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8.1

CORRECTIVE ACTION STUDY REPORT

Arkansas City, Kansas

Former Manufactured Gas Plant Site

B&V PROJECT NO. 165406

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PREPARED FOR

Westar Energy

REVISED AUGUST 2013

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PREPARED FOR

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Professional Engineer under the laws of the State of Iowa.

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1.0 Introduction

This report documents the corrective action study (CAS) for the former manufactured gas plant (MGP) site in Arkansas City. It was prepared to summarize the process used to develop corrective action alternatives for the site. Black & Veatch (B&V) prepared this report for Westar Energy in accordance with Consent Order No. 94-E-0172 with the Kansas Department of Health and the Environment (KDHE 1994). The CAS was conducted following KDHE guidance document BER-RS-20, *Scope of Work for a Comprehensive Investigation/Corrective Action Study* (KDHE 2005a), the U.S. Environmental Protection Agency's (EPA's) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA 1988a), and Subpart E of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

1.1 PURPOSE AND ORGANIZATION OF THE CAS REPORT

The purpose of the CAS report is to develop and evaluate corrective action alternatives based on the findings and conclusions of previous investigations, to recommend and justify a specific corrective action for the site, and to determine the health and environmental effects of the corrective action. The CAS report contains the following information:

- Report purpose and site background information (Section 1.0).
- Corrective action objectives (Section 2.0).
- Applicable or relevant and appropriate requirements (ARARs) (Section 3.0).
- Corrective action alternative development (Section 4.0).
- Comparative analysis of corrective action alternatives (Section 5.0).
- References (Section 6.0).

1.2 SITE BACKGROUND

This subsection provides an overview of the site location and description, history, physical site characteristics, and nature and extent of contamination.

1.2.1 Site Location and Description

The site is located in south central Arkansas City in Cowley County, just west of the intersection of First Street and Quincy Avenue. The property occupies 1.43 acres in an area currently zoned for heavy industrial use, and is bounded by First Street to the east, railroad tracks and a canal to the west, and industrial properties to the north and south. The areas west and east of the MGP property are currently zoned as single family residential and general business districts, respectively, although both currently contain only residences. The properties to the north (Archer-Daniels Midland grain elevators) and south of the MGP site are zoned as a heavy industrial district.

The northern portion of the former MGP property is owned by the Unified School District 470 (USD 470) and is used for storage and maintenance of equipment. A brick storage building and a concrete block vehicle garage are present on the property. Most of the property is fenced and covered with grass and/or gravel. The southern portion of the former MGP property is owned by Tom Bay (Bay property) and includes two buildings currently used for storage. This property is covered with grass and is partially surrounded with a fence. The site map is presented on Figure 1-1.

1.2.2 Site History

The Arkansas City Gas and Electric Light Company and the Arkansas Valley Gas, Oil and Improvement Company produced manufactured gas by coal carbonization at the MGP between 1890 and 1905. Detailed information related to the volumes of gas produced, production processes, and other historical details is provided in the preliminary assessment report (BVWST 1993). Historical information indicates that the plant consisted of an operations building housing the retorts, purifying room, lime room, and other support operations; a gas holder; and two small support buildings (coal shed/pipe shop and an electrical supply house).

Sanborn fire insurance maps dated 1912 through 1947 show the gas plant building as being occupied by Beard's Foundry and Machine Works, and the gas holder no longer present after 1925. The 1947 Sanborn map indicates that the Kansas Gas and Electric Company constructed a supply and meter warehouse (current storage building) north of the foundry. The 1947 Sanborn map also shows a building labeled as an auto repair shop on the northwest portion of the property. The locations of the former gas plant structures are shown on Figure 1-1. None of the structures associated with the original gas plant are currently visible at the site, with the exception of a low stone wall along the south fence line of the USD 470 property that may be a footing for the former operations building.

1.2.3 Physical Site Characteristics

A canal located southwest of the MGP site receives storm water run-off from the City of Arkansas City and the site, which slopes downward to the southwest. The canal typically contains standing water, and can contain significant flows during rain events and flooding. The canal discharges to the Walnut River east of Arkansas City.

The subsurface materials encountered during site investigations include fill, alluvium, and limestone bedrock. The fill unit consists of both cohesive and granular materials generally less than four feet in thickness. The alluvium consists of both cohesive and granular materials, although cohesive materials were not encountered consistently across the site. When present, cohesive materials are suspended within the granular alluvium or overlying bedrock primarily in the western and southern portions of the site.

The bedrock surface is irregular, with the exception of the area near the storage building and the southeast corner of the former MGP property where the bedrock is relatively flat. The bedrock contains a depression to the southwest and a general dip to the northeast. The physical condition and strength of the limestone varies from fresh to extremely weathered with a high instance of fractures (B&V 2004).

The four site monitoring wells are screened in alluvial materials above the alluvium/bedrock interface. The depth to groundwater ranges from approximately 9 to 18 feet below ground surface (bgs). Groundwater flow in the alluvium is to the northeast in the western portion of the site, and to the east in the eastern portion of the site. These flow directions are opposite of the slope of the ground surface, which is to the west-southwest toward the canal, which is consistent with previous measurements presented in the Remedial Investigation (RI) Report (B&V 2003) and subsequent Groundwater Monitoring Reports (B&V 2005, 2006, 2007, and 2009).

The geometric mean of the hydraulic conductivities of the four wells is 4.1×10^{-5} centimeters per second. The calculation for the flow velocity within the saturated alluvium was based on the

geometric mean of the hydraulic conductivities, the hydraulic gradient between monitoring wells MW-2 and MW-3 (0.5 percent), and an effective porosity for poorly graded sand of 20 percent (Fetter 1992). The average horizontal groundwater flow velocity across the site within the saturated alluvium was calculated to be approximately 2 feet per year to the east-northeast. The hydraulic conductivity calculations are presented in the RI Report (B&V 2003).

Well survey records obtained from the Kansas Geological Survey (KGS) and KDHE indicate that 30 registered water wells are located within a one section radius (approximately 1 mile) of the site (KGS 2002). All but two of these wells are located between the site and the Arkansas River to the south and west.

Additional details on bedrock units, regional hydrology, surface water flow, sensitive environments, and wetlands are presented in the remedial investigation report (B&V 2003).

The canal, adjacent to the site to the west, discharges into the Walnut River downstream of Arkansas City. As shown on the cross-section on Figure 3-1A of the RI Report, the ground surface on site has a gradual slope toward the west. In contrast, the slope of the bedrock surface is to the northeast, as shown on Figure 3-2 of the RI Report. Bedrock is fairly shallow in the site area, is composed of limestone, and is part of an unconfined aquifer system with the alluvial unit overlying it. While groundwater flow often mimics the slope of the ground surface, the shallow bedrock underlying an alluvial unit interconnected with the Walnut River appears to have a greater impact on groundwater flow in the site area.

During heavy storm events, overland flow toward the canal is likely. Any surface water infiltration into the subsurface would migrate with the groundwater upon reaching the water table. Since surface water flow is toward the canal, run-off could reach the canal before infiltrating into the subsurface. The site is covered primarily with grass or gravel, with concrete foundations near the northeast and northwest corners. This surface covering prevents underlying soil to be carried along with surface water run-off. While it is possible that some soil could be transported along with the run-off, it would encounter grass, thick brush, and a tree line before reaching the canal. These barriers prevent soil erosion and inhibit soil from the site from reaching the canal.

1.2.4 Extent of Soil Contamination

Site investigations to determine the extent of MGP-related impacts to soil were conducted in 1993 and 2003. Figure 1-1 shows the location of soil probes advanced during these investigations, and Table 1-1 summarizes the concentrations of PAHs; benzene, toluene, ethylbenzene, and total xylenes (BTEXs); cyanide; and Resource Conservation and Recovery Act (RCRA) metals detected in soil samples representative of soil remaining on site. Sample locations within areas removed during the 2005 soil removal (refer to Section 1.2.5) are not included in the table.

Impacts likely associated with historical use of the site, including operation of the MGP and foundry, were found as well as petroleum fuel associated with a former leaking underground storage tank (LUST). Elevated levels of PAHs were detected in three probes (MW-2, SP-6, and SP-7) advanced south and west of the former gas plant.

Table 1-1 Residual Soil Concentrations Compared to KDHE RSK Values

Chemical	KDHE Tier 2 RSK Values (mg/kg)				Sample Location and Depth (feet bgs) (mg/kg)						
	Residential		Non-residential		MW-1		MW-2		MW-3		
	Soil	Soil to GW	Soil	Soil to GW	0.5 - 5.0	8.0 - 9.8	0.5 - 4.5	8.0 - 8.5	0.0 - 0.5	0.5 - 5.0	6.0 - 9.0
Arsenic	11.3	NA	38	NA	2.92	2.36	14.2	1.64	NA	ND	1.15
Barium	15300	NA	277000	NA	45.4	66.5	69	100	NA	62.7	81.9
Chromium	33.6	NA	111	NA	6.58	9.49	19.5	10	NA	7.81	9.87
Lead	400	NA	1000	NA	29.7	6.35	53.5	8.38	NA	6.25	8.15
Selenium	391	NA	10200	NA	ND	5.45	43.9	7.35	NA	6.39	9.09
Silver	391	NA	10200	NA	ND	ND	ND	ND	NA	ND	ND
Mercury	2	NA	20	NA	ND	ND	0.259	ND	NA	ND	ND
Cyanide	1560	NA	40900	NA	ND	ND	0.372	0.187	NA	ND	ND
Anthracene	18000	3770	221000	8180	ND	ND	95	ND	0.015	ND	ND
Benzo(a)anthracene	10.9	7.89	33.8	26.5	ND	ND	190	0.0075	0.054	ND	ND
Benzo(a)pyrene	1.09	23.5	3.38	23.5	ND	ND	120	0.0086	0.073	ND	ND
Benzo(b)fluoranthene	10.9	19.2	33.8	64.4	ND	ND	87	0.0057	0.052	ND	ND
Benzo(k)fluoranthene	109	190	338	638	ND	ND	62	ND	0.026	ND	ND
Chrysene	1090	805	3380	2710	ND	ND	180	0.0082	0.071	ND	ND
Dibenzo(a,h)anthracene	1.09	3.08	3.38	10.3	ND	ND	80	ND	ND	ND	ND
Fluoranthene	2440	2830	35200	15200	ND	ND	480	ND	0.13	ND	ND
Fluorene	2360	297	25900	626	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	10.9	45.5	33.8	153	ND	ND	ND	ND	0.083	ND	ND
Naphthalene	30.5	0.349	64.7	0.659	ND	ND	ND	ND	ND	ND	ND
Pyrene	1830	2190	26400	11900	ND	ND	370	0.0099	0.091	ND	ND
Benzene	15.9	0.168	28.2	0.168	ND	ND	ND	ND	ND	ND	ND
Toluene	4320	51.2	29800	51.2	ND	ND	ND	ND	ND	ND	ND

Table 1-1 Residual Soil Concentrations Compared to KDHE RSK Values (Continued)

Chemical	KDHE Tier 2 RSK Values (mg/kg)				Sample Location and Depth (feet bgs) (mg/kg)					
	Residential		Non-residential		MW-4			SP-2	SP-5	
	Soil	Soil to GW	Soil	Soil to GW	0.0 - 0.5	1.0 - 5.0	6.5 - 9.0	1.7 - 2.2	1.0 - 4.5	6.5 - 9.0
Arsenic	11.3	NA	38	NA	NA	11.5	2.52	NA	11	1.44
Barium	15300	NA	277000	NA	NA	235	114	NA	58.2	69.2
Chromium	33.6	NA	111	NA	NA	12.9	9.81	NA	11.2	7.99
Lead	400	NA	1000	NA	NA	371	7.79	NA	11.3	12.7
Selenium	391	NA	10200	NA	NA	41	9.18	NA	34.7	7.24
Silver	391	NA	10200	NA	NA	0.835	ND	NA	ND	ND
Mercury	2	NA	20	NA	NA	0.418	ND	NA	ND	ND
Cyanide	1560	NA	40900	NA	NA	ND	ND	NA	0.945	0.198
Anthracene	18000	3770	221000	8180	0.0082	0.056	ND	0.022	ND	ND
Benzo(a)anthracene	10.9	7.89	33.8	26.5	0.037	0.22	ND	0.062	0.0086	0.0095
Benzo(a)pyrene	1.09	23.5	3.38	23.5	0.059	0.32	ND	0.074	0.015	0.015
Benzo(b)fluoranthene	10.9	19.2	33.8	64.4	0.040	0.18	ND	0.057	0.013	0.010
Benzo(k)fluoranthene	109	190	338	638	0.020	0.12	ND	0.031	0.0065	0.0056
Chrysene	1090	805	3380	2710	0.045	0.27	ND	0.058	0.011	0.011
Dibenzo(a,h)anthracene	1.09	3.08	3.38	10.3	ND	0.29	ND	0.029	ND	ND
Fluoranthene	2440	2830	35200	15200	0.066	0.42	ND	0.093	0.016	0.014
Fluorene	2360	297	25900	626	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	10.9	45.5	33.8	153	0.068	0.042	ND	0.010	0.023	0.015
Naphthalene	30.5	0.349	64.7	0.659	ND	ND	ND	ND	ND	ND
Pyrene	1830	2190	26400	11900	0.040	0.34	ND	0.090	0.013	0.014
Benzene	15.9	0.168	28.2	0.168	ND	ND	ND	ND	ND	ND
Toluene	4320	51.2	29800	51.2	ND	ND	ND	ND	ND	ND

Table 1-1 Residual Soil Concentrations Compared to KDHE RSK Values (Continued)

Chemical	KDHE Tier 2 RSK Values (mg/kg)				Sample Location and Depth (feet bgs) (mg/kg)						
	Residential		Non-residential		SP-7		SP-8			SP-9	
	Soil	Soil to GW	Soil	Soil to GW	4.0 - 5.1	8.0 - 9.0	0.0 - 0.5	4.0 - 4.5	8.0 - 8.5	1.5 - 2.6	7.3 - 8.5
Arsenic	11.3	NA	38	NA	NA	NA	NA	NA	NA	ND	1.57
Barium	15300	NA	277000	NA	NA	NA	NA	NA	NA	72.8	98.2
Chromium	33.6	NA	111	NA	NA	NA	NA	NA	NA	8.72	11.7
Lead	400	NA	1000	NA	NA	NA	NA	NA	NA	25.2	8.47
Selenium	391	NA	10200	NA	NA	NA	NA	NA	NA	6.07	10.1
Silver	391	NA	10200	NA	NA	NA	NA	NA	NA	ND	ND
Mercury	2	NA	20	NA	NA	NA	NA	NA	NA	ND	ND
Cyanide	1560	NA	40900	NA	0.166	0.499	NA	NA	NA	ND	ND
Anthracene	18000	3770	221000	8180	ND	ND	0.016	0.024	ND	ND	ND
Benzo(a)anthracene	10.9	7.89	33.8	26.5	ND	ND	0.069	0.10	0.0063	ND	ND
Benzo(a)pyrene	1.09	23.5	3.38	23.5	ND	ND	0.069	0.12	0.0066	ND	ND
Benzo(b)fluoranthene	10.9	19.2	33.8	64.4	0.0042	ND	0.074	0.12	0.0074	ND	ND
Benzo(k)fluoranthene	109	190	338	638	ND	ND	0.032	0.062	ND	ND	ND
Chrysene	1090	805	3380	2710	ND	ND	0.073	0.10	0.0066	ND	ND
Dibenzo(a,h)anthracene	1.09	3.08	3.38	10.3	ND	ND	0.13	0.12	ND	ND	ND
Fluoranthene	2440	2830	35200	15200	ND	ND	0.11	0.18	0.012	ND	ND
Fluorene	2360	297	25900	626	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	10.9	45.5	33.8	153	ND	ND	0.14	ND	ND	ND	ND
Naphthalene	30.5	0.349	64.7	0.659	ND	ND	ND	ND	ND	ND	ND
Pyrene	1830	2190	26400	11900	0.0062	ND	0.12	0.15	0.017	ND	ND
Benzene	15.9	0.168	28.2	0.168	ND	ND	ND	ND	ND	ND	ND
Toluene	4320	51.2	29800	51.2	ND	ND	ND	ND	ND	ND	ND

