DEPARTMENT OF THE ARMY
US ARMY INSTALLATION MANAGEMENT COMMAND
US ARMY ENVIRONMENTAL COMMAND
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AMIM-AEC-M (1200C) February 11, 2025

SUBJECT: October 2023 Monitored Natural Attenuation Groundwater Data
WDNR BRRTS #02-57-001002
Former Badger Army Ammunition Plant

Mr. Luke Lampo
Wisconsin Department of Natural Resources
South Central Region
3911 Fish Hatchery Road
Fitchburg, WI 53711-5397

Dear Mr. Lampo:

Enclosed is the Former Badger Army Ammunition Plant (BAAP) October 2023 monitored natural attenuation (MNA) groundwater data. This was a special sampling event conducted in the Propellant Burning Ground (PBG) Plume. On October 10, 2023, SpecPro Professional Services, LLC (SPS) collected groundwater samples from 16 monitoring wells associated with the PBG Plume (see Figure 1).

The 16 monitoring wells selected are part of the current groundwater sampling plan being conducted by SPS. The monitoring wells were selected to obtain upgradient groundwater data (PBM-8909) along with wells along the center line of the PBG Plume. Wells screened near the water table (A level) were selected closer to the PBG source areas. From the BAAP boundary to Highway 78, deeper wells screened beneath the water table (B and C levels) were selected. The volatile organic compounds (VOCs) found in the PBG Plume have migrated downward in the groundwater aquifer along with moving horizontally from the source areas (PBG) towards the Wisconsin River (southeast).

The PBG Plume boundary depicted on Figure 1 is based on groundwater data collected during 2023 and 2024. The plume boundary outlines where either VOCs or total dinitrotoluene (DNT) were detected above the NR 140 Enforcement Standard (ES) or NR 140 Preventive Action Limit (PAL). VOCs that exceed either the NR 140 ES or PAL in the PBG Plume include bromodichloromethane, carbon tetrachloride, chloroform, ethyl ether, and trichloroethene. 2,4-DNT, 2,6-DNT and total DNT also are present in the PBG Plume above the NR 140 ES.

This October 2023 MNA groundwater sampling event analyzed groundwater samples for geochemical parameters to provide a baseline of MNA conditions in the PBG Plume. Groundwater samples were collected from monitoring wells using low-flow sampling techniques with dedicated air bladder pumps. The field parameters collected were depth to water, dissolved oxygen, oxygen reduction potential, pH, specific

conductivity, and temperature. The following inorganic parameters were laboratory analyzed: alkalinity, chloride, nitrate, sulfate, total organic carbon, and total inorganic carbon. The following metals were laboratory analyzed: ferric/total iron, ferrous/dissolved iron, total lead, dissolved lead, and dissolved manganese. The following dissolved hydrocarbon gases (DHG) were laboratory analyzed: ethane, ethene, and methane. The groundwater sampling field parameter data and analytical results are summarized in Table 1. The sampled monitoring wells are listed in Table 1 from closest to the source areas (top) to the farthest downgradient (bottom). PBN-9101C and PBM-9001D are located 2.8 miles downgradient (southeast) of the PBG source areas.

The geochemical parameters selected were based on the WDNR's guidance "*Understanding Chlorinated Hydrocarbon Behavior in Groundwater: Investigation, Assessment and Limitations of Monitored Natural Attenuation,* RR-699, April 2003".

Monitoring well PBM-8909 was used as the background well to compare groundwater field parameters and analytical results. PBM-8909 is located on the north side (upgradient) of the PBG Plume (see Figure 1).

The PBG Plume is a well-oxygenated (aerobic) groundwater system with little or no organic matter. Reducing groundwater conditions are present in some deeper monitoring wells screened near the bedrock surface.

Groundwater Field Parameter Results

Groundwater field parameters were measured and recorded for all 16 monitoring wells. The field parameters included the following: depth to water, dissolved oxygen, oxygen reduction potential, pH, specific conductivity, and temperature. The groundwater sampling field parameter data are provided in Table 1.

