an extensive introduction to MGP technical issues. Much of the information in this guidance is at least topically referenced in the GRI text. This guidance expands on emerging technical and regulatory issues related to air quality and air management around MGP sites, with emphasis on public health.

Manufactured gas plants in Wisconsin. Manufactured gas plants operated in Wisconsin from the late 1800s to the mid-twentieth century. These facilities produced fuel gas comprised of methane, hydrogen, carbon monoxide, nitrogen, and other gases produced (Buckley 1983, GRI 1996) by heating coal, steam and coke, or steam and oil. In Wisconsin, some of these former manufactured gas plant (MGP) sites retain original buildings; others have since been converted to other uses but still have subsurface MGP wastes. Coal tars, light oils, and inorganic wastes typically found in soil, sediment, and groundwater near former MGPs are an environmental and public health concern.

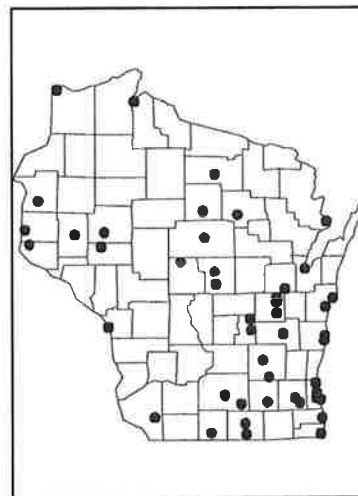


Figure 1. Former Manufactured Gas Plants are found throughout Wisconsin

DHFS role in evaluating former MGP sites. The Wisconsin Department of Health and Family Services (DHFS) supports the long-term public health and environmental benefits of MGP remediations, but recognizes the potential for short-term environmental health problems caused by the clean-up work. To prevent health problems, DHFS provides technical advice to the lead regulatory agency, usually the Wisconsin Department of Natural Resources (DNR), on public health issues related to MGP projects. DHFS also participates in statewide policy discussions conducted by the DNR manufactured gas plant team. The DNR has identified more than forty five sites in Wisconsin (Figure 1) for investigation and possible remediation. The type and extent of contamination, as well as the remediation challenges, vary with the size of the original operation, the gas manufacturing process used, and the physical geography of the remediation site. Most of these sites are in locations that are now urban areas or town centers. The proximity of residences and business to these sites presents the additional challenge of avoiding exposure hazards to the public during cleanup work.

Identification of air impacts as a key public health concern during MGP remedies. In Wisconsin, people have been exposed to MGP-related hydrocarbons through contact exposure to tar-contaminated surface water and sediment, through contact with subsurface tars by workers digging trenches, and by inhalation of volatile organic hydrocarbons (VOCs) released during excavation. In addition, the ingestion of well water contaminated with MGP wastes is a potential threat that is being monitored at some MGP sites in Wisconsin. Of the identified exposure pathways, the release of hydrocarbons to air during remediation work has the greatest potential to affect the general public. MGP-related contaminants may become airborne during removal, either through volatilization, or dispersed as soil dust. People who live or work nearby can be affected by air containing these substances. Nationwide, there has been increased emphasis on emissions control and air monitoring during MGP cleanups (Pluhar 2004). The recommendations proposed here seek to minimize the public's exposure to airborne contaminants from MGP sites.

Odor vs. safety: nuisance vs. measurable health effects. An important topic of this paper is its address of odor control at MGP sites as a public health issue. Air monitoring data from MGP sites in Wisconsin indicates that site managers have been generally successful at maintaining federal standards and guidelines for safe ambient air quality. Unfortunately, even at safe levels for VOCs and particulates, strong tar odors may still be evident. The gap between safe and "odor free" can affect public acceptance of an MGP project, especially when there are neighbors with either a real or perceived increased health risk from airborne exposure to MGP wastes. When MGP sites are excavated in sensitive public locations, it is advisable to extend air management of volatile compounds beyond existing health and environmental guidelines, and set air management targets that are closer to odor thresholds. DHFS recognizes that this is technically challenging and not always feasible. However, leading environmental consultants and utility companies conducting MGP projects in Wisconsin have been responsive to the goal and the challenges of controlling tar odors. This guidance does not advocate for specific air management targets beyond existing standards and guidelines. But, as a practical public health and community relations' goal, DHFS believes that neighbors of MGP excavation

and treatment projects should be able to escape tar odors within the refuge of their homes when doors and windows are closed. Meeting this practical goal will sometimes entail adopting stringent site management methods and increased emphasis on community outreach.

Developing an Air Management Plan

The Air Management Plan (AMP) lays out the key factors related to the project and surrounding area that influence the potential for air quality problems. The Air Management Plan can be considered in four parts. 1) Identify, and communicate with, the nearby population that could be affected by air quality from the site. 2) Establish measurable and protective air quality goals and action levels based on contaminant concentrations and distance from community members. 3) Identify the appropriate monitoring methods for the contaminants of concern. 4) Plan the overall project to minimize air quality impacts, and develop an action plan of responses to be taken when action levels are exceeded. Air management issues of this nature are inherently complex, making it important to have a contingency plan with feedback and response loops that detect and accommodate changing or unforeseen conditions.

Conceptual Air Management Plan. Responsible parties and their consultants are encouraged to contact state environmental and health agencies early in the project planning process to discuss a conceptual plan of the project. Contacting interested agencies at the conceptual stage allows ideas to be presented and concerns to be raised before investing effort in plans that might require extensive revision. This is especially true for unusual projects or for parties new to the State of Wisconsin. The development of cooperative, helpful relationships with agency staff is an added benefit in any remediation project.

Community Involvement

Informing neighborhoods and building public acceptance for MGP remedies. Most environmental consultants have a good deal of experience planning the logistics of a cleanup. Characterizing community interests that relate to air management can be a more complicated process. It is important to identify as much as possible where the nearest residents or workers will be with respect to the cleanup. Pay close attention to the locations of sensitive populations such as schools, hospitals, daycare centers, or nursing homes. The air management plan is designed to protect each of these populations from unhealthy exposures to contaminants from the cleanup project. The characteristics of the nearby population will play a role in decision-making when scheduling the project dates, operating times of day, planning truck routes, on- or off-site treatment, as well as the locations and types of perimeter air monitoring that would be conducted.