Table 1-1 Residual Soil Concentrations Compared to KDHE RSK Values (Continued)

Chemical	KDHE Tier 2 RSK Values (mg/kg)				Sample Location and Depth (feet bgs) (mg/kg)						
	Residential		Non-residential		SP-10		SP-11		SP-12	SP-13	
	Soil	Soil to GW	Soil	Soil to GW	0.0 - 0.5	2.0 - 2.8	1.9 - 2.7	8.0 - 8.6	0.5 - 1.5	2.2 - 3.0	6.8 - 7.3
Arsenic	11.3	NA	38	NA	NA	NA	1.41	1.44	NA	1.24	1.57
Barium	15300	NA	277000	NA	NA	NA	85.8	83.1	NA	86.5	75.7
Chromium	33.6	NA	111	NA	NA	NA	9.45	7.98	NA	9.72	11.3
Lead	400	NA	1000	NA	NA	NA	11.7	7.32	NA	12.1	8.49
Selenium	391	NA	10200	NA	NA	NA	6.83	8.05	NA	8.15	9.87
Silver	391	NA	10200	NA	NA	NA	ND	ND	NA	ND	ND
Mercury	2	NA	20	NA	NA	NA	ND	ND	NA	ND	ND
Cyanide	1560	NA	40900	NA	NA	NA	ND	ND	NA	ND	ND
Anthracene	18000	3770	221000	8180	0.0059	ND	0.0046	ND	0.031	0.018	0.0078
Benzo(a)anthracene	10.9	7.89	33.8	26.5	0.036	0.47	0.029	ND	0.12	0.11	0.018
Benzo(a)pyrene	1.09	23.5	3.38	23.5	0.0071	0.57	0.035	ND	0.21	0.14	0.016
Benzo(b)fluoranthene	10.9	19.2	33.8	64.4	0.054	0.50	0.062	0.0041	0.15	0.18	0.014
Benzo(k)fluoranthene	109	190	338	638	0.017	0.27	0.0058	ND	0.079	0.088	0.0083
Chrysene	1090	805	3380	2710	0.022	0.40	0.019	0.0044	0.13	0.14	0.016
Dibenzo(a,h)anthracene	1.09	3.08	3.38	10.3	0.023	ND	0.033	ND	0.24	0.16	ND
Fluoranthene	2440	2830	35200	15200	0.028	0.71	0.015	ND	0.21	0.16	0.033
Fluorene	2360	297	25900	626	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	10.9	45.5	33.8	153	0.023	1.4	ND	0.0050	0.31	0.17	0.023
Naphthalene	30.5	0.349	64.7	0.659	ND	ND	ND	ND	ND	ND	ND
Pyrene	1830	2190	26400	11900	0.066	0.44	0.040	0.0072	0.14	0.14	0.036
Benzene	15.9	0.168	28.2	0.168	ND	ND	ND	ND	ND	ND	ND
Toluene	4320	51.2	29800	51.2	ND	ND	ND	ND	ND	ND	ND

Table 1-1 Residual Soil Concentrations Compared to KDHE RSK Values (Continued)

Chemical	KDHE Tier 2 RSK Values (mg/kg)				Sample Location and Depth (feet bgs) (mg/kg)						
	Residential		Non-residential		SP-14	SP-16		SP-17		SP-18	
	Soil	Soil to GW	Soil	Soil to GW	2.1 - 2.7	0.0 - 0.5	2.0 - 2.8	0.0 - 0.5	1.2 - 2.5	4.0 - 4.5	8.0 - 9.0
Arsenic	11.3	NA	38	NA	NA	NA	NA	NA	NA	NA	NA
Barium	15300	NA	277000	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	33.6	NA	111	NA	NA	NA	NA	NA	NA	NA	NA
Lead	400	NA	1000	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	391	NA	10200	NA	NA	NA	NA	NA	NA	NA	NA
Silver	391	NA	10200	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	2	NA	20	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	1560	NA	40900	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	18000	3770	221000	8180	0.0056	0.075	0.062	0.22	0.0078	0.028	0.0041
Benzo(a)anthracene	10.9	7.89	33.8	26.5	0.023	0.15	0.25	0.64	0.036	0.077	0.029
Benzo(a)pyrene	1.09	23.5	3.38	23.5	0.025	0.15	0.26	0.77	0.028	0.074	0.059
Benzo(b)fluoranthene	10.9	19.2	33.8	64.4	0.020	0.13	0.17	0.58	0.036	0.057	0.040
Benzo(k)fluoranthene	109	190	338	638	0.011	0.081	0.12	0.32	0.022	0.038	0.020
Chrysene	1090	805	3380	2710	0.028	0.14	0.24	0.82	0.030	0.061	0.036
Dibenzo(a,h)anthracene	1.09	3.08	3.38	10.3	0.036	0.15	0.24	1.0	ND	0.067	0.013
Fluoranthene	2440	2830	35200	15200	0.044	0.27	0.47	1.2	0.058	0.15	0.041
Fluorene	2360	297	25900	626	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	10.9	45.5	33.8	153	ND	ND	ND	0.80	0.037	0.038	0.10
Naphthalene	30.5	0.349	64.7	0.659	ND	ND	ND	ND	ND	ND	ND
Pyrene	1830	2190	26400	11900	0.039	0.80	0.34	0.95	0.038	0.097	0.035
Benzene	15.9	0.168	28.2	0.168	ND	ND	ND	ND	ND	ND	ND
Toluene	4320	51.2	29800	51.2	ND	ND	ND	ND	ND	ND	ND

Table 1-1 Residual Soil Concentrations Compared to KDHE RSK Values (Continued)

Chemical	KDHE Tier 2 RSK Values (mg/kg)				Sample Location and Depth (feet bgs) (mg/kg)						
	Residential		Non-residential		SP-23	SP-24	SP-25	F01	SW02	SW03	SW04
	Soil	Soil to GW	Soil	Soil to GW	1.0 - 5.0	1.0 - 5.0	1.0 - 5.0	13	11	11	11
Arsenic	11.3	NA	38	NA	NA	NA	NA	NA	NA	NA	NA
Barium	15300	NA	277000	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	33.6	NA	111	NA	NA	NA	NA	NA	NA	NA	NA
Lead	400	NA	1000	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	391	NA	10200	NA	NA	NA	NA	NA	NA	NA	NA
Silver	391	NA	10200	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	2	NA	20	NA	NA	NA	NA	NA	NA	NA	NA
Cyanide	1560	NA	40900	NA	ND	ND	NA	NA	NA	NA	NA
Anthracene	18000	3770	221000	8180	0.110	ND	ND	ND	ND	0.1	ND
Benzo(a)anthracene	10.9	7.89	33.8	26.5	0.443	0.0136	0.0154	0.017	ND	0.075	0.090
Benzo(a)pyrene	1.09	23.5	3.38	23.5	0.352	0.0126	0.019	0.012	ND	0.055	0.098
Benzo(b)fluoranthene	10.9	19.2	33.8	64.4	0.468	0.0166	0.0131	0.010	ND	0.046	0.095
Benzo(k)fluoranthene	109	190	338	638	0.222	ND	0.00613	0.006	ND	0.028	0.053
Chrysene	1090	805	3380	2710	0.463	ND	ND	0.015	ND	0.069	0.10
Dibenzo(a,h)anthracene	1.09	3.08	3.38	10.3	0.203	ND	0.0104	ND	ND	ND	ND
Fluoranthene	2440	2830	35200	15200	0.678	ND	ND	0.05	ND	0.28	0.2
Fluorene	2360	297	25900	626	ND	ND	ND	ND	ND	0.08	ND
Indeno(1,2,3-cd)pyrene	10.9	45.5	33.8	153	0.255	0.0106	ND	0.009	ND	0.046	0.10
Naphthalene	30.5	0.349	64.7	0.659	ND	ND	ND	ND	ND	0.1	ND
Pyrene	1830	2190	26400	11900	0.872	0.0231	0.0158	0.04	ND	0.2	0.2
Benzene	15.9	0.168	28.2	0.168	ND	0.00709	0.0131	ND	NA	NA	NA
Toluene	4320	51.2	29800	51.2	ND	0.00623	0.0131	ND	NA	NA	NA

Notes:

1) In locations where primary and duplicate samples were collected, the highest concentration reported is shown.
2) Soil samples not collected from all probes for chemical analysis (SP-19, SP-20, SP-21, SP-22, SP-33).
3) Shaded cells indicate concentrations above KDHE Tier 2 RSK value (latest edition).
4) No chemicals detected in probes SP-1 (4-4.5', 8-8.5'), SP-2 (8-9'), SP-3 (4-4.6', 9-9.6'), SP-4 (2-2.8', 8.6-9.3'), SP-10 (6.5-7.2'), SP-12 (8-8.8'), SP-14 (8-9'), SP-15 (2.5-3.5', 8-9') SP-16 (8.5-9.8'), SP-17 (6-7.4').
5) Probes SP-6, SP-7, SP-26, SP-27, SP-28, SP-29, SP-30, SP-31, and SP-34 were located within excavated areas. Probe SP-7 samples in table were collected at depths greater than excavation depth.

The PAH contamination is related to either MGP operations or residuals associated with the foundry that operated in the former gas operations building. Shallow material across the southern site area contains slag and cinder, including locations where the majority of the PAH detections occurred in the southern portion of the site. Visible contamination and odors related to petroleum fuel were encountered in several soil probes in the general area of the LUST that historically contained gasoline. The LUST was removed from the USD 470 property in 1990. Figure 1-2 shows the location of the former LUST.

At soil probe MW-2, located southwest and hydraulically upgradient of the former LUST area, fuel odors were observed but no visible contamination was evident. Slag and cinders were encountered in the upper two feet of the probe. Eleven PAHs were detected in the shallow subsurface soil sample at concentrations ranging from 62 mg/kg of benzo(k)fluoranthene to 480 mg/kg of fluoranthene. PAHs were only detected at concentrations near detection limits in the deep soil sample collected from the same location. Concentrations of RCRA metals were also elevated in the shallow sample. Concentrations of arsenic (14.2 mg/kg), chromium (19.5 mg/kg), and selenium (43.9 mg/kg) were greater in this sample than any collected elsewhere at the site. Because of the lack of visible contamination throughout the large sample interval, the concentrations exceeding RSKs may reflect the slag and cinders in the sample, and not general subsurface conditions from 0 to 5 feet bgs.

At probe SP-6, tar-coated fill materials were encountered from 9.2 to 13.2 feet bgs and slag and cinder fill material were present at 9 feet bgs. Probe SP-6 appears to have been advanced into a possibly man-made pit. Based on the lack of visible contamination and elevated levels of PAHs in the probes advanced around probe SP-6 (SP-20, SP-21, SP-22, and MW-5), the contamination was isolated. The presence of a large interval of slag and cinders in this probe and its proximity to the former retort room suggest that by-products of manufactured gas production or residuals associated with the former foundry were placed at this location. The tar observed in probe SP-6 is most likely related to former gas operations, and possibly to the above ground gas holder formerly located to the northeast. Concentrations of the 12 PAHs detected in this sample ranged from 140 mg/kg of benzo(k)fluoranthene to 4,800 mg/kg of naphthalene. This soil sample was collected from 12.0 to 12.6 feet bgs in fill materials (not granular alluvium) consisting of tar-coated slag. PAHs were also detected at this location in the shallow (2.0 to 2.5 feet bgs) subsurface soil sample at concentrations ranging from 3.1 to 9.5 mg/kg.

The surface soil sample collected from probe SP-7 contained chrysene at a concentration (8.3 mg/kg) that exceeded the RSK levels for benzo(a)pyrene (6.1 mg/kg) and dibenzo(a,h)anthracene (5.7 mg/kg) also exceeded the RSK levels. Fill material has reportedly been placed into this area for several years because it continues to sink. Therefore, the PAHs detected in the near surface soil at this location are probably not related to former MGP or foundry operations, particularly if the fill materials are from an offsite source.

The only RCRA metal to be detected at a concentration exceeding the RSKs was arsenic. Shallow samples from the soil probes for wells MW-2 (0.5 – 4.5 feet) and MW-4 (1.0 – 5.0 feet) contained arsenic at concentrations of 14.2 and 11.5 mg/kg. The residential RSK for arsenic is 11.3 mg/kg. The MW-2 sample was collected from an interval containing cinder and slag.

No soil samples contained cyanide at concentrations above the RSKs. The highest concentrations were detected in the probe advanced within the former purifying room as would be expected.

Cyanide residuals are primarily associated with the gas purification process used for the coal carbonization (GRI 1996).

1.2.5 2005 Soil Removal

In August 2005, approximately 79 tons of soil were removed from areas around probes SP-6 and SP-7 containing PAH concentrations exceeding RSK levels. Since PAH levels in the shallow soil did not exceed RSK levels at probe SP-6, uncontaminated overburden from the SP-6 area excavation (0 to 9 feet bgs) was used as backfill after the removal (KDHE 2010). Contaminated soil and other materials were excavated from 9 to 13 feet bgs in the SP-6 area and blended with the one foot of soil removed from the SP-7 area. The excavated material was transported to the Clean Harbors Lone Mountain Landfill in Waynoka, OK, for disposal.

During excavation in the SP-6 area, a rectangular structure (possibly a tar holder) was encountered. The concrete floor of this structure present at a depth of about 12 feet was removed, revealing clean sand beneath the floor. The east and west walls of the structure were also removed, while the northern wall was left intact because probe SP-21 (located approximately 8 feet north of the northern excavation limit) did not indicate any visible evidence of contamination in the area. No southern wall was encountered.

Soil confirmation samples collected from the walls and base of the SP-6 excavation indicate that residual soil contains PAHs at concentrations below the RSK levels for both residential and non-residential scenarios with the exception of two PAHs in the primary sample of a primary/duplicate sample pair collected from the south excavation wall. Concentrations of these compounds in the SW-01 duplicate sample are below both the residential and non-residential RSKs. The discrepancy between the primary and duplicate sample concentrations is likely associated with the heterogeneous nature of soil, which can result in relative percent differences (RPDs) between primary and duplicate samples of greater than 50 percent. For benzo(a)pyrene, the average of the primary and duplicate SW-01 sample results (1.17 mg/kg) is less than the RSK residential value of 1.2 mg/kg. For indeno(1,2,3-cd)pyrene, the average value of the sample pair (0.79 mg/kg) is higher than the residential and non-residential RSK value of 0.76 mg/kg. Figure 1-2 shows the locations of confirmation samples collected following excavation. Figure 1-3 shows a cross-section view of the excavation area in relation to the site. Figures 1-4 and 1-5 show cross-section views of other areas of the site.