The dissolved oxygen in the shallower wells (A, B & C levels) was high, averaging 8.4 milligrams per liter (mg/l). The dissolved oxygen in deeper wells (D level) PBN-9303D, SPN-9104D and SWN-9103D was below 1.0 mg/L. This data indicates that the shallow groundwater in the PBG Plume is well oxygenated and the deeper groundwater (D level) near the bedrock is lacking oxygen or anaerobic. The one exception to this is that PBM-9001D had dissolved oxygen at 7.5 mg/L. The dissolved oxygen data is similar to field data collected during 2024.

The oxygen reduction potential in the shallower wells (A, B & C levels) was high, averaging 140 millivolts. The oxygen reduction potential in deeper wells (D level) PBN-9303D and SPN-9104D was below -100 millivolts. This data indicates that the deeper groundwater (D level) near the bedrock is under reducing conditions. The oxygen reduction potential data is similar to field data collected during 2024.

The specific conductivity readings in monitoring wells south of the PBG were higher than the background well (PBM-8909). The specific conductivity averaged 800 microsiemens per centimeter and similar to the 2024 field data.

Inorganic Parameter Results

The following inorganic parameters were laboratory analyzed in all 16 monitoring wells: alkalinity, chloride, nitrate, sulfate, total organic carbon, and total inorganic carbon. The groundwater inorganic laboratory data are provided in Table 1.

The average alkalinity concentration in monitoring wells south of the PBG was 308 mg/L, which is similar to the background well alkalinity of 300 mg/L.

The chloride concentration in the background well (PBM-8909) was 11 mg/L. The average chloride concentration in monitoring wells downgradient of the PBG was 25 mg/L. The increase in chloride downgradient of the PBG may indicate that chlorinated solvents have degraded.

The average nitrate concentration in monitoring wells south of the PBG was 5.3 mg/L, which is similar to the background well concentration of 5.9 mg/L. The nitrate concentration in deeper wells (D level) PBN-9303D and SPN-9104D was below 0.12 mg/L.

The average sulfate concentration in monitoring wells south of the PBG was 34 mg/L, which is similar to the background well concentration of 11 mg/L. The sulfate concentration in deeper wells (D level) PBN-9303D and SPN-9104D was above 100 mg/L.

Total organic carbon was not detected in all 16 monitoring wells sampled. The average total inorganic carbon concentration in monitoring wells south of the PBG was 84 mg/L, which is similar to the background well concentration of 82 mg/L.

Metal Results

The following metals were laboratory analyzed in all 16 monitoring wells: ferric/total iron, ferrous/dissolved iron, total lead, dissolved lead, and dissolved manganese. The groundwater metals laboratory data are provided in Table 1.

The ferric/total iron concentration in the background well (PBM-8909) was 45.2 micrograms per liter (µg/l). Elevated ferric/total iron was detected in PBN-9303D (24,200 µg/l) and PBN-2301C (570 µg/l). The ferrous/dissolved iron concentration in the background well (PBM-8909) was below 14 µg/l. Elevated ferrous/dissolved iron was detected in PBN-9303D at 7,610 µg/l. The presence of elevated ferrous/dissolved iron in groundwater is indicative of reducing conditions.

The total lead concentration in the background well (PBM-8909) was below 1.4 µg/l. Elevated total lead was detected in PBN-9303D at 7,610 µg/l. Dissolved lead was not detected in all 16 monitoring wells sampled.

The dissolved manganese concentration in the background well (PBM-8909) was below 1.4 µg/l. Elevated dissolved manganese was detected in PBN-9303D (472 µg/l) and SPN-9104D (597 µg/l). The presence of elevated dissolved manganese in groundwater is indicative of reducing conditions.