Public outreach is important *prior to* and *during* any MGP site remediation, both to avoid problems and alleviate concerns. Public meetings and literature should permit the public to anticipate odors and other air emissions, and their effects. Fact sheets and public meetings can be used to inform the public of site activities. Special efforts should also be made to identify and inform sensitive or less mobile people in the affected area.

Regulatory requirements for community involvement. In Wisconsin, parties responsible for contaminated sites, including former MGPs, have requirements under Chapter NR 714.07(1-6) of the Wisconsin Administrative Code for public information and participation (see <http://www.legis.state.wi.us/rsb/code/nr/nr700.html>). Each responsible party must evaluate the need for informing the community about the contaminants and the cleanup plan, and then decide on the best methods for sharing the information with the public. This may include posting signs, holding meetings, developing fact sheets, sending letters, etc. Further, if the DNR determines that these activities are not adequate, the department may require the responsible party to conduct specific public information activities. In addition, state and local officials such as DNR, DHFS, the local Health Department, and local government may choose to conduct public information activities. These activities might be conducted independently from, or in cooperation with, the activities required of responsible parties. Cooperative efforts between responsible parties and environmental, health, and government officials can be challenging, but ultimately builds credibility and accelerates community acceptance of the MGP remediation project.

Benefits of risk communication. Despite the long-term public health benefits of the remediation of former MGPs, there is often public concern over possible health effects from air releases during the clean-up work. Such concerns speak directly to public acceptance of MGP remediations, and sometimes results in organized resistance to particular projects. Risk communication efforts should anticipate community concerns, should seek to provide credible and authoritative information, and recognize the community as a stakeholder in local environmental quality with a right to community self-determination. State and local health departments are staffed with people trained in environmental risk communication who are available to assist, where appropriate, with public information activities. The responsible party may also choose to develop a local representative to serve as a credible point-of-contact and liaison to the public. For resources on risk communication, see bibliography.

Points of contact from public. A 24-hour phone number should be available to public and businesses so they can call with questions or complaints. To be most responsive to the community, the phone “hotline” should request specific information from callers, such as weather conditions, an odor description, and any health symptoms. The hotline should also tell the caller what would be done with the information they provide. Site managers need to immediately follow-up on air incidents and odor complaints in order to ensure that complaints have been appropriately treated and to avoid repeat events.

The point-of-contact representing remediation management should maintain, in the form of a phone log, a record of the public’s phone inquiries and complaints. The phone log should note the contractor’s response to each inquiry, and should be available to

regulatory inspection, to be submitted at the project's completion along with the other permanent records of the work.

Identifying, accommodating, and communicating with individuals with special needs.

One of the public health challenges associated with MGP remediation projects is to identify and accommodate neighbors who are extremely sensitive to the VOCs released from soil and groundwater. In Wisconsin, MGP site managers are usually quite successful in limiting air releases to within the safe levels agreed upon in air management plans. However, maintaining these safe levels may not preclude the presence of coal tar odors. These odors can be irritating, and people vary in their tolerance of odor and their perceived risk from exposure (Dalton *et al.* 1997, Dalton 1996). Other people may have conditions such as bronchitis, emphysema, or asthma (see DHFS 2001 for prevalence) that present additional unknowns from low level exposure. To address these unknowns, DHFS recommends first, that every effort be made to mitigate coal tar odors beyond established standards and guidelines such that nearby residents can not smell odors indoors when doors and windows are closed. Second, prior to the excavation, every individual within a close radius (approximately 200-400 yards, depending upon the site) of the excavation should be personally informed of the work by letter or phone call. This contact should inform neighbors that air quality will be maintained at safe levels, but if they have any preexisting health condition that is a concern, then they may contact the health department and/or their physician for advice. The information provided must be clear and sufficient to allow individuals to self-identify their need to seek additional advice. The points-of-contact representing both the responsible party and local health should be mutually aware of any individuals responding with advance concerns. Third, responsible parties should have advance agreement with local health officials over how they will accommodate individuals reporting actual health complaints ranging from a nuisance odor to acute respiratory effects. Such accommodation might range from simple advice and reassurance (close windows, dispatch technician with PID to home) to providing temporary relocation where necessary.

Accommodating individuals, particularly involving relocation, is a public risk perception challenge. People may become concerned unnecessarily because they want to be treated equally and may not recognize individual needs. Also, it is difficult to evaluate individual needs that may only manifest as a temporary discomfort or irritation to the evaluator, but may be intolerable to the complainant. For these reasons, health concerns and complaints raised after excavation commences should also be directed to a physician. Health departments and other stakeholders should be prepared to provide descriptions of the MGP project to physicians that will help them evaluate exposure. Stakeholders should have advance agreement of the accommodations that will be made following a physician's recommendation. Such agreements may require extended discussions among stakeholders of possible complaint scenarios, but at sensitive locations where complaints are expected, advance discussions and agreements will ultimately help the remediation to proceed smoothly.

Reporting. DHFS, DNR, and the Local Health Department should receive weekly reports by email or fax during MGP remediation work. These reports should include the status of site activities, perimeter air monitoring data & reports, daily exposure air monitoring

reports, calls or contacts about odor or health questions or complaints from the public and nearby businesses, and a copy of air monitoring logs from the portable air sampling program.

DNR, DHFS and the Local Health Department should be directly notified by phone or email if there are health or odor complaints, or if site activities result in air conditions that exceed agreed-upon “alarm” conditions. Also, someone with access to the air-monitoring log should be available at all times to address odor complaints from the public. The air management plan should include details for a 24-hour emergency telephone line to take calls from the public or from regulatory agencies. Records of these calls should be maintained to include who, what, why, and the response to each call. Part of the planned response to odor complaints should be to dispatch a portable instrument to the site of the complaint in order to verify there is a problem or to provide reassurance that odors are within safe levels. The log should include all readings collected during the perimeter monitoring, samples collected (when and where), and actions taken in response to any high values.