In October 2005, an additional 41 tons of soil were removed from the south end of the SP-6 excavation. Further excavation was performed to remove the soil in the area where sample SW-01 was collected and to find the southern wall of the structure. No wall and no visible contamination were encountered. However, a concrete and brick foundation (likely remnants of the former retort structure) was visible in the upper 3 feet of this excavation at the USD 470 property line. Confirmation sample SW-04 was collected from the final southern excavation sidewall. The results from this sample were below both the residential and non-residential RSK values. Soil was removed from beneath the foundation approximately two feet beyond the property line. The excavated soil was also transported to the Clean Harbors landfill.

1.2.6 Extent of Groundwater Contamination

Six rounds of groundwater samples were collected from the four site monitoring wells between 2003 and 2009. Table 1-2 summarizes the analytical data results associated with these sampling events for PAHs, BTEXs, total and amenable cyanide, and RCRA metals. The complete data results are presented in historical reports (B&V 2003, 2004, 2006, 2009, BVWST 1993).

In general, concentrations of MGP-related chemicals have decreased over time. BTEXs have not been detected in any wells since 2003. Historically, PAHs have been detected in wells MW-2 (June 2004, October 2005, and April 2006) and MW-5 (July 2003) at concentrations exceeding residential RSKs. PAHs have never been detected in wells MW-1 and MW-3, and no PAHs have been detected in well MW-5 since 2003. However, because current analytical laboratory technology is not capable of reaching detection limits as low as the RSK for dibenzo(a,h)anthracene, it is possible that this PAH may be present in the groundwater at concentrations exceeding the RSK. Review of the most recent groundwater data collected in 2007 and 2009 show a continued trend in the decrease of PAH concentrations in well MW-2, with no concentrations exceeding the RSKs.

Total and/or amenable cyanide have periodically been detected in wells MW-2 and MW-3, consistently detected in well MW-5, and never detected in well MW-1. In May 2009, the only well to contain total and amenable cyanide was well MW-5 in both the primary and duplicate samples. The primary and duplicate samples contained total cyanide at 0.98 mg/L, and amenable cyanide at 0.68 and 0.75 mg/L, respectively. The concentration of amenable cyanide is above the RSK level for free (amenable to chlorination) cyanide of 0.2 mg/L. The 2009 total cyanide level is lower than historical levels. Cyanide concentrations in well MW-5 have fluctuated between 0.152 and 0.9 mg/L between June 2004 and May 2009, with the highest concentrations detected in April 2007. The 2009 amenable cyanide concentrations are higher than detected in October 2007, but comparable to concentrations detected in April 2007.

Total and dissolved arsenic have not been detected since 2003. In 2009, total and dissolved cadmium, chromium, lead, mercury and silver were not detected. Total and dissolved barium were detected in all wells, ranging from 0.04 to 0.209 mg/L. Both total and dissolved selenium were detected (0.019 mg/L) in well MW-5. No concentrations exceed the residential RSK levels.

Analytical data from 2007 and 2009 demonstrate that concentrations of PAHs in well MW-2 are decreasing, MGP-related contamination is not migrating off site, and the levels of cyanide in well MW-5 are low and isolated. This is supported by the following:

- Contaminated soil and isolated source material (tar residuals) were removed from two MGP-impacted areas in 2005.
- No highly concentrated MGP residuals remain at the site based on the 2005 removal and the probing activities completed in the areas of probe SB-6 and well MW-2, although low-level residual soil contamination remains on site as presented in Table 1-1.
- Soil sampling in the area of well MW-5 and the former purifying room indicate non-detects or concentrations near the detection limits for cyanide.
- No PAHs have been detected above the residential RSK levels in any monitoring well since 2006.
- No PAHs, BTEXs, or amenable cyanide have ever been detected in the downgradient monitoring well MW-3.

Table 1-2 Summary of Groundwater Monitoring Data

Parameter	Non-Res RSK	Res RSK	MW-1							MW-2						
			7/11/03	6/29/04	10/17/05	4/18/06	4/2/07	10/18/07	5/27/09	7/11/03	6/29/04	10/17/05	4/18/06	4/3/07	10/18/07	5/27/09
BTEXs (µg/L)																
Toluene	1,000	1,000	<0.29	<0.125	<0.15	<5	<5	0.18J	0.07J	<0.29	<0.125	<0.15	<5	<5	0.14J	<0.06J
Total Xylenes	10,000	10,000	<0.28	<0.233	<0.4	<10	<10	0.15J	<0.1J	<0.28	<0.233	<0.4	<10	<10	0.10J	<0.1J
PAHs (µg/L)																
Anthracene	1,150	2,500	<2.6	<0.024	<0.21	<0.8	<0.6	<0.004	<0.004J	<2.6	<0.024	<0.21	<0.5	<0.5	0.005J	0.008J
Benzo(a)anthracene	0.75	0.223	<1.8	<0.032	<0.02	<0.2	<0.1	0.02J	<0.01J	<1.8	0.618	0.3	0.2	<0.1	0.03J	0.07J
Benzo(a)pyrene	0.2	0.2	<1.5	<0.033	<0.02	<0.2	<0.1	<0.007	<0.007J	<1.5	0.449	0.3	0.2	<0.1	0.04J	0.095J
Benzo(b)fluoranthene	0.543	0.16	<1.9	<0.016	<0.03	<0.2	<0.1	<0.03	<0.003J	<1.9	0.602	0.4	0.2	<0.1	0.03J	0.07J
Benzo(g,h,i)perylene	None	None	<2	<0.016	<0.06	<0.2	<0.1	<0.008	<0.008J	<2	0.152	0.2	0.2	<0.1	0.02J	0.044J
Benzo(k)fluoranthene	5.43	1.62	<1.2	<0.033	<0.02	<0.2	<0.1	<0.02	<0.02J	<1.2	0.244	0.2	0.1	<0.1	<0.02	0.04J
Chrysene	75	22.3	<1.6	<0.03	<0.68	<0.2	<0.1	0.02J	<0.02J	<1.6	<0.03	0.4	0.2	<0.1	0.03J	0.05J
Dibenzo(a,h)anthracene	0.027	0.00805	<1.9	<0.029	<0.05	<0.2	<0.1	<0.02	<0.02J	<1.9	<0.029	<0.05	<0.1	<0.1	<0.02	<0.02J
Fluoranthene	1,370	255	<1.9	<0.044	<0.23	<0.3	<0.2	<0.02	<0.1J	<1.9	0.466	0.9	0.9	<0.2	0.09J	<0.1J
Fluorene	341	162	<2.9	<0.099	<0.55	<0.3	<0.2	<0.03	<0.03J	<2.9	<0.099	<0.55	<0.2	<0.2	<0.03	<0.03J
Indeno(1,2,3-cd)pyrene	0.392	0.117	<1.6	<0.041	<0.02	<0.2	<0.1	<0.03	<0.03	<1.6	<0.041	0.4	0.3	<0.1	<0.01	0.08J
Naphthalene	2.11	1.11	<0.22	<0.124	<0.2	<1.6	<1	<0.07	<0.07J	<0.22	<0.124	<0.2	<1	<1	<0.07	<0.07J
Phenanthrene	None	None	<2.6	<0.025	<0.88	<0.8	<0.6	0.008J	<0.003J	<2.6	0.121	<0.88	<0.5	<0.5	0.01J	0.029J
Pyrene	1,090	202	<2	<0.034	<0.38	<0.3	<0.2	0.04J	<0.003J	<2	0.772	0.5	0.3	<0.2	0.05J	0.105J
Inorganics (mg/L)																
Dissolved Arsenic	None	None	NA	<0.0038	NA	NA	<0.01	0.003J	<0.002J	NA	<0.0038	NA	NA	<0.01	0.003J	<0.002J
Total Arsenic	0.01	0.01	0.013	<0.0038	NA	NA	<0.01	<0.0018	<0.002J	<0.0024	NA	NA	<0.01	<0.01	0.002J	<0.002J
Dissolved Barium	None	None	NA	NA	NA	NA	NA	NA	0.194	NA	NA	NA	NA	NA	NA	0.066
Total Barium	2	2	0.144	NA	NA	NA	NA	NA	0.209	0.342	NA	NA	NA	NA	NA	0.070
Dissolved Cadmium	None	None	NA	NA	NA	NA	NA	NA	<0.0003J	NA	NA	NA	NA	NA	NA	<0.0003J
Total Cadmium	5	5	<0.59	NA	NA	NA	NA	NA	<0.0003J	<0.59	NA	NA	NA	NA	NA	<0.0003J
Total Chromium	0.1	0.1	0.0182	NA	NA	NA	NA	NA	0.002J	<0.00034	NA	NA	NA	NA	NA	0.002J
Amenable Cyanide	0.2	0.2	NA	NA	NA	NA	<0.02	<0.02	<0.006J	NA	NA	<0.06	<0.02	<0.02J	<0.02	<0.006J
Total Cyanide	None	None	<0.002	NA	NA	NA	<0.02	<0.006	<0.006J	<0.002	NA	<0.006	<0.02	0.03J	0.015J	0.011J
Dissolved Lead	None	None	NA	NA	NA	NA	NA	NA	0.0029J	NA	NA	NA	NA	NA	NA	0.001J
Total Lead	0.015	0.015	<0.002	NA	NA	NA	NA	NA	0.0029J	<0.002	NA	NA	NA	NA	NA	0.0018J
Dissolved Mercury	None	None	NA	NA	NA	NA	NA	NA	0.00008J	NA	NA	NA	NA	NA	NA	0.0001J
Total Mercury	0.002	0.002	<0.000021	NA	NA	NA	NA	NA	<0.00003J	<0.000021	NA	NA	NA	NA	NA	<0.00003J
Dissolved Selenium	None	None	NA	NA	NA	NA	NA	NA	0.003J	NA	NA	NA	NA	NA	NA	<0.002J
Total Selenium	0.05	0.05	<0.0265	NA	NA	NA	NA	NA	0.002J	<0.0265	NA	NA	NA	NA	NA	<0.002J
Dissolved Silver	None	None	NA	NA	NA	NA	NA	NA	<0.001J	NA	NA	NA	NA	NA	NA	<0.001J
Total Silver	508	77.9	<1.6	NA	NA	NA	NA	NA	<0.001J	NA	<1.6	NA	NA	NA	NA	<0.001J

Table 1-2 Summary of Groundwater Monitoring Data (Continued)

Parameter	Non-Res RSK	Res RSK	MW-3								MW-5									
			7/11/03	6/29/04	10/17/05		4/18/06	4/3/07	10/17/07	5/27/09	7/11/03		6/29/04		4/3/07		10/17/07		5/27/09	
					P	D					P	D	P	D	P	D	P	D	P	D
BTEXs (µg/L)																				
Toluene	1,000	1,000	<0.29	<0.125	<0.15	<0.15	<5	<5	0.21J	<0.06J	<0.29	<0.29	<0.125	<0.125	<5	<5	0.15J	0.12J	<0.06J	<0.06J
Total Xylenes	10,000	10,000	<0.28	<0.233	<0.4	<0.4	<10	<10	0.14J	<0.1J	<0.28	<0.28	<0.233	<0.233	<10	<10	0.17J	0.10J	<0.1J	<0.1J
PAHs (µg/L)																				
Anthracene	1,150	2,500	<2.6	<0.024	<0.21	<0.21	<0.05	<0.6	<0.004	<0.004J	<2.6	<2.6	<0.024	<0.0038	<0.5	<0.5	0.008J	0.005J	0.008J	0.018J
Benzo(a)anthracene	0.75	0.223	<1.8	<0.032	<0.02	<0.02	<0.1	<0.1	<0.01	<0.01J	<1.8	<1.8	<0.032	<0.032	<0.1	<0.1	0.02J	<0.01	0.02J	0.04J
Benzo(a)pyrene	0.2	0.2	<1.5	<0.033	<0.02	<0.02	<0.1	<0.1	<0.007	<0.007J	<1.5	<1.5	<0.033	<0.033	<0.1	<0.1	0.02J	0.007J	0.021J	0.047J
Benzo(b)fluoranthene	0.543	0.16	<1.9	<0.016	<0.03	<0.03	<0.1	<0.1	<0.03	<0.03J	<1.9	<1.9	<0.016	<0.016	<0.1	<0.1	<0.03	<0.03	<0.03J	0.03J
Benzo(g,h,i)perylene	None	None	<2	<0.016	<0.06	<0.06	<0.1	<0.1	<0.008	<0.008J	<2	<2	<0.016	<0.016	<0.1	<0.1	0.01J	<0.008	<0.008J	0.012J
Benzo(k)fluoranthene	5.43	1.62	<1.2	<0.033	<0.02	<0.02	<0.1	<0.1	<0.02	<0.02J	<1.2	<1.2	<0.033	<0.033	<0.1	<0.1	<0.02	<0.02	<0.02J	0.02J
Chrysene	75	22.3	<1.6	<0.03	<0.68	<0.68	<0.1	<0.1	<0.02	<0.02J	<1.6	<1.6	<0.03	<0.03	<0.1	<0.1	<0.02	<0.02	<0.02J	0.03J
Dibenzo(a,h)anthracene	0.027	0.00805	<1.9	<0.029	<0.05	<0.05	<0.1	<0.1J	<0.02	<0.02J	<1.9	<1.9	<0.029	<0.029	<0.1	<0.1	<0.02	<0.02	<0.02J	<0.02J
Fluoranthene	1,370	255	<1.9	<0.044	<0.23	<0.23	<0.2	<0.2	<0.03	<0.1J	<1.9	<1.9	<0.044	<0.044	<0.2	<0.2	0.07J	<0.03	<0.1J	<0.1
Fluorene	341	162	<2.9	<0.099	<0.55	<0.55	<0.2	<0.2	<0.03	<0.03J	<2.9	<2.9	<0.099	<0.099	<0.2	<0.2	<0.03	<0.03	<0.03J	<0.03J
Indeno(1,2,3-cd)pyrene	0.392	0.117	<1.6	<0.041	<0.02	<0.02	<0.1	<0.1	<0.03	<0.03J	<1.6	<1.6	<0.041	<0.041	<0.1	<0.1	<0.01	<0.01	<0.03J	0.05J
Naphthalene	2.11	1.11	<0.22	<0.124	<0.2	<0.2	<1	<1.2	<0.07	<0.07J	12	10	<0.124	<0.124	<1	<1	<0.07	<0.07	<0.07J	<0.07J
Phenanthrene	None	None	<2.6	<0.025	<0.88	<0.88	<0.5	<0.6	0.006J	<0.003J	<2.6	<2.6	<0.025	<0.025	<0.5	<0.5	0.03J	0.01J	0.028J	0.062J
Pyrene	1,090	202	<2	<0.034	<0.38	<0.38	<0.02	<0.2	<0.006	<0.003J	<2	<2	<0.034	<0.034	<0.2	<0.2	0.03J	0.02J	0.029J	0.066J
Inorganics (mg/L)																				
Dissolved Arsenic	None	None	NA	<0.0038	<0.0026	<0.0026	<0.01	<0.01	0.003J	<0.002J	NA	NA	<0.0038	<0.0038	<0.01	<0.01	0.003J	0.003J	<0.002J	<0.002
Total Arsenic	0.01	0.01	0.0115	<0.0038	<0.0026	<0.0026	<0.01	<0.01	<0.0018	<0.002J	0.0133	<0.0024	NA	NA	<0.01	<0.01	<0.0018	<0.0018	<0.002J	<0.002
Dissolved Barium	None	None	NA	NA	NA	NA	NA	NA	NA	0.123J	NA	NA	NA	NA	NA	NA	NA	NA	0.040	0.040
Total Barium	2	2	0.305	NA	NA	NA	NA	NA	NA	0.120J	0.0497	0.0483	NA	NA	NA	NA	NA	NA	0.041	0.041
Dissolved Cadmium	None	None	NA	NA	NA	NA	NA	NA	NA	<0.0003J	NA	NA	NA	NA	NA	NA	NA	NA	<0.0003J	<0.0003J
Total Cadmium	5	5	<0.59	NA	NA	NA	NA	NA	NA	<0.0003J	<0.59	<0.59	NA	NA	NA	NA	NA	NA	<0.0003J	<0.0003J
Total Chromium	0.1	0.1	0.00813	NA	NA	NA	NA	NA	NA	<0.002J	<0.00034	<0.00034	NA	NA	NA	NA	NA	NA	<0.002J	0.003J
Amenable Cyanide	0.2	0.2	NA	NA	<0.006	<0.006	<0.02	<0.02	<0.02	<0.006J	NA	NA	0.152	0.169	0.7J	0.9J	<0.2	0.2	0.68	0.75
Total Cyanide	None	None	<0.002	<0.0038	<0.006	<0.006	<0.02	0.02J	0.006J	<0.006J	0.67	0.651	0.433	0.436	2.2J	2.5J	2.8	3.2	0.98	0.98
Dissolved Lead	None	None	NA	NA	NA	NA	NA	NA	NA	0.0022J	NA	NA	NA	NA	NA	NA	NA	NA	0.0029J	0.0027J
Total Lead	0.015	0.015	0.00888	NA	NA	NA	NA	NA	NA	0.0023J	<0.002	<0.002	NA	NA	NA	NA	NA	NA	0.002J	0.0021J
Dissolved Mercury	None	None	NA	NA	NA	NA	NA	NA	NA	<0.03J	NA	NA	NA	NA	NA	NA	NA	NA	0.00004J	0.016J
Total Mercury	0.002	0.002	<0.021	NA	NA	NA	NA	NA	NA	0.00018J	<0.000021	<0.000021	NA	NA	NA	NA	NA	NA	0.00014J	0.013J
Dissolved Selenium	None	None	NA	NA	NA	NA	NA	NA	NA	0.005J	NA	NA	NA	NA	NA	NA	NA	NA	0.02	0.019
Total Selenium	0.05	0.05	<0.0265	NA	NA	NA	NA	NA	NA	0.003J	<0.0265	<0.0265	NA	NA	NA	NA	NA	NA	0.019	0.019
Dissolved Silver	None	None	NA	NA	NA	NA	NA	NA	NA	<0.001J	NA	NA	NA	NA	NA	NA	NA	NA	<0.001J	<0.001J
Total Silver	508	77.9	<1.6	NA	NA	NA	NA	NA	NA	<0.001J	<1.6	<1.6	NA	NA	NA	NA	NA	NA	<0.001J	<0.001J