Dissolved Hydrocarbon Gas Results

Dissolved hydrocarbon gases groundwater samples were analyzed for ethane, ethene, and methane. The groundwater laboratory results are summarized in Table 1. Neither ethane nor ethene were detected in the 16 monitoring wells. Methane was detected in four wells (PBN-9303D, SPN-8904C, SPN-9104D, and SWN-9103B) at concentrations ranging from 0.48 to 2.9 µg/L. The highest methane concentration of 2.9 µg/L was detected in SPN-9104D. The well screen bottom of SPN-9104D is located six feet above the bedrock surface (212 feet below grade). SPN-9104D is located on the BAAP boundary and in the middle of the PBG Plume (see Figure 1). The presence of elevated methane in groundwater is indicative of strong reducing conditions. The field readings, low dissolved oxygen (0.6 mg/L) and low oxygen reduction potential (-140 mV), measured in SPN-9104D also indicate strong reducing conditions are present.

Quality Review

SPS conducted an internal quality control review of the groundwater data. The internal review did not find any issues with the groundwater data. All groundwater samples were analyzed by CT Laboratories, LLC (CT Lab) in Baraboo, Wisconsin. CT Lab is a WDNR Chapter NR 149 certified laboratory and accredited by the Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP).

Please do not hesitate to contact me at scott.a.benson25.civ@army.mil or 520-725-4326 if you have any questions.

Sincerely,

BENSON.SCOTT.ALAN.1456242754
Digitally signed by BENSON.SCOTT.ALAN.1456242754
Date: 2025.02.11 13:53:50 -06'00'