Other important avenues of communication. Environmental contractors should continually strive to improve site management. In particular, communication between contractors and subcontractors, via the site Health and Safety Officer, should ensure that defined protocols are followed.

DHFS recommends following completion of the site remedy, that DNR project managers debrief their regional member of the MGP team to discuss lessons learned with regard to air management.

Airborne Contaminants of Concern at MGP Remediation Sites

Major components, of MGP wastes found in soil and groundwater. MGP sites are typically contaminated with a complex mixture of coal tars and inorganic wastes (Table 1; Figure 2). These residual process or coal tars are primarily represented by 500 to 3000 separate polycyclic aromatic hydrocarbons (PAHs) of three to six benzene rings, phenolics, volatile organic compounds (VOCs), and inorganic compounds of sulfur and nitrogen (Hatheway 2002). MGP production wastes also included large quantities of ammoniacal liquors (spent condensation waters of coal gas plants), and gas liquors (spent condensation waters of carburetted water gas plants). Also common were tar sludges removed from the sumps of the condensation devices. MGP oxide box wastes contain high concentrations of sulfur oxides and metal cyanides (Luthy *et al.* 1994). Groundwater contamination by light oils and tars is also common, depending upon the location and method of disposal of MGP wastes, and the depth and confinement of perched water and groundwater aquifers at individual sites. Many former MGPs were sited along waterways that now have public access. At a number of such sites in Wisconsin, DHFS has observed MGP exposed oxide box wastes in soils, and coal tar and

oil sheens around soil, sediments, and surface water that are a direct-contact human health concern.

VOCs. A variety of volatile and semi-volatile hydrocarbons have been reported in soil and groundwater investigated at former MGP sites (Table 1). For example, total VOCs in groundwater have been observed to exceed 400 mg/L at Wisconsin MGP sites (Dames and Moore 2000). The VOCs typically found to exceed DNR groundwater standards (Wisconsin Administrative Code *ch.* NR 140) are benzene, ethylbenzene, naphthalene, xylenes, styrene, and toluene.

Benzene and naphthalene are key VOC residuals. Of the VOCs found in airborne releases from excavation of MGP sites, benzene is the compound that typically drives public health concerns. The exposure limit of benzene is low enough to solely define the regulated toxicity of the MGP-related VOC mixture, and MGP air management decisions and action levels should focus on the potential for benzene release. Benzene, a by-product of coal coking or gas manufacturing processes, has both known human carcinogenicity (EPA class A) and high volatility (vapor pressure 75 mm Hg, 20°C) (ATSDR 1997).

Naphthalene is another key compound of concern during MGP excavations. The volatility and toxicity of naphthalene are lower than benzene, although more similar to benzene than to other major VOCs (Table 2). The low odor threshold of naphthalene makes the presence of coal tar evident at low concentrations.

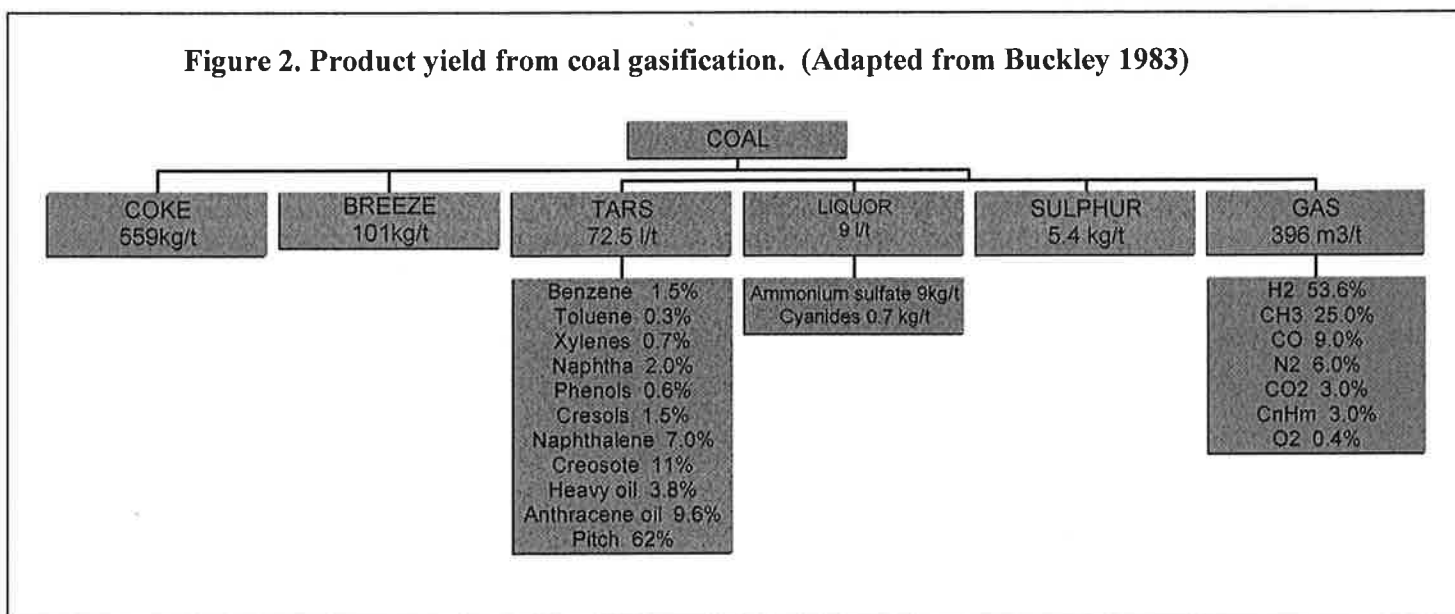
Monitoring naphthalene alongside VOCs requires additional work. Naphthalene is not detected quantitatively in EPA method TO-14/15 (SUMMA can samples; EPA 1999b), photo-ionization detectors (PID) calibrated for total VOCs, or particulate monitoring. In addition, losses during sampling render standard PUF plug sampling ineffective. Quantitative detection of naphthalene requires EPA method TO-13 (EPA 1999a) using a combination PUF/XAD2 collection medium or equivalent. Instantaneous readings of naphthalene can be made using a portable gas chromatograph with surface acoustic wave detector (GC/SAW) or another portable GC with a column suitable for naphthalene.