Abbreviations:

NA not analyzed

< not detected above method detection limit

Note:

Highlighted cells exceed non-residential and /or residential RSKs.

A possible source of cyanide at MGP sites are residuals of the gas purification process. The purifying room was historically located south of the gas holder and considerably east of well MW-5. Four soil samples were collected within or near the purifying area. The cyanide detected was at levels four orders of magnitude less than the residential RSK (SP-5, within the purifying room) or not detected (MW-4, northeast of room). The concentrations of cyanide detected in other site areas are lower. Therefore, it does not appear that the cyanide detected in well MW-5 is associated with former purifying operations at the MGP. The cyanide at well MW-5 appears to be isolated and is not migrating off site–no amenable cyanide has ever been detected in downgradient well MW-3, located at the northeast corner of the USD property.

1.2.7 Groundwater Statistical Evaluation

The stability of the groundwater plume was evaluated using the statistical portions of the Monitoring and Remediation Optimization System (MAROS) software developed at the Air Force Center for Environmental Excellence (AFCEE) (AFCEE 2006). The software incorporates three analyses to determine trends in a data set: Mann-Kendall (M-K), Linear Regression (LR), and Coefficient of Variation (COV).

M-K is a nonparametric first-order regression analysis, which can be effectively applied to either normal or skewed data sets. If the confidence in the trend is less than 90 percent in the M-K statistics, MAROS uses the COV to determine if a plume is stable or too variable to determine trend. The COV is a numerical value that measures the degree of variability in a data set, and is equal to the standard deviation divided by the arithmetic mean of the data set. If analytical results are fairly consistent over time, the COV value will be less than one and the concentrations are considered "stable". When there is greater variability in the analytical results and the COV ≥ 1, the data are typically more random and the trend analysis yields "no trend". The results of the M-K and COV statistical analyses for each data set were applied to the MAROS decision matrix (Table 1-3) to determine trends and plume stability (AFCEE 2006).

Table 1-3 M-K Analysis Decision Matrix

M-K Statistic	Confidence In Trend	Concentration Trend
S > 0	> 95%	Increasing
S > 0	90-95%	Probably Increasing
S > 0	< 90%	No Trend
S ≤ 0	< 90% and COV ≥ 1	No Trend
S ≤ 0	< 90% and COV < 1	Stable
S < 0	90-95%	Probably Decreasing
S < 0	95%	Decreasing

A groundwater contaminant trend analysis was conducted for each PAH compound and amenable cyanide using analytical data collected between 2003 and 2009, if detected in at least two samples collected from the same monitoring well. For the purpose of completing the trend analyses, compounds that were not detected were assumed to be present at one-half the method detection limit for that compound.

For wells where primary and duplicate samples were collected, the average concentration was used. Appendix A contains the M-K trend analyses worksheets. Table 1-4 presents a summary of the trend analyses when a M-K trend could be established for PAHs in well MW-2.

Table 1-4 M-K Trends in Well MW-2

Chemical Parameters	Percentage Detections	COV	M-K Results
MW-2			
Benzo(a)anthracene	42.8	2.03	Decreasing
Benzo(a)pyrene	42.8	2.08	Decreasing
Benzo(b)fluoranthene	42.8	1.99	Decreasing
Benzo(g,h,i)perylene	42.8	2.29	Decreasing
Benzo(k)fluoranthene	42.8	2.27	Decreasing
Chrysene	28.6	2.21	Probably Decreasing
Fluoranthene	42.8	1.63	Probably Decreasing
Indeno(1,2,3-c,d)pyrene	28.6	1.98	Decreasing
Pyrene	42.8	1.81	Decreasing

All M-K trends established for well MW-2 were decreasing or probably decreasing. Wells MW-1 and MW-3 did not have enough detections of PAHs or amenable cyanide to establish any M-K trends. No M-K trends were established for well MW-5 because the concentrations were near the detection limits and did not consistently increase or decrease.

When no trend could be established with the M-K statistic, the LR graphs were reviewed. LR is a parametric statistical procedure used for normally distributed data. However, LR analyses provide an additional illustration of contaminant concentrations over time. No additional trends were established for well MW-2 using the LR graphs. Wells MW-1 and MW-3 did not have enough detections of PAHs or amenable cyanide to establish any LR trends. Well MW-5 showed a probably increasing trend for amenable cyanide; with concentrations fluctuating between 0.152 and 0.9 mg/L. The LR analyses data sheets are included in Appendix A.

2.0 Corrective Action Objectives

The KDHE guidance document BER-RS-20, *Scope of Work for a Comprehensive Investigation/ Corrective Action Study* (KDHE 2005a), requires selection of remedial actions that attain a degree of cleanup that ensures the protection of human health and the environment, are cost effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In conjunction with this guidance, corrective action objectives were developed for the Arkansas City former MGP site to determine the degree of cleanup required. The objectives were developed based on the site conditions and nature and extent of contamination discussed in Section 1.0.

The corrective action objectives for the site are the following:

- Prevent exposure to soil contamination exceeding Kansas RSK levels.
- Ensure that MGP-related groundwater contamination exceeding Kansas RSK levels does not migrate off site.
- Prevent residential development of the historical MGP property. Prevent exposure to any residual MGP-related contamination on site.
- Prevent use of groundwater for any potable or non-potable purpose other than collecting environmental samples.
- Restore groundwater to background conditions to the extent practicable as needed to control exposure pathways and limit migration.

The first objective has already been met with the soil removal completed in 2005. Therefore, this document addresses groundwater issues only. Six rounds of monitoring conducted since mid-2004 show that MGP-related contamination is not migrating off site.

3.0 Applicable or Relevant and Appropriate Requirements

This section identifies the ARARs for the Arkansas City MGP site per KDHE (KDHE 2005b). The purpose of this analysis is to summarize the requirements that are applicable or relevant and appropriate to the alternatives being considered and describe how these alternatives meet the requirements. Section 121(d) of CERCLA, as amended by SARA, states that any remedial action selected for a site must, at a minimum, attain a degree of cleanup that ensures the protection of human health and the environment. In addition, at the completion of the remedial action, a level or standard of control under federal or state environmental law must be attained and meet legally "applicable or relevant and appropriate requirements" for any hazardous substance, contaminant, or pollutant that remains on site.

The EPA guidance *CERCLA Compliance with Other Laws Manual Part I* (EPA 1988b) and *CERCLA Compliance with Other Laws Manual Part II: Clean Air Act and Other Environmental Statutes and State Requirements* (EPA 1989) establish how requirements of federal and state laws are identified and applied to remedial actions at environmental sites. ARARs are identified by applying a two-tier test to first determine if the requirement is applicable, and second, if it is not applicable, to determine if it is relevant and appropriate. Following are the definitions of "applicable" and "relevant and appropriate" requirements:

- Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant or contaminant, remedial action, location, or other circumstances at a CERCLA site" (EPA 1988b).
- Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental requirements promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. However, in some circumstances, a requirement may be relevant but not appropriate for the site-specific situation" (EPA 1988b).

The judgment as to the relevance and appropriateness of a requirement can be made on the basis of several factors, including the type of the corrective action contemplated, the hazardous substances in question, or the physical characteristics of the site. Only portions of requirements may be relevant and appropriate for a particular corrective action; however, any requirement or portion thereof that is determined to be relevant and appropriate must be fulfilled to the same degree as if it were applicable (EPA 1988b).

There are three types of ARARs. The first type, chemical-specific ARARs, establish health and risk-based concentration limits for the various environmental media at a site. The chemical-specific ARARs may set a level of cleanup or discharge. The second type, location-specific ARARs, set limitations on corrective activities due to site characteristics which can include restrictions for activities in wetlands, flood plains, and historical sites. The third type, action-specific ARARs, establish controls on corrective action activities. These controls can include compliance with transportation, treatment, storage, and disposal requirements.

Tables 3-1, 3-2, and 3-3 present a listing of the chemical-specific, location-specific, and action-specific ARARs, respectively, that are relevant to or have the potential to be relevant for the Arkansas City MGP site (KDHE 2005b). Table 3-4 presents a list of guidance to be considered. Because ARAR selection is a dynamic process and is subject to change, the tables list only the ARARs selected on the basis of currently identified contaminants of concern and available information.

Table 3-1 Potential Chemical-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Description	Comment
Federal Chemical-Specific ARARs		
Resource Conservation and Recovery Act (RCRA) Solid Waste Disposal Facility Criteria (40 CFR 257-258)	Regulations apply to owners and operators of facilities that treat, store or dispose of solid wastes.	Potential ARAR if additional soil excavation is performed.
RCRA Standards for Identification and Listing of Hazardous Waste (40 CFR 261)	Provides criteria for identification of hazardous and solid wastes.	Potential ARAR if additional soil excavation is performed.
RCRA Standards Applicable to Generators of Hazardous Waste (40 CFR 262)	Regulates manifesting, pre-transport requirements, and record keeping and reporting for hazardous waste generators.	Potential ARAR if additional soil excavation is performed.
RCRA Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)	Establishes standards that apply to transporting hazardous waste if the waste requires a manifest under RCRA.	Potential ARAR if additional soil excavation is performed.
Federal hazardous Materials Transportation Law 49 U.S.C. § 5101 et seq.	Regulates the transportation of hazardous wastes and hazardous substances by aircraft, railcars, vessels, and motor vehicles. Requires employers to train, test, and maintain training records for all hazmat employees.	Potential ARAR if additional soil excavation is performed.
Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 42 U.S.C. § 11001 et seq.	Designed to help local communities protect public health, safety, and the environment from chemical hazards. Enables states and communities to prepare to respond to unplanned release of hazardous substances. Requires facilities with hazardous substances to report the presence to emergency responders and to report any release of hazardous substances.	Potential ARAR for in situ remediation using chemical oxidants.
Clean Air Act (42 USC Section 7401-7642)		
EPA Guidelines Establishing Test Procedures for the Analysis of Pollutants (40 CFR Part 136)	Establishes test procedures for the analysis of pollutants.	Potential ARAR. Remedial actions may require sampling and analysis of groundwater.
Clean Water Act (33 USC Sections 1251-1376)		
National Pretreatment Standards (40 CFR Part 403)	Sets standards to control pollutants that pass through or interfere with treatment at wastewater treatment plants.	Potential ARAR. Purge water generated during groundwater sampling may require disposal at an offsite treatment facility.

Table 3-1 Potential Chemical-Specific ARARs (Continued)

Standard, Requirement, Criteria, or Limitation	Description	Comment
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980		
42 U.S.C. § 9601 et seq. as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986	Enacted to provide Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health and the environment. Established a trust fund to provide for cleanup when no responsible party is identified. Provides for liability of persons responsible for releases of hazardous substances. Established prohibitions and requirements for closed and abandoned hazardous waste sites.	Potential ARAR. While MGP contamination is not a hazardous waste, chemicals of concern are hazardous.
40 CFR 300.440, Offsite Rule	Establishes procedures for planning and implementing offsite response actions. Requires determination of compliance status of disposal facility during any response action.	Potential ARAR.
Safe Drinking Water Act (SDWA) of 1974		
42 U.S.C. § 300f et seq. as amended in 1986	Established to protect the quality of drinking water. Focuses on all waters actually or potentially designed for drinking use, whether from aboveground or underground sources. Authorized EPA to establish safe standards of purity and required all owners/operators of public water supply systems to comply with primary health-related standards.	May be applicable or relevant and appropriate at sites where waters that are used or may potentially be used as drinking water supplies are impacted or threatened.
National Primary Drinking Water Regulation and Implementation (40 CFR Part 141 and 142)	Establishes maximum contaminant levels (MCLs) which are health risk based standards for public water systems.	Applicable ARAR since federal guidelines state that this is an ARAR at groundwater cleanup sites where potential drinking water sources are impacted.
State of Kansas Chemical-Specific ARARs		
KDHE, Bureau of Environmental Remediation (BER), Risk Based Standards for Kansas, RSK Manual, March 1, 2003, as amended (October 2010).	Establishes risk-based action levels for chemicals in soil and groundwater.	Applicable because of potential for exposure to chemicals at concentrations above risk-based action levels.