Scott Benson
Environmental Support Manager
U.S. Army Environmental Command

Attachments
Copy furn: Joel Janssen, SpecPro Professional Services, LLC

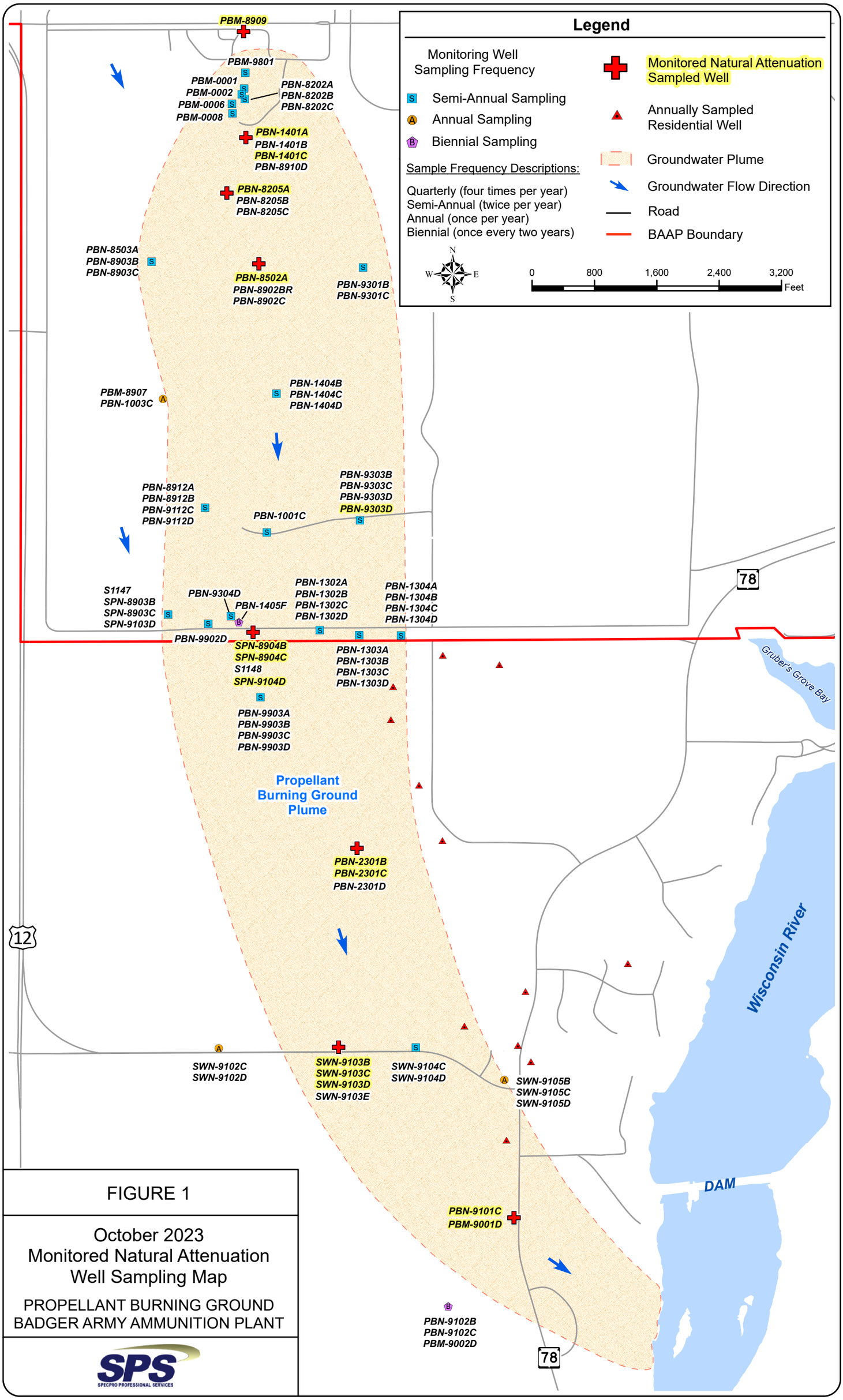

FIGURE 1

October 2023
Monitored Natural Attenuation
Well Sampling Map

PROPELLANT BURNING GROUND
BADGER ARMY AMMUNITION PLANT

SPS
SPECPRO PROFESSIONAL SERVICES

Table 1
Monitored Natural Attenuation Sampling - October 2023
Propellant Burning Ground Plume
Former Badger Army Ammunition Plant

					Inorganic Parameters						Metals					Dissolved Gases		
Well Name	**Well ID**	**Date Sampled**	**Well Depth (feet)**	**Well Type**	**Alkalinity (mg/L)**	**Chloride (mg/L)**	**Nitrate Nitrogen (mg/L)**	**Sulfate (mg/L)**	**Total Organic Carbon (mg/L)**	**Total Inorganic Carbon (mg/L)**	**Ferric/Total Iron (µg/L)**	**Ferrous/ Dissolved Iron (µg/L)**	**Total Lead (µg/L)**	**Dissolved Lead (µg/L)**	**Dissolved Manganese (µg/L)**	**Ethane (µg/L)**	**Ethene (µg/L)**	**Methane (µg/L)**
				Lab Method	E310.2	SW9056	SW9056	SW9056	SW9056	SW9056	SW6010	SW6010	SW6010	SW6010	SW6010	RSK-175	RSK-175	RSK-175
PBM-8909 (1)	639	10/10/23	124.4	OW	**300**	**11**	**5.9**	**11**	<0.4	**82**	**45.2**	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
PBN-1401A	782	10/10/23	132.2	OW	**290**	**35**	**2.8**	**21**	<0.4	**81**	**118**	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
PBN-1401C	784	10/10/23	203.3	PZ	**290**	**40**	**2.6**	**20**	<0.4	**82**	**201**	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
PBN-8205A	622	10/10/23	112.5	OW	**330**	**26**	**2.9**	**20**	<0.4	**91**	**24.5**	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
PBN-8502A	632	10/10/23	138.1	OW	**330**	**23**	**6.0**	**18**	<0.4	**91**	<14	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
PBN-9303D	675	10/10/23	224.5	PZ	**370**	**24**	<0.12	**120**	<0.4	**97**	**24,200**	**7,610**	**63.1**	<1.4	**472**	<0.38	<0.59	**0.74**
SPN-8904B	720	10/10/23	75.0	PZ	**300**	**20**	**4.3**	**20**	<0.4	**84**	**14**	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
SPN-8904C	721	10/10/23	106.5	PZ	**310**	**23**	**4.8**	**23**	<0.4	**84**	**21.3**	<14	<1.4	<1.4	<1.4	<0.38	<0.59	**0.58**
SPN-9104D	726	10/10/23	206.0	PZ	**360**	**38**	<0.12	**150**	<0.4	**97**	<14	**177**	<1.4	<1.4	**597**	<0.38	<0.59	**2.90**
PBN-2301B	544	10/10/23	120.0	PZ	**310**	**14**	**6.9**	**27**	<0.4	**84**	**76**	<14	<1.4	<1.4	**2.1**	<0.38	<0.59	<0.45
PBN-2301C	545	10/10/23	180.0	PZ	**310**	**16**	**6.4**	**33**	<0.4	**84**	**570**	<14	<1.4	<1.4	**2.3**	<0.38	<0.59	<0.45
SWN-9103B	571	10/10/23	113.4	PZ	**270**	**19**	**9.9**	**21**	<0.4	**74**	<14	**15.4**	<1.4	<1.4	<1.4	<0.38	<0.59	**0.48**
SWN-9103C	572	10/10/23	162.8	PZ	**260**	**20**	**1.2**	**47**	<0.4	**71**	<14	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
SWN-9103D	573	10/10/23	209.1	PZ	**330**	**26**	**4.0**	**80**	<0.4	**88**	<14	**28.6**	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45
PBN-9101C	561	10/10/23	152.5	PZ	**270**	**29**	**8.5**	**37**	<0.4	**75**	<14	<14	**1.4**	<1.4	<1.4	<0.38	<0.59	<0.45
PBM-9001D	981	10/10/23	210.5	PZ	**290**	**24**	**8.2**	**72**	<0.4	**79**	<14	<14	<1.4	<1.4	<1.4	<0.38	<0.59	<0.45