Particulates. Particulate matter, or PM, is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets (EPA, 2003a). Particulates, especially those from combustion sources, are solid mixtures of hydrocarbons, minerals, metals, and inorganics such as NO_x and SO_x. Particulates should be regarded not as inert dust but rather as chemical mixtures that have toxicological effects when inhaled. The high concentration of PAHs in MGP-contaminated soil makes the airborne dispersal of these waste soils a topic of interest and concern.

Potential sources of respirable (< 2.5µm: PM_{2.5}) and inhalable (< 10 µm: PM₁₀) particulates dispersed during MGP remediations include the handling of excavated PAH-contaminated soil, construction vehicle exhaust, construction road dust, PAH contaminated soil stockpiles, treated stockpiles, and potentially from malfunctioning thermal desorber stack emissions. Maintaining each of these sources to workplace and public health standards entails a combination of site management and air monitoring

techniques. Perhaps most important is anticipating dry, windy conditions that disperse stockpiles. In Wisconsin, occasional problems have occurred around MGP sites where winds have dispersed particles and odors from pretreated stockpiles awaiting thermal desorption. In these cases, irritating odors in nearby buildings were resolved using surfactant controls on stockpiles and closing building openings where necessary. With experience, site managers can anticipate and prevent such problems. For example, at a summer MGP excavation in an urban residential location in Wisconsin, site managers found it prudent to cease excavation work during hot or windy afternoons to avoid potential air releases that would generate complaints from the public.

Figure 2. Product yield from coal gasification. (Adapted from Buckley 1983)



PAHs. Polycyclic aromatic hydrocarbons are a diverse group of hydrocarbons that comprise a large proportion of MGP wastes (Figure 2). PAHs are also a focal component of the particles targeted in the NAAQS. The PAHs commonly studied in the environmental literature and included in environmental reports from MGP sites are 2-6 ringed, with molecular weights in the range of 128-300 (Boström *et al.* 2002). The actual breadth of PAH structures present in MGP wastes is probably much greater (Hathaway 2002) if included are little-studied larger molecular weight structures, PAHs with side-chain substituents, and PAHs with sulfur- or nitrogen-containing rings. The tendency of PAHs to disperse ranges from semi-volatile (e.g. naphthalene, vapor pressure 0.08 mm Hg;), to non-volatile structures that are dispersed via surface adsorption to particulate matter. A number of PAHs are toxic following their oxidation to a corresponding reactive structure (ATSDR 1995, Boström *et al.* 2002). Activation to a reactive structure can occur through photooxidation in the case of skin contact, or metabolically in the case of ingestion or inhalation. Benzo(a)pyrene (B(a)P) is one of several PAHs that form

reactive, tumorigenic metabolites. B(a)P is the prototypical PAH in toxic equivalency comparisons, although several authors assign higher toxic equivalency factors (TEF) to dibenzo[*a,h*]pyrene, dibenzo[*a,i*]pyrene, dibenzo[*a,l*]pyrene, and dibenzo[*a,h*]anthracene (ATSDR 1995, Boström *et al.* 2002). Most of our lifetime exposure to PAHs occurs from ambient sources such as diesel exhaust; consequently PAHs are listed as one of the six major air pollutants targeted for reduction in ambient air by the national ambient air quality standards (NAAQS) of the clean air act (U.S. EPA 2003a). The current federal standard for particulate matter (PM₁₀) is 150 micrograms per cubic meter (µg/m³) of air averaged over 24 hours and 50 µg/m³ averaged over a one-year period. PAHs in excavated tars and tar-contaminated soils at MGP sites clearly have the potential to temporarily affect local air quality if allowed to disperse. All MGP remediation projects should include air management plans to control the dispersal of PAHs in excavated tars, tar-contaminated soil, and soil stockpiles awaiting treatment or transport.

Air standards for PAH particulates. Limiting the dispersion of PAHs is of primary concern during MGP remediation. However, as noted above, particulates released at MGP remediation sites are a mixture of substances representing the range of wastes and sources on site. The 150 µg/m³ PM₁₀ NAAQS is designed to address this variety of potential particulate sources. From a public health standpoint, the NAAQS is an appropriate air quality goal for the MGP site perimeter, and is more useful than, for example, a modification of the OSHA standards for carbon black, coal dust, or silica. A perimeter action level used to meet the NAAQS for particulates should be based on short-term exposure limit. A public health-based, short-term exposure limit for generic particulates is not widely used. Based on the ACGIH (2003) industrial recommendation of 10 mg/m³ for inhalable particles and an uncertainty factor of 10 (for sensitive humans), a short term (15 minute) exposure limit of 1 mg/m³ for inhalable (PM₁₀) particles is protective of public health. The action level for particulates that has been used at several MGP sites in Wisconsin is also 1 mg/m³, although this action level was derived from standards for lead-contaminated soil (GZA, 2000). Although this action level for particulates has been empirically acceptable in most respects, it has the shortcoming of serving as a surrogate for monitoring naphthalene. Structurally, naphthalene is a PAH, but functionally is a VOC. Particulate measurements are not adequate to monitor naphthalene, a major component of MGP wastes, or other semi-volatile PAHs. See further discussion below under *Contaminants of Concern: VOCs*.

