U.S. Geological Survey Technical Review of "Draft Final Remedial Investigation/Feasibility Study for Site-Wide Groundwater at the Former Badger Army Ammunition Plant, Baraboo, Wisconsin, November 2019"

April 14, 2020

Summary

The US Geological Survey Water Mission Area (USGS) has an agreement with Army Environmental Command (AEC) to provide science technical assistance for selected AEC projects. The USGS has a long history of providing science support to many local, state, and federal partners in areas of geology, water quality, groundwater, surface water, and modeling to name a just few. In addition, it should be noted that the USGS is nonregulatory and does not make or set policy actions. As part of the agreement with AEC, the USGS has provided a technical review of the draft final RI/FS for site groundwater at the former Badger Army Ammunition Plant in Baraboo, Wisconsin.

The Badger site has been in active remediation for several years and many different remedial actions have taken place over time. The USGS reviewers for this report have not previously worked on the site. There are likely comments and questions by the USGS reviewers that have been asked previously and possibly new comments that have not been made before.

The main objective of this review by the USGS was related to the hydrogeology and water-quality. The hydrology and water quality data collected to date are within the USGS scope for review and comment. In other areas of the report such as in the human risk assessment section the USGS lacks the proper qualifications. However, one of the USGS reviewers for this report has had considerable experience with RI/FS reports over the years, and subsequently that reviewer did have a basic understanding of the risk assessment process and did review the risk assessment portions to his best of his ability.

In general, the report documents by a logical methodology the data collected, and actions completed at the Badger site. The report is well written and has good figures and tables to support the text. Finally, it should be noted that the installation of various nested wells at site in the past were vital in providing critical information for hydraulic heads, flow directions, and vertical extent of contamination at the site.

Background

The background listed below is from the executive summary from the remedial investigation and feasibility study:

This Remedial Investigation/Feasibility Study (RI/FS) presents updated groundwater investigation results, human health risk assessment findings, and the analysis of remedial alternatives for contaminated groundwater at the former Badger Army Ammunition Plant (BAAP). The RI/FS is prepared in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the 1986 Superfund Amendments and Reauthorization Act (SARA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and the Defense Environmental Restoration Program (DERP) requirements.

BAAP was constructed in 1942 to produce smokeless gunpowder and solid rocket propellant as munitions components for World War II. The former BAAP is located on the Sauk Prairie, between the Baraboo Range and the Wisconsin River. Because of production and waste disposal practices that were common at the time, soil and groundwater at the former BAAP were impacted. The Department of the Army (Army) has transferred a majority of the total 7,275 acres of BAAP to other Federal agencies.

The Army began assessing potential waste management areas that may be sources of soil and groundwater contamination in 1980. When the Army applied for a Resource Conservation and Recovery Act (RCRA) permit in 1988, the State of Wisconsin did not have authorization to implement certain elements of RCRA, also known as the Hazardous and Solid Waste Amendments of 1984, so the Army operated under a dual federal-state permit, where the Wisconsin Department of Natural Resources (WDNR) regulated the RCRA operating and/or closure requirements and the United States Environmental Protection Agency (USEPA) addressed RCRA corrective action requirements.

RCRA closure and post-closure requirements were managed through an *In-Field Conditions Report* (IFCR), which WDNR issued in 1987. As required by the IFCR, the Army has been conducting groundwater monitoring of both monitoring wells and residential wells since 1987. The current site-wide groundwater monitoring program follows the IFCR dated September 4, 2013 and subsequent revisions up through July 24, 2018. Currently, the Army is sampling 166 monitoring wells and 54 residential wells at varying frequencies.

In 2011, the Army submitted a Revised Alternative Feasibility Study, Groundwater Remedial Strategy report to the WDNR. The selected groundwater remedy was Monitored Natural Attenuation (MNA). Due to the relatively long timeframe for the MNA remedy to achieve the proposed cleanup levels, the proposed remedy included construction and operation of a municipal drinking water system that would provide residents in the communities surrounding the former BAAP with drinking water while groundwater contamination continued to diminish over time. During an evaluation by the Army's Office of General Counsel it was determined the Army did not have the legal or funding authority to procure and operate a municipal water system as identified in the 2011 Revised Alternative Feasibility Study.

While a draft Decision Document (DD) for Site-Wide Groundwater was being prepared in 2012, the Army identified several areas where the draft DD did not meet both legal and policy requirements. Specifically, a human health risk assessment was not prepared, incorrect legal standards were identified for the selected groundwater remedy and key components of the proposed response action were outside the Army's authority. In 2017, the Army coordinated with the WDNR and informed the public regarding the need to align the Badger Site-Wide Groundwater remedy selection to comply policy, and funding authorities. The Army communicated the need to reevaluate the groundwater remedy at BAAP in a letter dated July 25, 2017.