Table 1
Monitored Natural Attenuation Sampling - October 2023
Propellant Burning Ground Plume
Former Badger Army Ammunition Plant

					Field Parameters					
Well Name	**Well ID**	**Date Sampled**	**Well Depth (feet)**	**Well Type**	**Specific Conductivity (uS/cm)**	**Oxygen Reduction Potential (mV)**	**Dissolved Oxygen (mg/L)**	**pH (S.U.)**	**Temperature (°C)**	**Depth to Water**
				Lab Method						
PBM-8909 (1)	639	10/10/23	124.4	OW	703	129	10.7	7.0	10.2	106.50
PBN-1401A	782	10/10/23	132.2	OW	776	196	8.2	6.8	10.2	111.59
PBN-1401C	784	10/10/23	203.3	PZ	801	203	8.2	6.9	10.2	111.37
PBN-8205A	622	10/10/23	112.5	OW	790	224	9.5	6.8	9.9	103.91
PBN-8502A	632	10/10/23	138.1	OW	818	236	10.5	6.8	10.5	125.58
PBN-9303D	675	10/10/23	224.5	PZ	1,031	-170	0.3	7.0	10.1	45.88
SPN-8904B	720	10/10/23	75.0	PZ	755	61	9.2	6.9	9.9	38.64
SPN-8904C	721	10/10/23	106.5	PZ	773	25	8.5	7.0	9.8	37.52
SPN-9104D	726	10/10/23	206.0	PZ	1,091	-140	0.6	7.3	10.2	36.90
PBN-2301B	544	10/10/23	120.0	PZ	772	104	9.4	7.0	10.1	79.98
PBN-2301C	545	10/10/23	180.0	PZ	799	112	8.1	7.0	10.0	79.82
SWN-9103B	571	10/10/23	113.4	PZ	756	128	9.6	7.0	10.2	82.00
SWN-9103C	572	10/10/23	162.8	PZ	706	115	1.1	7.2	10.1	82.05
SWN-9103D	573	10/10/23	209.1	PZ	929	127	0.7	7.0	10.5	82.49
PBN-9101C	561	10/10/23	152.5	PZ	817	136	8.0	7.2	10.4	87.95
PBM-9001D	981	10/10/23	210.5	PZ	879	122	7.5	7.3	11.1	89.09

Notes:
(1) PBM-8909 is the background well
OW = Water Table Observation Well
PZ = Piezometer
°C = degrees Celsius
mV = millivolts
mg/L = milligrams per liter (ppm)
µg/L = micrograms per liter (ppb)
µs/cm = microsiemens per centimeter