Metals. Metals, especially iron, are found in contaminated soils at MGP sites. Other metals found could include lead, arsenic, etc. The amount of these metals at MGP sites varies with the gas manufacturing process and with subsequent uses of these properties. These metals are nonvolatile but are potentially dispersed as inhalable and respirable particles. DHFS review of metal concentrations in soil data from MGP sites indicates that the public is adequately protected from metal exposure when dust control measures are followed and ambient air quality standards (PM₁₀) for particulates are met. Further public health review might be necessary at sites having extensive metal contamination from more recent activities.

Cyanides. Cyanide wastes at MGP sites exist mostly as stable iron cyanide complexes, such as ferric ferrocyanide, which are associated with oxide box wastes common to coal gas sites. A small percentage (< 5%; Luthy *et al.* 1994) of the total cyanide-containing waste is in the form of less stable metallo-cyanides and cyanide salts. The potential for free cyanides to be released from these materials into groundwater is a topic that has received both scientific and regulatory attention (Ghosh, *et al.* 1999a, 1999b; EPA 2003d). The release of cyanide to air at MGP sites is theoretically possible, but because such releases would occur from very slow dissociation of iron cyanides followed by rapid volatilization and dissipation, this is unlikely to be an exposure issue. DHFS has identified no public health concern from cyanide exposure to the general public at the site perimeter. Still, prudent management of worker safety at MGP sites suggests that cyanide should be monitored in air within the work zone when Prussian Blue soils are encountered.

Table 1. Composition of MGP wastes (From Gas Research Institute 1996). Chemicals in bold have been found to be an environmental or public health concern in soil, sediment, and groundwater at MGP sites in WI.

Inorganics	Metals	VOCs	Phenolics	PAHs
Ammonia	Aluminum	Benzene	Phenol	Acenaphthene
Cyanide	Antimony	Ethyl	Methyl	Acenaphthylene
Nitrate	Arsenic	Benzene	phenol	Anthracene
Sulfate	Barium	Toluene	Dimethyl	Benzo(a)anthracene
Sulfide	Cadmium	Xylenes	Phenol	Benzo(a)pyrene
Thiocyanates	Chromium	Styrene		Benzo(b)fluoranthene
	Copper			Benzo(g,h,i)perylene
	Iron			Benzo(k)fluoranthene
	Lead			Chrysene
	Manganese			Dibenzo(a,h)anthracene
	Mercury			Dibenzofuran
	Nickel			Fluoranthene
	Selenium			Fluorene
	Silver			Indeno(1,2,3-cd)pyrene
	Vanadium			Naphthalene
	Zinc			Phenanthrene
				Pyrene
				2-Methylnaphthalene

Sulfur compounds. Sulfur-containing compounds, produced by pyrolysis or combustion of coal, are common in soil and groundwater at MGP sites. This is especially true in oxide box wastes, which may contain 40% sulfur oxides (Luthy *et al.* 1994). Pulmonary

damage from sulfur-containing materials, particularly sulfur dioxide (ATSDR MRL=10ppb), are well known (Kleinman 2003) but have not been well addressed as an air issue during MGP remediations. Sulfides (S^{2-} ; metal-sulfur compounds), sulfates (SO_4^{2-} ; compounds of oxygen and sulphur combined with one or more metals), and sulfites, where present, are predictably dispersed with soil and dust particles during MGP excavations. At this time, DHFS recommends that non-volatile sulfur compounds be managed in the context of NAAQS for particles discussed above.

Table 2. Toxicity, odor, volatility, and relative prevalence of major volatile compounds in air at MGP sites.

	Toxicity RBC ppb ^a	Odor threshold ppb ^b	Vapor pressure mmHg, 68F	Prevalence in air at one example MGP site ^c	
				Excavation (total volatiles= 4103 $\mu\text{g}/\text{m}^3$)	Perimeter (total volatiles = 1117 $\mu\text{g}/\text{m}^3$)
Benzene	10	61,000	75	21.7%	7.7%
Naphthalene	0.6	40	0.08	46.3%	6.3%
Xylenes	23	20,000	7	11.5%	56.4%
Toluene	106	1,600	21	8.3%	17%
Styrene	235	140	5	Not reported	Not reported
Ethylbenzene	230	100-600	7	11.9%	12.5%

^aEPA, *Integrated Risk Information System, 2004*. Reference concentration chronic inhalation.

^bAIHA 1989

^cCollins *et al.* 1999

Developing Air Quality Goals and Action Levels

Recommended sentinel compounds. Many different volatile chemicals are present in MGP wastes, but on-site air management decisions are usually based on the monitoring of just a few of these (Collins *et al.* 1999). The choice of representative sentinel compounds in an air management plan should be based both on the risk imparted by a compound's prevalence and toxicity, as well as the analytical ability to detect these compounds. The odor threshold of particular VOCs also factors into their inclusion as a sentinel compound, since tar odors around MGP excavations speaks directly to public risk perception surrounding the remediation work. MGP projects often extrapolate from the fuel spill model, choosing the BTEX group (benzene, toluene, ethylbenzene, xylenes) as representative VOCs. Other candidate sentinel compounds should be considered, based on environmental assessment. For example, groundwater from an MGP test well

in Wisconsin having 23,000 µg/L total VOCs included, as prevalent compounds, benzene (29%), naphthalene (31%), xylenes (17%), styrene (6%), and toluene (12%) (Dames and Moore 2000). Other PAHs, including acenaphthene, fluorene, anthracene, fluoranthene, and pyrene comprise a small percentage of volatile chemicals detectable in air (Collins *et al.* 1999). DHFS recommends choosing sentinel compounds at each remediation based on prior environmental assessment. However, based on prevalence, toxicity, volatility, and odor, benzene and naphthalene tend to define the volatile mixture around MGP sites (Table 2). Notably, the proportion of each of the major volatiles may not be the same in the excavation zone as at the perimeter (Table 2), indicating the need for separate air monitoring in the work zone and the perimeter. The minimum perimeter air monitoring recommended by DHFS would include total VOCs and benzene, using instruments sensitive to intermediate and maximum action levels defined in the site air management plan.