Table 3-1 Potential Chemical-Specific ARARs (Continued)

Standard, Requirement, Criteria, or Limitation	Description	Comment
Solid Waste Management K.A.R. 28-29-1 to 28-29-121 and K.A.R. 28-29-2101 to 28-29-2113	Provides standards for management of solid wastes. Establishes administrative procedures. Establishes requirement for developing and submitting Solid Waste Management Plans.	Potential ARAR if additional soil excavation is performed.
Primary Drinking Water Regulations K.A.R. 28-15	Provides maximum contaminant levels for inorganic and organic chemicals. Provides monitoring and analytical regiments.	Applicable ARAR since groundwater is a potential drinking water source and has been impacted.
Kansas Water Quality Standards (KAR 28.16.28)	Provides for the maintenance and protection of public health and welfare or uses of surface water for aquatic life, agricultural, domestic, industrial water supply, and recreation.	Potential ARAR. Water Quality Standards may be applicable to alluvial aquifers demonstrated to be hydraulically connected to surface water bodies.
Hazardous Waste Management Standards and Regulations K.A.R. K.A.R. 28-31-124 through 28-31-279	Identifies the characteristics and listing of hazardous waste. Prohibits underground burial of hazardous waste except as granted by EPA or KDHE. Establishes restrictions on land disposal, and standards for generators or transporters of hazardous waste, hazardous waste storage, and treatment and disposal facilities.	Potential ARAR if additional soil excavation is performed.
Note: Only applicable and potentially applicable ARARs are included in the table. Most categories in the "universe" of ARARs are not applicable or relevant and appropriate because the groundwater at the site is not used as a public water supply and no hazardous waste will be produced.		

Table 3-2 Potential Location-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Description	Comment
Federal Location-Specific ARARs		
Endangered Species Act (16 USC 1531 et seq., 50 CFR Part 200, 50 CFR Part 402)	Requires action to conserve endangered species within critical habitats upon which endangered species depend (includes consultation with Department of Interior).	Potential ARAR. Several endangered species may be present in Sumner County according to the Kansas Department of Wildlife and Parks (KDWP).
Fish and Wildlife Service List of Endangered Species and Threatened Wildlife and Plants (50 CFR Section 17.11)	Provides a list of endangered species and threatened wildlife and plants.	Potential ARAR. Several endangered species may be present in Sumner County according to KDWP.
State of Kansas Location-Specific ARARs		
Non-Game, Threatened or Endangered Species K.A.R. 115-15-1 to 115-15-4	Identifies Threatened and Endangered Species	Potential ARAR. While the area is zoned industrial and wildlife is limited, several endangered species are present in Sedgwick County as determined by the Kansas Department of Wildlife, Parks, and Tourism.
Voluntary Cleanup and Property Redevelopment Program K.A.R. 28-71-1 to 28-71-12	Provides a mechanism for property owners, facility operators, prospective purchasers, and local government to voluntarily address contaminated properties with technical and regulatory guidance from KDHE. Identifies remedial standards for environmental cleanup. Establishes groundwater cleanup levels based on the most beneficial use of the groundwater.	May be applicable if a site meets the criteria for acceptance into the Voluntary Cleanup Program. Remedial standards established under KAR 28-71-11 are relevant and appropriate for all other sites being managed under KDHE oversight.
Note: Only applicable and potentially applicable ARARs are included in the table. Most categories in the "universe" of ARARs are not applicable or relevant and appropriate because the site is located in an urban area.		

Table 3-3 Potential Action-Specific ARARs

Standard, Requirement, Criteria, or Limitation	Description	Comment
Federal ARARs		
Occupational Safety and Health Standards (29 CFR 1910)	Provides standards for workers and the workplace: working surfaces; means of egress; ventilation; noise; hazardous materials; personal protective equipment; sanitation; medical services and first aid; fire protection, detection, and suppression; materials handling and storage; machinery and machinery guards; power tools; and welding and electrical equipment. Requires training for workers.	Applicable ARAR because it provides required training for workers on site and sets standard practices for work performed.
Safety and Health Regulations for Construction (29 CFR 1926)	Provides standards for construction activities including work practices, safety equipment, scaffolding and ladders, fall protection, heavy equipment; excavations, concrete and masonry construction, steel erection, tunnels and shafts, demolition, use of explosives, power transmission and distribution, and overhead protection.	Applicable to workers and workplaces where construction activities take place.
Clean Water Act		
National Pretreatment Standards (40 CFR Part 403)	Sets standards to control pollutants that pass through or interfere with treatment at wastewater treatment plants.	Potential ARAR. Purge water generated during groundwater sampling requires disposal at an offsite treatment facility, which may ultimately discharge to a sewer system.
National Pretreatment Standards (40 CFR Part 141 and 142)	Establishes MCLs which are health risk based standards for public water systems.	Applicable ARAR since federal guidelines state that this is an ARAR at groundwater cleanup sites where potential drinking water sources are impacted.
Storm Water Discharge Requirements NPDES (40 CFR 122.26) Federal Water Quality Standards (40 CFR 131)	Regulates discharge of pollutants from any point source into waters of the US. Provides requirements to obtain permit to discharge to the storm water sewer system under the NPDES program.	Potential ARAR. Purge water generated during groundwater sampling requires disposal at an offsite treatment facility, which may ultimately discharge to a sewer system.

Table 3-3 Potential Action-Specific ARARs (Continued)

Standard, Requirement, Criteria, or Limitation	Description	Comment
General Pre-treatment Regulations for Existing and New Sources of Pollution for Publicly Owned Treatment Works (40 CFR 403)	Establishes methods and requirements for states in the development of ambient water quality criteria for the protection of aquatic organisms and/or the protection of human health. Provides effluent limitations and guidelines for existing sources, standards of performance for new sources, and pre-treatment standards for new and existing sources.	Potential ARAR. Purge water generated during groundwater sampling would require disposal at an offsite treatment facility, which may ultimately discharge to a sewer system.
Safe Drinking Water Act (SDWA) of 1974		
National Primary Drinking Water Regulation and Implementation (40 CFR Part 141 and 142)	Establishes MCLs which are health risk based standards for public water systems.	Applicable ARAR since federal guidelines state that this is an ARAR at groundwater cleanup sites where potential drinking water sources are impacted.
Underground Injection Control Program (40 CFR 144 to 148)	Ensures that underground injection will not endanger drinking water sources. Provides regulations governing the use of underground injection wells-identification of the classifications of injection wells, and permitting, construction, operation, monitoring, testing, and reporting requirements. Provides requirements for abandoning injection wells.	Potentially applicable if injection is used as part of a site remedy.
State of Kansas Action-Specific ARARs		
Wastewater Discharge Control Law (KSA 65.161-171w)	Provides state regulations of wastewater discharge from industrial and other sites.	Potential ARAR. Purge water generated during groundwater sampling may require disposal at an offsite treatment facility.
Kansas Water Appropriations Act K.A.R. 5-1-1 through 5-10-6 and K.A.R. 5-50-1 to 5-50-8	Establishes requirements for obtaining, maintaining, and transferring water appropriations.	Potentially applicable for in situ remedies using chemical oxidants and water.
Underground Injection Control Regulations K.A.R. 28-46-1 to 28-46-44	Provides regulations governing the use of underground injection wells-identification of the classifications of injection wells, and permitting, construction, operation, monitoring, testing, and reporting requirements. Provides requirements for abandoning injection wells.	Potentially applicable for in situ remedies using chemical oxidants and water.

Table 3-3 Potential Action-Specific ARARs (Continued)

Standard, Requirement, Criteria, or Limitation	Description	Comment
K.S.A. 65-1,221 to 65-1,235 Environmental Use Controls (EUC)	A EUC "means an institutional control or administrative control, a restriction, prohibition or control of one or more uses, or activities on, a specific property, as requested by the property owner at the time of issuance, to ensure future protection of public health and the environment when environmental contamination which exceeds department standards for unrestricted use remains on the property following the appropriate assessment and/or remedial activities as directed by the department pursuant to the secretary's authority".	Applicable ARAR. Legal mechanism and associated application process for imposing restrictions, prohibitions, and conditions on land use for property with residual contamination at levels prohibiting unrestricted use.
Water Well Contractor's License; Water Well Construction and Abandonment K.A.R. 28-30-1 to 28-30-10	Establishes requirements for licensing of drillers. Regulates drilling activities including well construction.	Applicable for drilling and/or well construction and abandonment at the site.
Kansas Board of Technical Professions		
Kansas Board of Technical Professions K.A.R. 66-6-1 through 66-14-12	Establishes requirements for licensing of engineers, land surveyors, geologists and architects.	Applicable. The services of a geologist, engineer, or land surveyor are required for site investigations or remediation.
Kansas Board of Technical Professions K.A.R. 28-30-1 to 28-30-10	Establishes requirements for licensing of drillers. Regulates drilling activities including the construction of wells.	Applicable. Drilling and/or well construction or abandonment will be conducted.
Note: Only applicable and potentially applicable ARARs are included in the table. Most categories in the "universe" of ARARs are not applicable or relevant and appropriate because the groundwater at the site is not used as a public water supply and no hazardous waste will be produced.		

Table 3-4 To Be Considered Guidance

Citation	Description
Kansas Department of Health and Environment (KDHE), Bureau of Environmental Remediation (BER), Risk Based Standards for Kansas, RSK Manual, March 1, 2003, as amended.	Compiles risk-based cleanup screening goals for contaminants in soil and groundwater
Evaluating Future Land Use, KDHE BER Policy #BER-RS-005.	Future land use influences the types and frequencies of exposures that may occur to any residual contamination remaining on the site and therefore must be considered in making corrective action decisions.
Consideration for Remedial Standards, KDHE BER Policy #BER-RS-033.	Identifies remedial standards and situations where they should be used.
Monitored Natural Attenuation, KDHE BER Policy #BER-RS-042.	Provides further clarification of additional KDHE-BER requirements to the guidance on monitored natural attenuation provided by EPA Directive 9200.4-17P.
Considerations for Groundwater Use and Applying RSK Standards to Contaminated Groundwater KDHE BER Policy #BER-RS-045.	Establishes a mechanism for consistency across BER programs in protecting public health and the environment, in addition to protection of groundwater resources of the State.
Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, EPA540-G-89-004, October 1988.	Provides the methodology that Superfund program uses to characterize the nature and extent of risk posed by uncontrolled hazardous wastes sites and for evaluating potential remedial alternatives.
Guidance for Quality Assurance Project Plans, EPA240-R-02- 009, December 2002.	Describes the Quality Assurance Project Plan as four basic element groups covering project management, data generation and acquisition, assessment and oversight, and data validation and useability.
Guidance for the Data Quality Objectives Process, EPA600-R- 96-055, August 2000.	Provides a systematic planning process to develop acceptance or performance criteria for collection, evaluation, or use of environmental data.
Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers, EPA542-S-02-001, May 2002.	Identifies methods for sampling groundwater.
Remedial Design/Remedial Action Handbook, EPA540-R-95- 059, June 1995.	Provides an overview of the remedial design and remedial action processes.
Storm Water Management for Construction Activities EPA832-R-92-005, October 1992.	Describes storm water pollution prevention measures.

4.0 Development and Evaluation of Alternatives

This section describes the development of the corrective action alternatives for the Arkansas City MGP site. It also describes the evaluation of these alternatives, based on the criteria provided by KDHE, the NCP, and EPA guidance. These criteria are as follows:

- Overall Protection of Human Health and the Environment. This criterion provides an overall assessment of whether an alternative adequately protects human health and the environment. The overall protectiveness focuses on whether an alternative achieves adequate protection and how site risks are eliminated, reduced, or controlled through treatment, engineering, or institutional controls.
- Compliance with ARARs. This criterion assesses whether an alternative meets all federal and state ARARs for the site.
- Long-Term Effectiveness and Permanence. This criterion assesses the residual risk that remains at the site after achieving the corrective action objectives. The extent and effectiveness of the controls used to manage any treatment residuals or untreated media are assessed by qualitatively determining the magnitude of any residual risk remaining at the site at the conclusion of the remedial activities. Also, the adequacy and reliability of the controls that are used to manage any treatment residuals or monitor untreated media remaining at the site are assessed.
- Reduction of Toxicity, Mobility, or Volume Through Treatment. This criterion assesses the degree to which site media are treated to permanently and significantly reduce the toxicity, mobility, or volume of site contaminants. This is accomplished by analyzing the destruction of toxic contaminants, the reduction of the total mass of toxic contaminants, the irreversible reduction in contaminant mobility, or the reduction in total volume of contaminated material.
- Short-Term Effectiveness. This criterion addresses the effects of an alternative on site surroundings during the construction and implementation phases of the remedial action, before the corrective action objectives are achieved. These effects include consideration of the protection of workers and the community during corrective action implementation, environmental impacts that might result from construction or implementation, and the length of time until the objectives are achieved.
- Implementability. This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during implementation. Technical feasibility encompasses the technical difficulties and unknowns associated with the alternatives, the reliability of the technologies, the ease of undertaking additional remedial actions if necessary, and monitoring requirements. Administrative feasibility includes the activities required for coordination with other offices and agencies. Availability of services and materials includes the availability of necessary equipment and specialists, the ability to obtain competitive bids, and the availability of prospective technologies.
- Cost. The cost criterion involves an evaluation of the capital costs, the annual operation and maintenance (O&M) costs, and a present worth analysis. The cost estimates are order-of-magnitude level estimates, which are approximate estimates made without detailed engineering data. It is normally expected that an estimate of this type would be accurate to +50 percent and -30 percent for given unit quantities. The actual cost of the project would depend on the final scope of the corrective action, the schedule of implementation, actual labor and material costs at

the time of implementation, competitive market conditions, and other variable factors that may impact the project costs.

- Community acceptance. This evaluation includes determining which components of the alternatives the community supports, has reservations about, or opposes. It cannot be adequately assessed until after the CAS report is released for regulatory and public review.

The corrective action alternatives developed in this section of the CAS report are evaluated against the first seven criteria.

4.1 DEVELOPMENT OF CORRECTIVE ACTION ALTERNATIVES

The goals of developing corrective action alternatives are to provide both a range of cleanup options and sufficient detail to adequately compare alternatives with one another. KDHE requires that remedial actions meet the following criteria:

- Be protective of human health and the environment.
- Attain ARARs (or provide grounds for invoking a waiver).
- Be cost-effective.
- Utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element or provide an explanation of why it does not.

Because the extent of contamination at the Arkansas City MGP site is limited and no current receptors of MGP-related contamination exist, the range of alternatives to be evaluated is narrow. The following alternatives were developed for consideration at the site:

- Alternative 1-No Action
- Alternative 2-Environmental Use Controls and Limited Groundwater Monitoring
- Alternative 3-Environmental Use Controls and Long-Term Groundwater Monitoring
- Alternative 4-In Situ Chemical Oxidation (ISCO)

4.2 DISCUSSION AND EVALUATION OF ALTERNATIVES

The following subsections provide a general description of each alternative and the evaluation of each alternative against the criteria.

4.2.1 Alternative 1-No Action

The no action alternative would not involve any corrective action and the site would remain in its present condition. This alternative, required by the NCP and CERCLA, is a baseline alternative against which the effectiveness of the other alternatives can be compared. As specified in the NCP, a five-year review of the site would be conducted to determine if a future corrective action would need to be implemented.

4.2.1.1 Overall Protection of Human Health and the Environment. Because the use of the site would not be restricted under this alternative, human health and the environment would not be adequately protected from residual soil and groundwater contamination exceeding the RSKs. While not all corrective action objectives would be satisfied by implementing this alternative, six groundwater sampling events conducted since mid-2004 show that MGP-related contamination is

not migrating off site. The absence of an additional monitoring program would result in the inability to determine if groundwater contaminants in excess of the RSKs have migrated off site.

4.2.1.2 Compliance with ARARs. The potential ARARs for the site are presented in Section 3.0. Compliance with action-specific ARARs would not be required by this alternative because no corrective actions would be completed. Because no access restrictions would be implemented under the no action alternative, future populations could be exposed to onsite groundwater concentrations in excess of the RSKs if contact with groundwater occurred; therefore, this alternative would not meet the chemical-specific ARARs. No location-specific ARARs would be associated with this alternative.