Major Recommendations from USGS review of RI/FS:

1. Because rising groundwater is a threat to capped contaminant source areas in the PBG and DBG source areas, continuous, real-time groundwater level monitoring stations at selected wells near the source areas are recommended as part of a potential treatment and monitoring plan. These stations would help monitor recharge from precipitation events, effects of pump and treat on groundwater levels, and provide early warning about rising groundwater levels that might come in contact with contaminated soils. Collection of groundwater samples downgradient of the source areas could be coordinated with rises in groundwater levels.

2. The wells selected to be monitored have changed over time. As it is possible that contamination could show up again in unexpected locations, it is recommended that a more extensive groundwater synoptic sampling event occur every couple of years. Additional wells could include wells that were previously sampled or new wells. Also wells that would be useful for determining groundwater elevations, contours, and flow direction could be considered. A consistent network of wells should be selected that can be useful for examining potential trends in the future.

3. Given the age of the site and transmissivity of the aquifer, it is not possible to determine if contamination could have been transported beyond the sampling area. To help alleviate the concern that contamination could have been transported underneath, or beyond the Wisconsin River, it is recommended that the possibility of sampling under, or across the River be included or explored as part of the monitoring program. It may be useful to collect a sample of the river water at the time of groundwater collection.

4. Based on the table in section 9.7 (PBG plume), all the alternatives reach the cleanup level in 30 years. It seems that MNA without any other alternatives to reduce contaminant source or mass might require the longest time to achieve clean up goals. Perhaps explain why it takes 30 years for each alternative.

General Comments

1. Based on the text description of waste disposal practices within section 2.2.2 it was difficult to understand all the potential areas where waste was generated or disposed of. For instance, the text mentions that waste was transported in open ditches, but maps do not indicate where those ditches were located. Or in the case of the NC area, waste was transported in underground pipes that might have leaked and outflow discharged to an open ditch near the wastewater treatment plant. However, it doesn't appear there is any contamination near the wastewater treatment plant. If there were open ditches one might expect contamination at least in the soils in that area. In addition, the settling ponds and spoils disposal areas shown on figure 1 don't show any contamination based on map and text. Overall, based on source assessment and plume delineation, it appears sources are well known. There are just some areas here based on description of waste handling one might expect some sort of contamination. However, there could have been other disposal locations that were not documented.

2. The Army's waste pit soil removal, capping, soil vapor extraction, and biologically enhanced subsurface treatment (BEST) significantly reduced both volatile organics and explosives mass from further entering the water table. The investigation conducted by Shaw in 2005 to determine how effective BEST had worked on the soils beneath the pits only included one borehole per pit. Due to heterogeneity of soils this seems to be a very limited set of data to determine how effective the BEST had worked. Table 1 indicates the concentrations of the VOCs in soils at each of the single soil boreholes, but there are no previous values of VOCs provided for comparison. Based on depth of water at the site, most of these samples were most likely collected in saturated conditions, thus once COCs are in groundwater the standards change. The VOC reporting limit for the soils was 0.060 milligrams per kilogram. Since most of these samples were collected within saturated conditions a lower reporting level would be needed to determine if values were over any standard (for example, TCE reporting level of 5 micrograms per liter).

   Appendix B shows the waste pits soils result comparison after the BEST remediation and overall yes, the total DNT concentrations did decrease in pits 1 and 2. Waste Pit 3 showed an increase between 2003 to 2005 in DNT (table 6). The basic concern here is the COC mass was calculated on limited data and how much is still left in the unsaturated soils? Will this mass continue to contribute to groundwater contamination when water tables rise in the area?

After reviewing the remedial alternatives there did not appear to be an alternative to try to remediate the source areas under the cap again. The waste pits are capped with a membrane and clay, so it is understandable that the Army does not want to disturb on the integrity of cap. If the present cap is disturbed it could potentially create more problems of contamination with water flowing through the system. Based on current alternatives, pump and treat is one of the possibilities which could keep the water table from rising under the cap. When pump and treat ends, the water table might rise, encountering the plume source, potentially defeating the remediation of the existing plumes.

The evaluation of alternatives did not include any type of biowall or curtain technology due to depth of the plumes. However, another consideration might be the use of activated carbon-based technology (U.S. Environmental Protection Agency, 2018). This technology is now being used at sites to deeper depths to slow down plumes while remediation occurs within the plume.

3. The hydrogeological characterization of this site is very well done with good cross-sections, vertical head calculations, and hydraulic conductivity. One concern with contamination as it moves away from a source, is that it tends to go deeper into an aquifer, depending on the hydrogeological characteristics of aquifer. The plumes at this site are in a highly transmissive system allowing contamination to go deeper away from the source. However, there is an aquitard below the first main water bearing zone that is deterring the plume from transporting into deeper zones in the bedrock aquifer. Based on the cross sections that cross into the Wisconsin River channel (for example, Figure 23 and 33) the figures indicate that the Wisconsin River is a hydraulic barrier for the first main water bearing zone. The Wisconsin River may act as a capture zone for the upper portions of the groundwater plume and basically dilute concentrations down to acceptable levels. However, contamination in the deeper zone could be moving under the river or making a turn and following paleochannels or glacial outwash channels.