Development of action levels

Action levels vs. ambient air standards. During the review of air management plans (AMP) at MGP sites in Wisconsin, there has been discussion over the term “Action Level.” There has also been much discussion of whether action levels should be created as policy benchmarks for MGP work. Some of this discussion is clarified by defining action levels as distinct from an air quality standard or guideline. For the purposes of public health, action levels proposed within an air management plan are a site management tool used to maintain existing air quality standards and guidelines at the unsecured perimeter. These ambient (daily and annual) air quality standards and guidelines already exist for common VOCs and particulates.

There is no single set of ambient air quality rules for compounds of concern at MGP sites. The ambient air goals recommended by DHFS are a combination of enforceable standards (*e.g.* National Ambient Air Quality Standards; NR 445 Ambient Air Standards) and non-enforceable guidelines (*e.g.* ATSDR Minimal Risk Level; EPA Risk-Based Concentration). The NAAQS for total particulates (PM₁₀, 24 hour average) is 0.150 mg/m³. The guideline numbers for VOCs (Table 4) are presented where federal or state standards are absent. These guidelines are health-based environmental concentrations below which no harm is expected to the general public.

DHFS relies on existing ambient air standards and guidelines when asked to evaluate air monitoring plans and air monitoring data for MGP projects. The efficacy of action levels proposed in the AMP is ultimately defined by their ability to meet established standards and guidelines at the site perimeter. The action levels needed to protect public health could vary with the distance from the unsecured perimeter to the excavation, with the distance from the perimeter to stationary receptors such as residences or businesses unrelated to the MGP, with the time of year, and with the sensitivity and frequency of the monitoring program. Table 3 lists action levels that have been used successfully to maintain ambient air quality at several sites in Wisconsin. These action levels were used at sites using minimal air monitoring and sampling, and having low population density at

the site perimeter. DHFS recommends that these action levels be used as a starting point in developing the site AMP. However, higher concentration action levels have been used (GZA 2003) to maintain air quality in urban residential settings, but using sophisticated real-time air monitoring techniques. In either case, DHFS would make the same recommendation: maintain 24-hour ambient air quality within existing health-based standards and guidelines, and further reduce nuisance odors as needed to meet community health needs and avoid odor complaints.

Two other points to consider in developing the AMP are first, that air management performance must be verified with time-weighted (8 or 24 hour) air sampling. Second, it is likely that during the excavation of coal tars, air quality will intermittently exceed the ambient air goals for periods that are brief enough to still maintain ambient air quality over the 24-hour cycle. Assuming the site will be managed to keep peak releases brief, these brief releases should still be held within some “maximum.” Occupationally, this maximum would correspond to either a ceiling value or a 15-minute time-weighted average (TWA). But, no formal brief exposure standards exist for the general public that would correspond to the 15-minute occupational TWA. However, using an uncertainty factor of 10 for extrapolating from “normal” to “sensitive” humans, intermittent releases should not exceed, at the perimeter, one-tenth of the 15-minute time weighted average for either specific compounds or total VOCs. Table 4 contains recommended 15-minute maximum concentrations for perimeter air quality.

Air management plan action levels should provide immediate feedback needed to minimize air releases from the site. A prescribed set of site-specific responses should be proposed to accompany each action level. Table 3 lists a simple set of responses. Many AMPs use a more detailed decision tree or flow chart that integrates the various factors that enter into site management decisions (*e.g.* Lingle *et al.* 2000, Symonik *et al.* 1999). Environmental consultants and site managers are encouraged to develop and employ action levels that focus on achieving odor control rather than merely staying within short-term and 24-hour air standards.

DHFS recommends that air management plans use both intermediate and maximum action levels (Table 3). The response to exceeding an intermediate action level would be to monitor continuously and begin steps to mitigate air releases. Exceeding a maximum action level should result in immediately ceasing work until the air release is controlled. Continuing the excavation or material handling might require a shift in work strategy, such as more stringent air management techniques, or working on another part of the project until cooler or less windy conditions prevail. The use of intermediate action levels can be used to more closely anticipate releases and establish protocol for intermediate air management responses that will help avoid work stoppages.

Background exposure to VOCs. The development of action levels should consider that many MGP components have a background presence in ambient air. Background monitoring should be conducted prior to any excavation. The development of action levels should consider that public exposure VOC and PAH releases during excavation of MGP sites will rarely be zero due to the background presence of VOCs and PAHs. For

example, in St. Paul, Minnesota (Sexton *et al.* 2004), personal air samplers placed on 71 non-smoking adults revealed that during normal daily activities, these adults were exposed to benzene (7.6 $\mu\text{g}/\text{m}^3$), toluene (30.3 $\mu\text{g}/\text{m}^3$), and xylenes (27.8 $\mu\text{g}/\text{m}^3$).

Occupational guidelines are inappropriate air quality goals at the MGP site perimeter. Another point occasionally requiring clarification is the gap between occupational and public health standards. Occupational standards are designed for exposures of workday duration to healthy, non-pregnant adults. Public health standards account for sensitive individuals and longer exposure duration. In some cases public health standards are extrapolated from occupational standards; in other cases they are based upon separate experimental models. Perimeter action levels should trigger steps to maintain public ambient air quality while occupational standards should be used for air management decisions in the worker breathing zone. Unadjusted TLVs for ambient air at or beyond the perimeter of any site are not sufficiently protective of public health, whether the site is in a residential or commercial setting.

Table 3. Recommended range of action levels and interventions for perimeter air quality at former manufactured gas plant excavations.