4.2.1.3 Long-Term Effectiveness and Permanence. The residual risk to human health and the environment associated with this alternative would be the same as the current risk. An evaluation of the adequacy and reliability of controls is not applicable to this alternative. Because additional groundwater monitoring would not be conducted, there would be no mechanism by which to evaluate the protectiveness of this alternative if a risk develops in the future. However, six rounds of sampling events conducted since mid-2004 show that MGP-related contamination is not migrating off site.

4.2.1.4 Reduction of Toxicity, Mobility, or Volume Through Treatment. In implementing this alternative, there would be no reduction in the toxicity, mobility, or volume of site contaminants other than what may be achieved through natural fate and transport processes. Six monitoring events conducted since mid-2004 show that MGP-related contamination is not migrating off site.

4.2.1.5 Short-Term Effectiveness. There would be no increase in the short-term risk to workers or the community associated with this alternative because no actions would be conducted. Environmental impacts would also not occur. With implementation of the no action alternative, the corrective action objectives would not be adequately achieved.

4.2.1.6 Implementability. This criterion is not applicable because no corrective action would occur. Services, materials, and the activities normally needed to coordinate with other agencies would not be necessary.

4.2.1.7 Cost. There would be no capital costs associated with this alternative because no corrective actions would be conducted. O&M costs would be associated with the five-year review of the project. Five-year review costs would consist of a site visit for two people, and the labor and expenses associated with producing a five-year review report. These costs are presented in Table 4-1. The life of the alternative is assumed to be five years.

Table 4-1 Alternative 1 Cost Estimate – No Action

Cost Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Five Year Review Cost[1]	1	LS	$15,000	$15,000

Note:
[1] Five-year site review cost includes travel, expenses, and report preparation.

4.2.2 Alternative 2– Environmental Use Controls and Limited Groundwater Monitoring

Alternative 2 consists of placing environmental use controls (EUCs) on the USD 470 property and a portion of the adjacent Bay property to prevent development as a residential area and to control the exposure to residual soil and groundwater contamination exceeding the RSKs. The alternative would also include conducting a limited duration of groundwater monitoring to verify that chemicals of concern (PAHs and amenable cyanide) are not increasing and resulting in migration of the contaminant plume. Analysis for BTEXs and metals would not be performed based on historical data results (see Table 1-2).

An EUC is a legal mechanism for applying restrictions, prohibitions, and conditions on land use for a property that has environmental contamination at levels exceeding residential standards. EUCs can provide a landowner relief from environmental liability concerns, making property more attractive to redevelopment or prospective buyers. The EUC runs with the property, and is binding on the landowner and any subsequent owners, lessees, or other users of the property. Conditions that can be imposed include restricting future land use to industrial/commercial purposes, prohibiting the installation of drinking water wells, limiting or prohibiting digging or other types of excavation activities, requiring erosion controls on the property, limiting the type of vegetation to be grown on a subject property, or requiring maintenance of a protective structure or other engineered barrier.

In addition to the EUC, seven additional groundwater sampling events would be conducted to periodically to monitor contaminant levels in site wells and to verify that no groundwater contaminants are migrating off site. The monitoring program will consist of the following elements:

- Collecting groundwater samples semi-annually for two years and then annually for three additional years from wells MW-2, MW-3, and MW-5.
- Analyzing groundwater samples for PAHs and amenable cyanide.
- Preparing annual Groundwater Monitoring Reports. These reports will provide a discussion of the effectiveness of site monitoring, laboratory analytical data, and static water elevation measurements.
- In conjunction with the evaluation report, evaluating the stability of the groundwater plume using the statistical portions of the Monitoring and Remediation Optimization System (MAROS) software developed at the Air Force Center for Environmental Excellence. The software incorporates the analyses of linear regression, Mann-Kendall, and coefficient of variation to determine trends in a data set.
- Termination of groundwater monitoring if no statistical increase in PAH concentrations can be documented after seven monitoring events.

Although no PAHs have been detected above the residential RSKs since 2006 and concentrations in well MW-2 show an overall decreasing trend, amenable cyanide has been intermittently detected in the groundwater at well MW-5 at levels exceeding the RSK criterion of 0.2 mg/L for amenable (free) cyanide. However, no statistical trend could be determined based on the inconsistent detections at well MW-5 which have fluctuated between 0.152 and 0.9 mg/L between June 2004 and May 2009. Use controls would prevent exposure to potentially contaminated groundwater by prohibiting use of the groundwater. Groundwater monitoring for five years would be used to monitor if contamination is continuing to decrease on site. If concentrations remain above the RSK after 5 years of monitoring, monitoring may need to continue over the long-term.

4.2.2.1 Overall Protection of Human Health and the Environment. This alternative would be protective of human health and the environment by controlling future use and reducing the potential for contact with soil and groundwater. No adverse short-term health or environmental risks would be expected during implementation of this alternative because the only activity would be groundwater sampling. This alternative would determine if any contaminant concentrations in groundwater above the RSKs are migrating off site. Six groundwater sampling events conducted since mid-2004 show that no MGP-related contamination is migrating off site and that concentrations are decreasing.

4.2.2.2 Compliance with ARARs. By implementing and enforcing environmental use controls at the site, Alternative 2 would comply with the chemical and action-specific ARARs. Groundwater monitoring would comply with chemical and action-specific ARARs. No location-specific ARARs would be associated with this alternative.

4.2.2.3 Long-Term Effectiveness and Permanence. The EUCs would prohibit residential development and limit the use of groundwater. Therefore, Alternative 2 would provide long-term protection of human health from contaminants in soil and groundwater.

Although no active remediation of the site would occur, the magnitude of the residual risk would be less than the current risk because the EUCs would limit and control exposure to any contaminants in the groundwater. The long-term effectiveness of the alternative would depend on the adequate implementation and enforcement of the EUC. If properly enforced, the EUCs would be a reliable means of preventing exposure to site contaminants. Also, because additional groundwater monitoring would be conducted, there would be a mechanism by which to evaluate the effectiveness of this alternative if a risk develops in the future. However, as shown in Table 1-2, six rounds of sampling events conducted since mid-2004 show that MGP-related contamination is not migrating off site. Cyanide is also showing an overall decrease with the largest concentration detected in 2007, although concentrations have fluctuated since 2004.

4.2.2.4 Reduction of Toxicity, Mobility, and Volume Through Treatment. Implementation of Alternative 2 would not result in any reduction of the toxicity, mobility, or volume of site contaminants with the exception of what may be achieved through natural fate and transport processes. Six monitoring events conducted since mid-2004 show that MGP-related contamination is not migrating off site.

4.2.2.5 Short-Term Effectiveness. The risk to the public and the environment during implementation would be minimal. Purge water from groundwater sampling would be containerized and disposed of at an offsite facility in compliance with state and federal regulations. Risks to workers and the environment during sampling would be minimal if Occupational Safety and Health Administration requirements and guidelines are followed.

Objectives associated with preventing exposure to contaminants in groundwater on site would be achieved immediately upon implementation and enforcement of the EUCs. Compliance with the objective to determine if groundwater contaminants above the RSKs are migrating off site would be determined at the completion of each yearly monitoring review.

4.2.2.6 Implementability. Coordination with the current property owners and KDHE would be required to implement the EUCs. Because Westar Energy does not own the properties, establishing EUCs at the site may be more difficult to implement than if they owned the property.

4.2.2.7 Cost. The capital and operation and maintenance (O&M) costs associated with the implementation of Alternative 2 are presented in Table 4-2. The capital costs include coordinating with the property owners and KDHE to establish EUCs on the properties and costs associated with abandoning wells. The costs include coordinating with state and local authorities in enforcing the EUCs. O&M costs include groundwater sampling and reporting costs.

Table 4-2 Alternative 2 Cost Estimate – Environmental Use Controls and Limited Groundwater Monitoring

Cost Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Capital Costs				
Environmental Use Controls[1]	1	LS	$15,000	$15,000
Well Abandonment	1	LS	$10,000	$10,000
Semi-Annual O&M Costs[2]				
Groundwater monitoring	4	EVENT	$16,500	$66,000
Annual O&M Costs[3]				
Groundwater monitoring	3	EVENT	$18,000	$54,000
TOTAL COST				$145,000

Notes:
[1] Costs are legal and support fees to implement the environmental use controls, attend meetings, and perform other coordination activities.
[2] Estimate assumes that three wells would be sampled semi-annually for two years (including one duplicate sample) and analyzed for total and amenable cyanide and PAHs. Unit cost includes travel, sample collection, laboratory analysis, data validation, report preparation, and well abandonment.
[3] Estimate assumes that three wells would be sampled annually for three years (including one duplicate sample) and analyzed for total and amenable cyanide and PAHs. Unit cost includes travel, sample collection, laboratory analysis, data validation, report preparation, and well abandonment.

4.2.3 Alternative 3-Environmental Use Controls and Long-Term Groundwater Monitoring

Alternative 3 is the same as Alternative 2 except for the frequency of groundwater sampling would be annual the duration of sampling. While Alternative 2 assumes that monitoring can be terminated following a limited number of years, this alternative assumes 28 years of annual monitoring following two years of semi-annual sampling. If concentrations of MGP-related chemicals (e.g., PAHs) increase above the RSKs for for at least two consecutive sampling events, additional evaluation will be completed to determine if investigation and/or additional corrective action is necessary.

4.2.3.1 Overall Protection of Human Health and the Environment. This alternative would be effective in protecting human health and the environment by demonstrating that contaminants are not migrating off site at levels above the RSKs. The EUCs would prevent development as a residential area and control exposure to residual soil and groundwater contaminants. Because this alternative would prevent the exposure to residual contaminants and groundwater conditions would be monitored, this alternative would meet the corrective action objectives.

4.2.3.2 Compliance with ARARs. Alternative 3 would be implemented to comply with the chemical and action-specific ARARs. No location-specific ARARs would be associated with this alternative.

4.2.3.3 Long-Term Effectiveness and Permanence. The implementation of EUCs would limit the future use of the groundwater and prevent exposure to any residual contaminants in soil and groundwater. As long as the EUCs were enforced, the public would be protected from soil and groundwater contaminants above the RSKs.

The groundwater monitoring program and the yearly monitoring reviews would be adequate in determining if groundwater contaminants with concentrations above the RSKs are migrating off site and show if concentrations continued to show an overall decrease over time.

4.2.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment. No reduction of the toxicity, mobility, or volume of groundwater contaminants would occur, with the exception of what may be achieved through natural fate and transport processes. The monitoring program would track the mobility and concentration changes of any groundwater contaminants.

4.2.3.5 Short-Term Effectiveness. The overall risk to the public and environment would be minimal. Purge water from groundwater sampling would be containerized and disposed of at an offsite facility in compliance with state and federal regulations. Risks to workers and the environment during sampling would be minimal if Occupational Safety and Health Administration requirements and guidelines are followed.

Objectives associated with preventing exposure to contaminants in groundwater on site would be achieved immediately upon implementation and enforcement of the EUCs. Compliance with the objective to determine if groundwater contaminants above the RSKs are migrating off site would be determined at the completion of each yearly monitoring review.

4.2.3.6 Implementability. Continued groundwater monitoring at the site would be easy to implement. Coordination with the property owners and KDHE would be required to implement the EUCs. Because Westar Energy does not own the site property, establishing EUCs may be more difficult to implement and monitor.

4.2.3.7 Cost. The total capital and O&M costs associated with the implementation of Alternative 3 are presented in Table 4-3. The capital costs include placing EUCs on the properties. The O&M costs include groundwater monitoring and reporting.

4.2.4 Alternative 4-In Situ Chemical Oxidation

This alternative consists of using ISCO to treat groundwater. An oxidant would be injected into the impacted area using direct-push probing equipment in a pattern to allow the chemical to migrate through the subsurface in a radial configuration. A variety of chemical oxidants are available.

Persulfate is likely to be an appropriate chemical based on the presence of both PAHs and cyanide. There are several proprietary oxidants available from FHC/Adventus that may be suitable for application at the site. Klozur CR is a single, formulated product consisting of high pH - activated Klozur Persulfate and PermeOx® Plus engineered calcium peroxide. It can be used to treat both

Table 4-3 Alternative 3 Cost Estimate – Environmental Use Controls and Long-Term Groundwater Monitoring

Cost Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Capital Costs				
Environmental Use Controls[1]	1	LS	$15,000	$15,000
Well Abandonment	1	EVENT	$10,000	$10,000
Semi-Annual O&M Costs[2]				
Groundwater monitoring	4	EVENT	$16,500	$66,000
Annual O&M Costs[3]				
Groundwater monitoring	28	EVENT	$18,000	$504,000
TOTAL COST				$595,000

Notes:
(1) Costs are legal and support fees to implement the environmental use controls, attend meetings, and perform other coordination activities.
(2) Estimate assumes that three wells would be sampled semi-annually for two years (including one duplicate sample) and analyzed for total and amenable cyanide and PAHs. Unit cost includes travel, sample collection, laboratory analysis, data validation, report preparation, and well abandonment.
(3) Estimate assumes that three wells would be sampled annually for twenty-eight years (including one duplicate sample) and analyzed for total and amenable cyanide and PAHs. Unit cost includes travel, sample collection, laboratory analysis, data validation, report preparation, and well abandonment.

contaminant source zones and dissolved-phase groundwater contaminant plumes. Klozur CR can treat aromatic hydrocarbons (e.g., benzene), PAHs, petroleum hydrocarbons, chlorinated solvents, and pesticides. Studies have shown that with high pH, cyanide is also degraded with persulfate.

The oxidation reaction occurs wherever there is contact between the chemical oxidant and organic contaminants. In most cases, the reaction occurs with dissolved phase contaminants within the pore spaces of solid material. As the dissolved fraction of the contaminant mass is oxidized, more contaminants are drawn into solution and similarly destroyed. An effective oxidant is one that either aggressively draws contaminants into solution for destruction or persists in the subsurface long enough to allow sufficient desorption of contaminants from the soil matrix to solution. In either case, the measure of an effective oxidant is the percent reduction of the contaminant mass per application. This would first be determined in a laboratory bench test and then confirmed in the field through soil sampling.

Following injection, groundwater would be sampled quarterly for three years, semi-annually for two years, and annually for five years to monitor the performance of ISCO in treating groundwater contaminants to below RSKs and to verify that MGP-related chemicals do not rebound after injection.

An EUC would be implemented as outlined in Alternatives 2 and 3 to address residual soil contamination exceeding RSKs.

4.2.4.1 Overall Protection of Human Health and the Environment. This alternative would be effective in protecting human health and the environment by reducing the concentration of or eliminating the presence of groundwater contaminants through treatment and prevent exposure to residual soil contamination through institutional controls. Therefore, the alternative would meet

the corrective action objectives. However, six groundwater sampling events conducted since mid-2004 already show that no MGP-related contamination is migrating off site and concentrations are decreasing. Therefore, corrective action objectives are met without implementing active groundwater remediation.

A consequence of subsurface injection is day-lighting of oxidant at the surface away from the injection point. Day-lighting occurs when the injected material migrates to the surface through preferential pathways, resulting in misplacement of the injected material. As the injection material migrates, contaminants will usually migrate with it, potentially exposing personnel at the surface.

4.2.4.2 Compliance with ARARs. Alternative 4 would be implemented to comply with the chemical and action-specific ARARs. No location-specific ARARs would be associated with this alternative.

4.2.4.3 Long-Term Effectiveness and Permanence. Since the source of the contamination was removed during the 2005 soil removal, injection and subsequent groundwater treatment should result in no MGP-related contamination remaining in groundwater. However, after chemical oxidants are exhausted, studies have shown that groundwater contaminants often "rebound" in concentration, often requiring multiple injection events.