   The extent of the plumes are interesting because several plumes have not migrated far compared with other plumes. Overall, even though there are some geological changes from west to east the aquifer is very transmissive. This may suggest that perhaps plume migration might be more of a function of source mass, water use, and discharge at the various source areas.

4. Appendix E includes plots of concentration over time for many of the wells. Overall, the data is showing that the mass of COCs in groundwater appears to be decreasing in most wells. This shows, as stated before, the Army's efforts to mitigate additional source to groundwater has worked well. However, some DNT concentrations are above standards and a few minimal VOCs slightly exceed as well. A statistical tend test of selected well concentrations might be useful. Also, the time series plots might be easier to see on the lower concentration end if the y-axis was converted to log scale.

There are several wells that have had increases in COC concentrations after pump and treat has been shut down. This might be an indication that water levels have raised underneath the capped areas, thus coming into contact with unsaturated soils containing source contamination. Recommend comparing groundwater elevations to COC concentrations to determine if there is any statistical relationship.

6. The reviewer assumes that groundwater samples are being collected by low-flow techniques. In sandy, well mixed systems this sample technique is normally a good way to sample. However, in more heterogenous hydrogeology and in wells with very long screens this sampling technique can be problematic since a representative sample might not be collected due to the hydraulic properties of the well and surrounding material. Large variability in sample concentrations in a well over various sampling events can be an indicator of this problem (Barcelona and others, 1994). There have been studies that have even shown that contamination has been missed in wells because of differences in sampling depth and depth of the contamination within the screened interval. If there are wells that show variability in concentrations (especially wells with long screened intervals), there is a program called Purge Analyzer Tool (Harte, 2017) that can calculate the sample purge volume necessary for the sample being taken to be representative of the screened interval. If there are wells that indicate micro-purge might be problematic, another option would be to use passive samplers throughout screen length to determine areas of higher contamination. If there are zones with higher contamination, then the sampling and remediation can be focused on those zones for a more effective clean up.

Minor Comments

1. **Page ii, minor editorial comment:** First use of DNT and NR. Should spell out or define for the first usage.

2. **Page iii, first paragraph minor editorial comment:** EPA Reference November 2018 is listed as EPA 2017 in reference list. Please verify correct date.

3. **Page iii, second paragraph minor editorial comment**: First use of CTET and TCE. Please spell out/define.

4. **Page iii, third paragraph minor editorial comment:** First use of COC and TCA. Please spell out/define.

5. **Page 3, Section 2.1, minor editorial comment:** FUDS and BIA should be added to list of acronyms.

6. **Page 5, third paragraph**: Suggest using same terminology on map (Sanitary WWTP) as in text (WWTP). Reviewer was looking for a WWTP near the source location, but WTTP plant is to west of PBG ground plume. If there was open ditch flow near the wastewater treatment plant wouldn't there be a good chance infiltration to the groundwater in that area. Plumes don't seem to indicate that near the WWTP or in settling pond area in the south.

7. **Section 4.4.1:** Given the general concern about the source areas, suggest a little more explanation of "How the cap influences the local groundwater flow?" and "How do the groundwater contours show that the cap is protecting the subsurface?"

8. **Page 24, last paragraph, minor editorial comment:** Minor typo, change "Stated" to States. Please add USGS to acronym list.

9. **Page 42, Figure 16:** Suggest for future figures to include well number and water level elevations used for contouring.

10. **Table 7:** Reference for United States Army Environmental Center, April 1993 is missing from reference list.

11. **Page 82, last paragraph, minor editorial comment:** The USEPA 1991 reference isn't located in the references. Please add.

12. **Page 89, Section 5.4.2:** First use of OSWER, please spell out/define here.

13. **Page 130:** First use of O&M, please spell out/define here.

14. **Page 133, section 9.4, minor editorial comment:** Please add EVO to acronym list.

References

Barcelona, M.J., Wehrraann, H.A., and Varljen, M.D., 1994, Reproducible well purging procedures and VOC stabilization criteria for ground water sampling: Ground Water, v. 32, no. 1, p. 12–22, accessed May 5, 2016, at https://doi.org/10.1111/j.1745-6584.1994.tb00605.x.

Harte P.T., 2017, In-well time-of-travel approach to evaluate optimal purge duration during low-flow sampling of monitoring wells. Environmental Earth Sciences. 76 : 6: 1-13

U.S. Environmental Protection Agency, 2018, Remedial Technology Fact Sheet – Activated Carbon-Based Technology for In Situ Remediation, U.S. EPA Fact Sheet 542-F-18-001, accessed at: https://semspub.epa.gov/work/HQ/100001159.pdf