Air Monitoring Location	Recommended DHFS Action Level (ppm)	Recommended Interventions When Action Levels are Reached or Exceeded
VOCs at Site Perimeter	0.1 to 1.0 total VOCs	-worker breathing protection -test for benzene
Benzene at Site Perimeter	0.1 to 0.5 benzene	-halt site activities
Particulates at Site Perimeter	0.150 to 1.0 mg/m^3 total particulates	-initiate dust control measures

Air Monitoring Methods

Perimeter air monitoring should be a part of the work plan at every MGP remediation site. The site workplan should include an air sampling protocol including: 1) location of sampling stations, 2) the sampling interval, 3) target substances (or surrogate), 4)

detection limit of target substances, 5) the action level and planned response for each target substance, 6) meteorologic conditions concurrent with sampling.

Air monitoring techniques for the MGP site perimeter. Although perimeter air monitoring should be a part of the work plan at every MGP remediation site, there is no single air monitoring approach best suited or appropriate for all sites. A number of methods are available, ranging from automated real-time gas chromatography to hand-held devices such as photoionization detectors. Automated gas chromatography has been used effectively to measure sentinel compounds around MGP sites and provide results in continuous 15 minute cycles. This feedback effectively teaches project officers how to manage their sites to avoid air emissions that affect both site workers and the off-site public. Real time air monitoring is particularly useful at sites that are technically complex and densely populated. Because of the cost and complexity of such a system, hand-held instruments may be appropriate at sites that are small, isolated, or where the duration of the excavation is relatively brief. To be useful for air monitoring at the site perimeter, the detection limit of the method used should be less than the intermediate action level agreed upon in the site Air Monitoring Plan. Alternatively the detection limit should be 2.4% of the occupational 8-hour time-weighted average for the substance being monitored, where 2.4% extrapolates from work week to full time exposure and incorporates a 10-fold uncertainty factor (40 hr/160 hr x 1/10 = 2.4%).

Table 4. DHFS-recommended 24-hour and short-term perimeter air quality values for MGP remediation sites.

	Acceptable 24-hour average concentration (ppb)	DHFS- Recommended Maximum	
		15 minute (ppb) ^d	Peak (ppb) ^f
Benzene	10 ^a	500	2,500
Naphthalene	20 ^b	15,000	*
Xylenes	23 ^a	15,000	*
Toluene	94 ^a	30,000	50,000
Styrene	235 ^a	10,000	20,000
Ethylbenzene	230 ^a	12,000	*
PM ₁₀	0.150 mg/m ³ ^c	1.0 mg/m ³ ^e	*

^a U.S. EPA reference concentration (RfC) for lifetime exposure.

^b DHFS-derived 14-day acute exposure.

^c National ambient air-quality standard for PM₁₀ (particulate matter < 10 um).

^d One-tenth of corresponding U.S. Occupational Safety and Health Administration value except where specified.

^e ACGIH

^f One-tenth of corresponding American Conference of Governmental Industrial Hygienists value.

*Occupational value not available.

ppb: parts per million

Instrumentation

Drager tubes. Drager tubes and similar single-use chemical detection tubes have limited application for perimeter air monitoring at MGP sites. Because of limited sensitivity, short shelf life, and high variability, they are best used semi-quantitatively, such as to determine if a specific contaminant is present. They are not recommended to measure the air contaminant concentrations at the site perimeter needed for making action level decisions (GRI 1996). Additional analysis is needed for any positive contaminant hit on a Draeger Tube. Detection limits published for compound-specific Draeger Tubes are: benzene (0.5 ppm), toluene (50 ppm), xylenes (10 ppm), styrene (1 ppm) (AFC International Inc. 2003. <http://www.afcintl.com/tubeac.htm>)

Photo-Ionization Detector. Hand-held photo-ionization detectors (PID) capable of detecting 1 ppb total organic vapors or 100 ppb benzene are commercially available, and are more sensitive and easier to use than gas detection tubes. Of particular note are benzene-specific PIDs. Because benzene at low concentrations (50 ppb; Table 3) often defines the toxicity of the MGP-related VOC mixture, low-concentration field screening for both benzene and total VOCs is recommended

Laboratory analysis using SUMMA canister samples. Up-wind and down-wind ambient air sampling for VOCs using EPA Method TO-14 or TO-15 from SUMMA canister samples (EPA 1999b) at locations where site perimeter monitoring with a PID detects greater than 0.5 total VOCs. In most cases, an up-wind and down-wind sample should be collected for VOCs at least once every three days regardless of the PID measurements.

Particle monitoring. Consistent with monitoring VOCs, monitoring particulates should employ a combination of real-time techniques for making action level decisions and time weighted techniques to verify compliance with NAAQS. A variety of separation and capture techniques are available for time-weighted sampling, including cyclonic separators, cascade impactors, and filters. Portable and semi-portable particle meters are available for instantaneous readings. An issue responsible parties should be aware of is the current shift from PM₁₀ to PM_{2.5} as the NAAQS. At this time, DHFS and DNR recommend continued use of the Federal Reference Method (FRPS 1287-065 or equivalent; U.S. EPA 2003c) for PM₁₀ as more appropriate for construction-phase activities at MGP sites, and continued use of the 1 mg/m³ action level.

Portable GC/MS. Gas chromatography/mass spectroscopy (GC/MS) has seen increasing use during MGP remediations. Semi-portable automated GC/MS systems have been developed that send results, over a 15 minute cycle, to a central monitoring location (GZA, 2000). Several GC/MS stations, placed around the perimeter of an MGP remediation, are used to simultaneously monitor an entire site, and to provide real-time feedback for making air management decisions. This system is expensive to employ, and the overall air mitigation performance is less than that of an enclosure. However, for sites where stringent air management is needed, but an enclosure is not possible, this is a useful method. GC/MS is also available in portable suitcase-sized units. A useful application of portable GC/MS is to provide sensitive field screening for VOCs in neighborhoods where there have been odor complaints. At some sites, local vagaries in

wind patterns raise the possibility that air releases are carried to locations not predicted by perimeter air monitoring. Portable VOC detection using GC/MS is a sensitive means to provide verification and reassurance to the public.

Gas Chromatography with Surface Acoustic Wave detector (GC/SAW) is a portable GC method that is sensitive to naphthalene and larger molecular weight volatiles and semi-volatiles. Field-portable GC/SAW instruments (e.g. zNose, Electronic Sensor Technology, Newbury Park, CA) have been promoted for use during MGP remediations (GEI 2004).