The groundwater monitoring program and the yearly monitoring reviews would be adequate in determining if groundwater contaminants decreased and/or returned to levels above the RSKs after the injection was complete.

The EUC would prevent exposure to residual soil contamination exceeding RSKs.

4.2.4.4 Reduction of Toxicity, Mobility, or Volume Through Treatment. Implementation of ISCO should result in a decrease in the toxicity and volume of groundwater contaminants through treatment with an appropriate oxidant. The monitoring program would track the mobility and concentration changes of any groundwater contaminants.

4.2.4.5 Short-Term Effectiveness. The overall risk to the public and environment would be minimal during implementation; however, it would be greater than during implementation of the other alternatives because of the potential for day-lighting of injection material.

Purge water from groundwater sampling would be containerized and disposed of at an offsite facility in compliance with state and federal regulations. Risks to workers and the environment during sampling would be minimal if Occupational Safety and Health Administration requirements and guidelines are followed.

Objectives associated with preventing exposure to contaminants in groundwater would be achieved after monitoring showed that injection reduced contaminant concentrations below the RSKs.

4.2.4.6 Implementability. Although the technology and equipment to perform ISCO are readily available, this alternative would be more difficult to implement than the other alternatives due to the intrusive nature of the remedy, the need to obtain permits from the State of Kansas before injection, and the probability of at least limited day-lighting of injected material to occur. Selection

of the most appropriate oxidant or oxidant mixture is critical in successful treatment. Laboratory-scale testing would be required to determine the appropriate oxidant and injection ratios.

Injection pressures would be maintained to minimize day-lighting; however, this may reduce injection efficiency and result in additional injection points. However, because only minimal contaminated material would be exposed at the surface, air monitoring and controls during implementation would be minimal.

To successful treat cyanide, the pH of the groundwater will need to be increased. This may be difficult considering the shallow groundwater on site is part of an unconfined unit with the underlying limestone bedrock. Although FHC has an oxidant that should be capable of achieving the optimal pH and even though laboratory-scale testing shows oxidation occurs, it may be difficult to control pH in the site-specific environment.

Continued groundwater monitoring at the site would be easy to implement.

4.2.4.7 Cost. The approximate total capital and O&M costs associated with the implementation of Alternative 4 are presented in Table 4-3. The capital costs include two rounds of injection of the FHC oxidants discussed previously. The O&M costs include groundwater monitoring and reporting.

Table 4-4 Alternative 4 Cost Estimate - ISCO

Cost Item	Quantity	Unit of Measure	Unit Cost	Total Cost
Capital Costs				
Well Abandonment	1	EVENT	$10,000	$10,000
Bench Test	1	EVENT	$25,000	$25,000
Injection	2	EVENT	$125,000	$250,000
Construction Subtotal				$285,000
Bid Contingency	25%			$71,300
Scope Contingency	25%			$71,300
Permitting and Legal	5%			$14,300
Construction Services	10%			$28,500
Engineering Design	8%			$22,800
Total Capital Costs				$493,200
Quarterly O&M Costs[1]				
Groundwater monitoring	12	EVENT	$13,000	$153,600
Semi-Annual O&M Costs[1]				
Groundwater monitoring	4	EVENT	$16,500	$66,000
Annual O&M Costs[1]				
Groundwater monitoring	5	EVENT	$18,000	$90,000
TOTAL COST				$802,800

Note:
[1] Estimate assumes that three wells would be sampled quarterly for three years, semi-annually for two years, and annually for five years (including one duplicate sample) and analyzed for total and amenable cyanide and PAHs. Unit cost includes travel, sample collection, laboratory analysis, data validation, report preparation, and well abandonment.

5.0 Comparative Analysis of Alternatives

The following sections compare the alternatives on the basis of the evaluation criteria developed and discussed in Section 4.0.

5.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Implementation of Alternative 1, the no action alternative, would not protect human health or the environment and would not determine if groundwater contaminants above the RSKs were migrating off site. Alternatives 2 and 3 would protect human health and the environment by controlling the future use of the properties and preventing exposure to residual contamination in soil and groundwater. Groundwater monitoring data show that contaminant concentrations above the RSKs have not migrated off site. Therefore, both of these alternatives would meet the corrective action objectives. While Alternative 3 provides additional data to document that no contamination is migrating off site, the additional data may not be necessary since groundwater sampling since mid-2004 already shows that no MGP-related contamination is migrating off site and that concentrations have decreased over time. While Alternative 4 may provide additional protection of human health through treatment of MGP-related residual contamination in the groundwater to below the RSKs, groundwater data already show that no contamination is migrating off site and concentrations are decreasing. Therefore, treatment does not currently appear to be necessary to meet the corrective action objectives.

5.2 COMPLIANCE WITH ARARS

The no action alternative, if implemented, would not comply with all of the ARARs because the alternative would not control the use of or limit exposure to groundwater. Alternatives 2, 3, and 4 could be implemented to comply with all ARARs.

5.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

A long-term risk would continue to be associated with Alternatives 1, 2, and 3 since residual contamination remains on site above the RSK in soil and groundwater. However, for Alternatives 2 and 3, the risk would be less than the current risk because the EUCs would limit the use of and control exposure to soil and groundwater, thereby protecting human health. The monitoring to be performed under Alternatives 2 and 3 would document that no contamination is migrating off site. However, with the six sampling events conducted since mid-2004 already show that MGP-related contamination is not migrating off site, monitoring for 30 years may not be necessary.

Implementation of ISCO to treat PAHs and amenable cyanide should eliminate any long-term risk associated with their presence at the site. However, the EUC proposed under Alternatives 2 and 3 should adequately manage the limited risk posed at the site.

5.4 REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT

Alternatives 1, 2, and 3 do not involve any treatment or containment of groundwater; therefore, there would be no reduction in the toxicity, mobility, or volume of contaminants, except through natural fate and transport processes. Implementation of Alternative 4 should reduce the toxicity and volume of contaminants through treatment. The monitoring proposed under Alternative 3 would provide documentation over the long-term that contamination is not migrating off site above

the RSKs. However, six sampling events since mid-2004 show that no MGP-related contamination is migrating off site.

5.5 SHORT-TERM EFFECTIVENESS

No short-term risks to the public, site workers, and the environment would occur during the implementation of Alternative 1 because no intrusive remedial actions would be implemented. The risk of implementing Alternatives 2 and 3 would be associated with the exposure to contaminants in groundwater during purging and sampling, but would be minimal if proper health and safety protocols are followed. Short-term risks would be greatest with Alternative 4 due to the handling and management of oxidants and the possibility of day-lighting during injection.

The time to achieve the corrective action objectives would vary between alternatives. Alternative 1 would never achieve the objectives. For Alternatives 2 and 3, the objective of preventing exposure to groundwater would be achieved upon instituting and enforcing the EUCs. For Alternative 4, the objectives would be met when monitoring confirmed that contaminant concentrations remained below the RSKs. Groundwater monitoring under Alternatives 2 and 3 would show that contaminants are not migrating off site above the RSK levels and if concentrations continue to decrease.

5.6 IMPLEMENTABILITY

The EUCs of Alternatives 2 and 3 may be more difficult to implement and enforce because Westar Energy does not own the site properties. If properly enforced, the EUCs would be a reliable means of preventing exposure to the groundwater. Alternative 4 would be more difficult to implement than groundwater monitoring and EUCs because of the associated equipment and technologies, and the issues with minimizing day-lighting and maintaining an elevated pH to oxidize cyanide.

5.7 COST

The approximate total present worth costs of the alternatives are as follows:

Alternative 1	$15,000
Alternative 2	$145,000
Alternative 3	$600,000
Alternative 4	$800,000

5.8 RECOMMENDED CORRECTIVE ACTION ALTERNATIVE

The recommended alternative is Alternative 2, w hich involves placing EUCs on the USD 470 property and a portion of the adjacent Bay property to control future groundwater use and prevent exposure to residual contamination in soil and groundwater. Although historically both PAHs and cyanide have been detected in onsite monitoring wells at levels above the RSKs, only amenable cyanide has been detected since 2006 exceeding RSK criterion. Well MW-5, which contains amenable cyanide above the RSKs, is not located in the area or downgradient of the former MGP structures that are typically responsible for cyanide residuals.

Six years of groundwater monitoring data show that MGP-related contaminants are not migrating off site. The five additional years of monitoring proposed with Alternative 2 should demonstrate that contaminants are not migrating off site above the RSK levels and the amenable cyanide in well

MW-5 is isolated and not increasing. If concentrations of amenable cyanide remain above the RSK after 5 years of monitoring, long-term monitoring as outlined in Alternative 3 will be implemented. If concentrations of additional MGP-related chemicals increase above the RSKs for at least two consecutive sampling events, additional investigation and/or corrective action will be considered.

6.0 References

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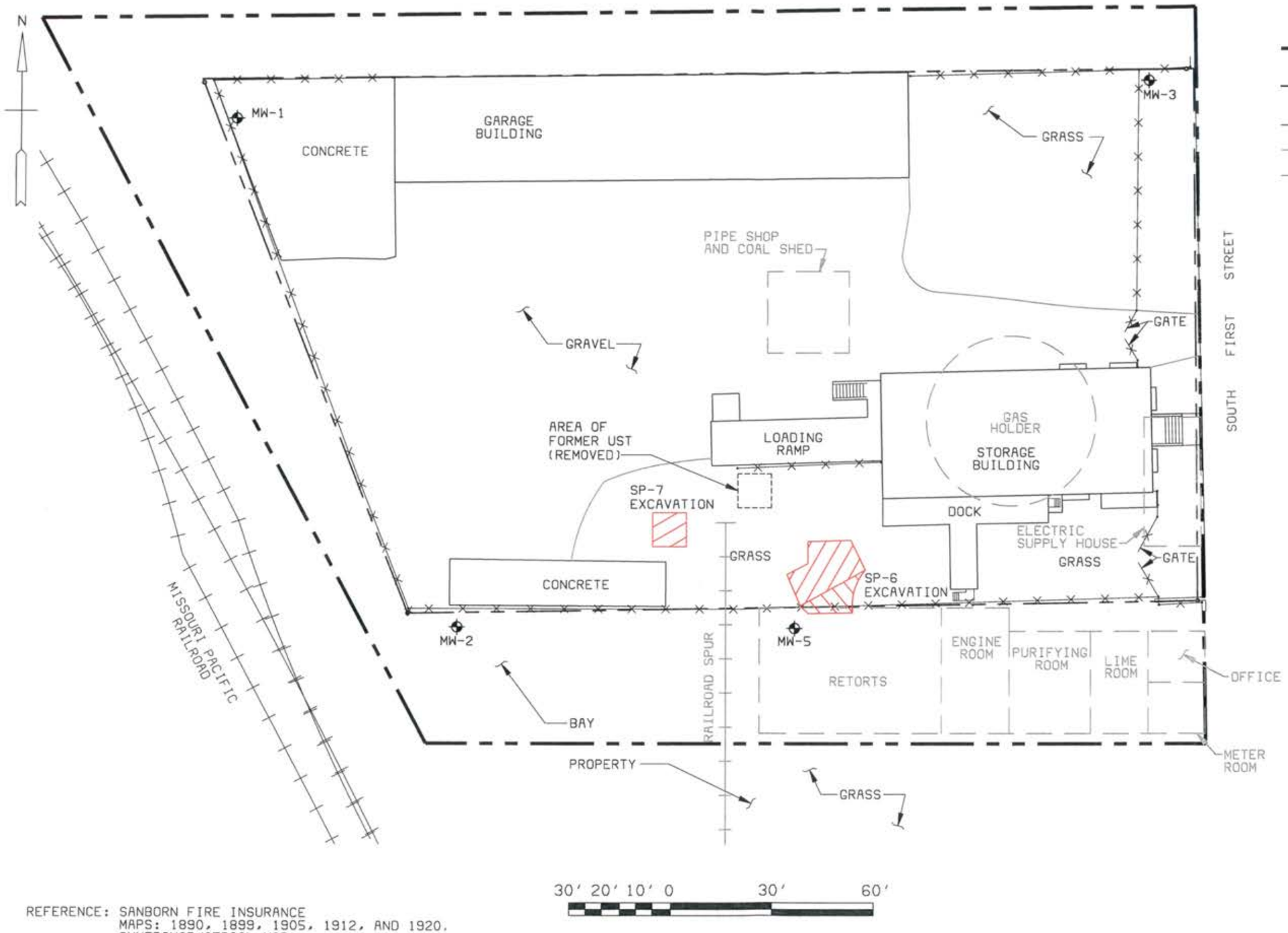
Figures



LEGEND:

- FORMER GAS PLANT PROPERTY BOUNDARY
- USD 470 PROPERTY BOUNDARY
- EXISTING STRUCTURE
- FORMER STRUCTURE
- FENCE
- MONITORING WELL
- AUG. 2005 EXCAVATION
- OCT. 2005 EXCAVATION

NOTES:

1. FORMER STRUCTURE LOCATIONS ARE APPROXIMATE.

REFERENCE: SANBORN FIRE INSURANCE MAPS: 1890, 1899, 1905, 1912, AND 1920. OWNERSHIP/AERIAL MAP, COWLEY COUNTY, KANSAS, 1986. SMITH & OAKES, INC ENGR: 2003.