Mitigation Techniques

Seasonal timing. Seasonal timing of an MGP excavation can have an important effect on air management strategies. In Wisconsin, as in other temperate regions, excavating MGP sites during cold weather simplifies many of the public health issues related to the remediation work. During cold weather, exposed hydrocarbons are less volatile, neighbors keep windows and doors closed, and there is generally less foot traffic. Direct benefits to site managers include fewer odor complaints and less need for foam and surfactants for odor control. DHFS recognizes there are problems with extreme cold weather work, including machinery failure, work stoppages, and ice-fouled water lines. Odor control techniques become more complicated when overspray from surfactants or misting systems create icy roads, and when plastic sheeting becomes stiff and brittle. Of all of these factors, DHFS believes that the simple fact that doors and windows are closed in winter has the greatest effect on minimizing public perception of the odor issue, thereby increasing public acceptance of MGP remediation projects.

Dust and odor control methods. The use of dust and odor control methods at MGP sites is commonplace and includes some combination of water, physical barriers such as plastic sheeting, wind screens, surfactants, and other chemical coatings such as foams (GEI 1996, sec. 12.4.2; U.S. EPA. 2003b). Perimeter misting systems supplemented with odor-masking perfumes have recently been used in Wisconsin. Scents added to the mist mask low concentrations of objectionable VOCs, but do not remove these VOCs from air. The mist does prevent dispersion of particulates, but only to the extent that precipitation follows interception. During hot or windy conditions, dispersion may still occur. Control of releases from source areas is still the primary mitigation technique. These various techniques and systems vary in cost and applicability. Ultimately, their effective use depends on the experience and judgement of on-site managers.

Excavation methods are another technique for reducing dust and odors. Most often cited is minimizing the excavation face combined with odor-encapsulating foam. A special form of excavation is Cassion-drilling, in which large-diameter drills (6 feet or more) bring up contaminated soil which can be immediately stabilized with cement and replaced in the drill hole. In terms of causing air releases, this technique presents the contrast of vigorously churned material, which enhances release, combined with a

minimal and intermittent excavation face that limits air releases. At this time it is unclear how much air monitoring and dust and odor control is needed to ensure public safety when Cassion drilling is used.

Enclosure methods. Many former MGPs were located on sites that now see urban-density commercial or residential uses. Public acceptance of excavation work at such sites may require the most stringent methods to control air emissions. A temporary structure, combined with an air purification system, is often the most effective way to control emissions. Temporary structures can also effectively enclose certain operations, such as the on-site oxidative treatment of coal tar, which would not otherwise be possible. Temporary structures have several disadvantages, such as rental and installation costs, scheduling constraints, limited interior space, and requirements for respiratory protection (Pluhar 2004). During the limited use of enclosures at MGP sites in Wisconsin, DHFS has seen that air releases of VOCs and particulates have been controlled to within public health guidelines, but that coal tar odors can still be irritating to adjacent residents (DHFS 2002). Although the aim of using enclosures is to preclude the displacement of sensitive residents, project managers are advised to carefully evaluate whether a proposed enclosure will actually meet community needs. More recent developments in enclosure methods include “air lock” doorways that address a key weakness in enclosure design (Pluhar 2004). DHFS will review field performance reports of improved enclosure designs as they become available.

Establishing the on-site decision making process

Action Level response plan. Where MGP work is in close proximity to residences, odor and health complaints from the public should be anticipated. The health and safety plan or air management plan for each MGP remediation project should include contingency plans of actions that can be taken to intervene and prevent inhalation exposures to the public.

Contingency plan. MGP remediation consultants should anticipate that on certain days, it may not be possible to maintain ambient air quality with the tools they have available. In addition to stated actions when intermediate and maximum action levels are exceeded, the air monitoring plan for each site should include discussion of such contingencies. Contingencies might range from rescheduling site actions to offering temporary relocation of residents.

Summary

This guidance was developed both to protect public health around MGP remediation projects and to help those projects proceed smoothly. One key to effective air management and public outreach at MGP remediation sites is collaboration among public health, environmental agencies, and responsible parties. DHFS experience at MGP sites in Wisconsin was used to illustrate how to anticipate community health needs and to create partnerships with state and local health agencies during the course of the remediation. Because the amount of air management and public outreach needed varies

with each site, this guidance avoids being overly prescriptive. However, in order for health departments to approach the community with credibility, some minimum air management and community health goals are recommended.

Conclusions

- Air management plans at MGP remediations in WI have been largely successful in meeting 24-hour air standards and guidelines for ambient air.
- Even where 24-hour health-based standards and guidelines are met, tar odors are typically evident.
- The control of tar odors plays an important role in the public's acceptance of the MGP remediation project.
- At sensitive locations, building public acceptance for an MGP project entails a combination of public outreach efforts and a stringent air management plan.

Recommendations

- Air quality at the unsecured perimeter of MGP remediation sites should meet existing public health-based 24-hour standards and guidelines for ambient air.
- Site air management plans, including monitoring and mitigation methods, and action levels, should be designed to protect perimeter air quality.
- Neighbors of MGP excavations should be able to avoid tar odors within their homes with doors and windows closed. Meeting this goal should focus on site management, but might also entail special accommodations for neighbors.
- At locations when MGP work will affect the public, detailed plans should be developed for risk communication, accepting and responding to complaints from the public, and accommodating individuals with special needs. Developing these plans usually entails discussion and advance agreement among major stakeholders.

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Abbreviations used. VOC: volatile organic carbon. PAH: polycyclic aromatic hydrocarbon. ATSDR: Federal Agency for Toxic Substances and Disease Registry. MCL: ATSDR's Maximum contaminant Level. NAAQS: National Ambient Air Quality Standard. GC/MS: gas chromatography/mass spectroscopy. PM: particulate matter.



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