FIGURE 1-1
SITE MAP
ARKANSAS CITY MGP SITE
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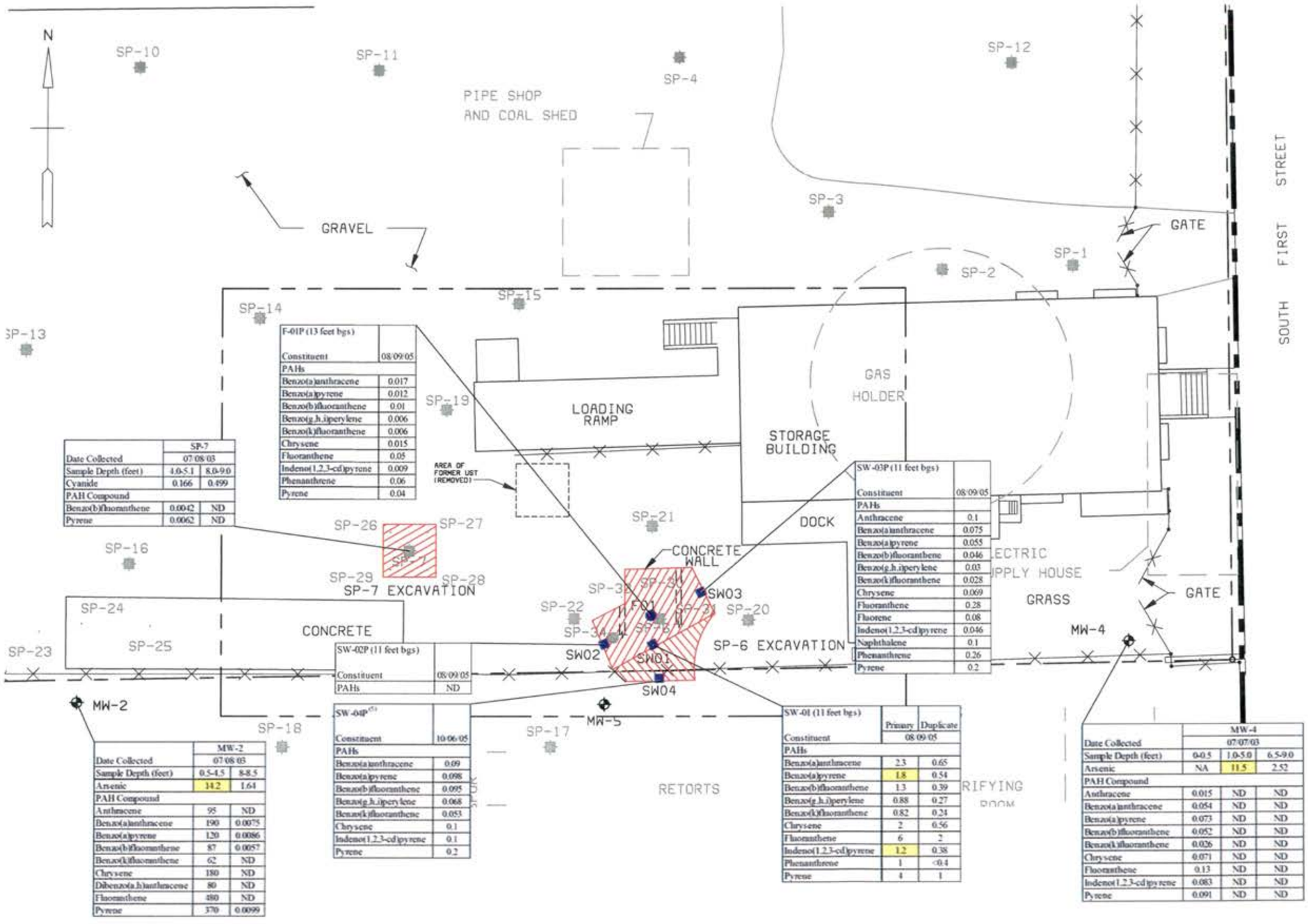

	SP-7	
Date Collected	07/08/03	
Sample Depth (feet)	4.0-5.1	8.0-9.0
Cyanide	0.166	0.499
PAH Compound		
Benzo(b)fluoranthene	0.0042	ND
Pyrene	0.0062	ND

F-01P (13 feet bgs)	
Constituent	08/09/05
PAHs	
Benzo(a)anthracene	0.017
Benzo(a)pyrene	0.012
Benzo(b)fluoranthene	0.01
Benzo(g,h,i)perylene	0.006
Benzo(k)fluoranthene	0.006
Chrysene	0.015
Fluoranthene	0.05
Indeno(1,2,3-cd)pyrene	0.009
Phenanthrene	0.06
Pyrene	0.04

SW-03P (11 feet bgs)	
Constituent	08/09/05
PAHs	
Anthracene	0.1
Benzo(a)anthracene	0.075
Benzo(a)pyrene	0.055
Benzo(b)fluoranthene	0.046
Benzo(g,h,i)perylene	0.03
Benzo(k)fluoranthene	0.028
Chrysene	0.069
Fluoranthene	0.28
Fluorene	0.08
Indeno(1,2,3-cd)pyrene	0.046
Naphthalene	0.1
Phenanthrene	0.26
Pyrene	0.2

SW-02P (11 feet bgs)	
Constituent	08/09/05
PAHs	ND

SW-04P[1]	
Constituent	10/06/05
PAHs	
Benzo(a)anthracene	0.09
Benzo(a)pyrene	0.098
Benzo(b)fluoranthene	0.095
Benzo(g,h,i)perylene	0.068
Benzo(k)fluoranthene	0.053
Chrysene	0.1
Indeno(1,2,3-cd)pyrene	0.1
Pyrene	0.2

SW-01 (11 feet bgs)	Primary	Duplicate
Constituent	08/09/05	
PAHs		
Benzo(a)anthracene	2.3	0.65
Benzo(a)pyrene	1.8	0.54
Benzo(b)fluoranthene	1.3	0.39
Benzo(g,h,i)perylene	0.88	0.27
Benzo(k)fluoranthene	0.82	0.24
Chrysene	2	0.56
Fluoranthene	6	2
Indeno(1,2,3-cd)pyrene	1.2	0.38
Phenanthrene	1	<0.4
Pyrene	4	1

	MW-2	
Date Collected	07/08/03	
Sample Depth (feet)	0.5-4.5	8-8.5
Arsenic	14.2	1.61
PAH Compound		
Anthracene	95	ND
Benzo(a)anthracene	190	0.0075
Benzo(a)pyrene	120	0.0086
Benzo(b)fluoranthene	87	0.0057
Benzo(k)fluoranthene	62	ND
Chrysene	180	ND
Dibenzo(a,h)anthracene	80	ND
Fluoranthene	480	ND
Pyrene	370	0.0099

	MW-4		
Date Collected	07/07/03		
Sample Depth (feet)	0-0.5	1.0-5.0	6.5-9.0
Arsenic	NA	11.5	2.52
PAH Compound			
Anthracene	0.015	ND	ND
Benzo(a)anthracene	0.054	ND	ND
Benzo(a)pyrene	0.073	ND	ND
Benzo(b)fluoranthene	0.052	ND	ND
Benzo(k)fluoranthene	0.026	ND	ND
Chrysene	0.071	ND	ND
Fluoranthene	0.13	ND	ND
Indeno(1,2,3-cd)pyrene	0.083	ND	ND
Pyrene	0.091	ND	ND

LEGEND:

- SW01 — SIDEWALL CONFIRMATION SAMPLE LOCATION
- F01 — FLOOR CONFIRMATION SAMPLE LOCATION
- MONITORING WELL
- JULY 2003 SOIL PROBE
- JUNE 2004 SOIL PROBE
- USD 470 PROPERTY BOUNDARY
- EXISTING STRUCTURE
- FORMER STRUCTURE
- FENCE
- AUG. 2005 EXCAVATION
- OCT. 2005 EXCAVATION

NOTES:

1. NON-DETECTS WERE NOT INCLUDED IN THE TABLES.
2. NO SIDEWALL SAMPLE WAS COLLECTED FROM THE NORTH SIDE OF THE EXCAVATION DUE TO THE PRESENCE OF A CONCRETE WALL. THIS WALL APPEARED TO BE PART OF THE SUSPECTED TAR HOLDER STRUCTURE THAT WAS ENCOUNTERED IN THE SP-6 EXCAVATION.
3. ALL RESULTS ARE IN MG/KG.
4. SHADED RESULTS INDICATE VALUES ABOVE KDHE RESIDENTIAL VALUES (KDHE 2013). SAMPLES WERE COLLECTED FROM AN INTERMEDIATE SIDEWALL LATER REMOVED DURING ADDITIONAL SOIL EXCAVATION.
5. SW04 WAS A COMPOSITE SAMPLE FROM 3-5, 5-9, AND 9-13 FEET BGS.

REFERENCE: SANBORN FIRE INSURANCE MAPS: 1890, 1899, 1905, 1912, AND 1920. OWNERSHIP/AERIAL MAP, COWLEY COUNTY, KANSAS, 1986. SMITH & OAKES, INC ENGR: 2003. FIELD MEASUREMENTS TAKEN 8/09/05.

20' 0 20' 40'

FIGURE 1-2
CONFIRMATION SOIL SAMPLES
ARKANSAS CITY MGP SITE
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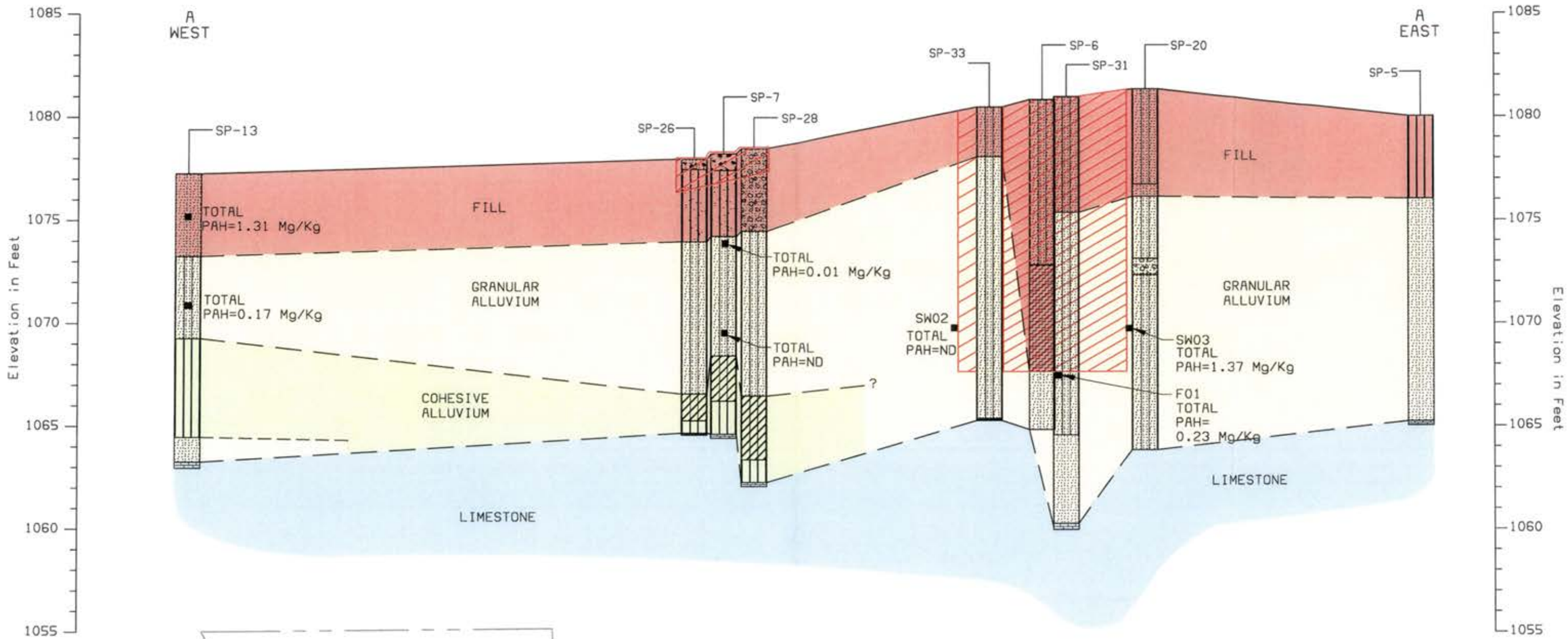

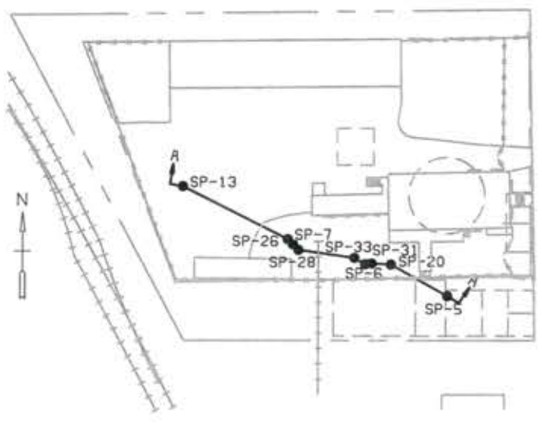

GEOLOGIC CROSS SECTION LOCATION KEY

LEGEND

- SILTY SAND
- LIMESTONE
- SILT
- SLAG AND CINDERS
- SAND
- SILTY CLAY
- SANDY SILT
- GRAVELLY SAND
- SANDY GRAVEL
- EXCAVATION AREA

15' 7.5' 0 15' 30'

FIGURE 1-3
GEOLOGIC CROSS SECTION A-A
ARKANSAS CITY MGP SITE
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B
SOUTHWEST

B'
NORTHEAST

1085
1080
1075
1070
1065
1060
1055
1050

ELEVATION IN FEET (MSL)

MW-2
SP-16
SP-7
SP-19
SP-15
SP-3
SP-12
MW-3

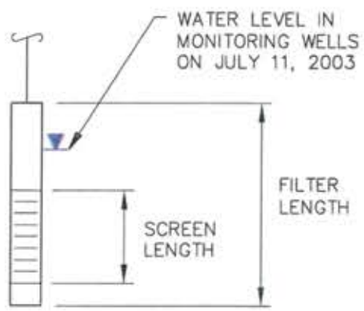
TOTAL PAH =1.66 Mg/Kg
TOTAL PAH =0.04 Mg/Kg
TOTAL PAH =0.23Mg/Kg
TOTAL PAH =0.01Mg/Kg
TOTAL PAH=ND
TOTAL PAH =0.01Mg/Kg
TOTAL PAH=ND
TOTAL PAH =0.60Mg/Kg
TOTAL PAH=ND
TOTAL PAH=ND

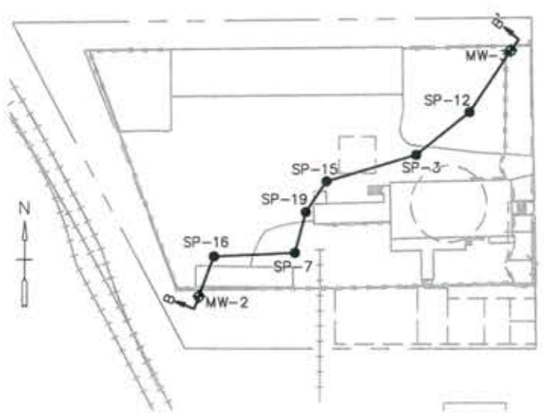
FILL
FILL

GRANULAR ALLUVIUM
GRANULAR ALLUVIUM

COHESIVE ALLUVIUM

LIMESTONE
LIMESTONE





GEOLOGIC CROSS SECTION LOCATION KEY

LEGEND

- SILTY SAND
- SILT
- SAND
- LIMESTONE
- GRAVELLY SAND
- GRAVEL
- SAND/SILTY SAND
- SANDY GRAVEL

20' 10' 0 20' 40'

FIGURE 1-4
GEOLOGIC CROSS SECTION B-B'
ARKANSAS CITY MGP SITE

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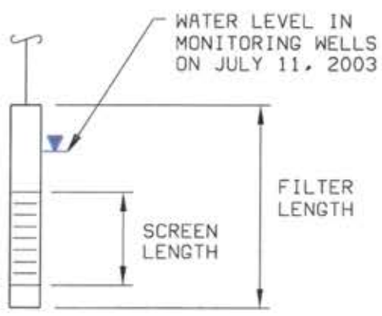

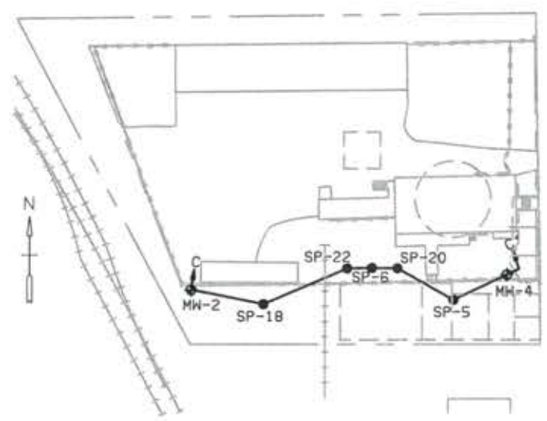

GEOLOGIC CROSS SECTION LOCATION KEY

LEGEND

- SILTY SAND
- LIMESTONE
- SILT
- SLAG AND CINDERS
- SAND
- CLAY
- GRAVELLY SAND
- EXCAVATION AREA

20' 10' 0 20' 40'

FIGURE 1-5
GEOLOGIC CROSS SECTION C-C'
ARKANSAS CITY MGP SITE

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