Comments on the *Draft Final Proposed Plan for LHAAP-47 Plant 3 Area, Solid Rocket Motor Fuel Production Longhorn Army Ammunition Plant, Karnack, Texas*, December 2012

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These comments are submitted on behalf of the Caddo Lake Institute. They are based on an evaluation of the *Draft Final Proposed Plan for LHAAP-47 Plant 3 Area, Solid Rocket Motor Fuel Production Longhorn Army Ammunition Plant, Karnack, Texas*[1], as well as supporting documents (see references).

LHAAP-47 is a 275 acre site in the north-central portion of the Longhorn Army Ammunition Plant (LHAAP)[2]. Rocket motors, pyrotechnics, and illumination devices were produced at the site between 1954 and 1997[3]. The site contained 53 waste sumps[4].

Goose Prairie Creek runs through the southern portion of the site[5]. The creek discharges to Caddo Lake about a mile north-east of the site[6]. It is underlain by interbedded sands, silts, and clays[7].

The Army has designated four groundwater zones at LHAAP-047: a shallow zone (12 to 36 feet below ground surface (bgs)), a shallow/intermediate zone (25 to 52 feet bgs), an intermediate zone (42 to 64 feet bgs), and a deep zone (83 to 95 feet bgs)[8]. A total of 69 monitor wells have been installed: 48 in the shallow zone, ten in the shallow/intermediate zone, eight in the intermediate zone, and three in the deep zone[9]. In general, groundwater flows to the east and northeast, although local flow directions may vary[10]. Groundwater levels fluctuate. In some years, the water table is below the bottom of Goose Prairie Creek. In other years, the water table is above the bottom[11]. When it is above the bottom, groundwater may discharge to the creek.

Soil at LHAAP-47 is contaminated with perchlorate. Although the perchlorate in the soil is not a direct threat to human health, it may migrate to the underlying groundwater[12].

Groundwater at LHAAP-47 is contaminated with volatile organic compounds (VOCs) (e.g., PCE, TCE, vinyl chloride), semi-volatile organic compounds (SVOCs) (pentachlorophenol, bis (2-ethylhexyl) phthalate), explosives (TNT, 2,4-DNT, and 2,6-DNT), metals (e.g., arsenic, cadmium, thallium), and perchlorate[13].

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[1] AECOM, 2012.
[2] US Army Corps of Engineers, 2002, page 9-1.
[3] US Army Corps of Engineers, 2002, page 9-1.
[4] US Army Corps of Engineers, 2002, page 9-1.
[5] US Army Corps of Engineers, 2002, figure 9-2.
[6] US Army Corps of Engineers, 2002, figure 1-2.
[7] US Army Corps of Engineers, 2002, page 9-5 and figures 9-3 - 9-6.
[8] Shaw, 2011, page 1-3.
[9] Shaw, 2011, page 1-3.
[10] Shaw, 2011, figures 1-4 – 1-6.
[11] Shaw, 2011, page 1-4.
[12] Shaw, 2011, page 2-4.
[13] AECOM, 2012, pages 7 and 8; and Shaw, 2011, tables 2-1 and 2-2.

Proposed cleanup plan

The Army evaluated four cleanup alternatives:[14]

1. No Action. Cost: $0.
2. Excavation, in-situ bioremediation, monitored natural attenuation (MNA), and land use controls (LUCs). Cost: $5,090,000[15].
3. Excavation, recirculating bioremediation, in-situ bioremediation, MNA, and LUCs. Cost: $7,620,000.
4. Excavation, pump and treat, in-situ bioremediation, MNA, and LUCs. Cost: $7,900,000.

The Army chose alternative 2[16].

Approximately 9000 cubic yards of perchlorate contaminated soil would be excavated and disposed in an off-site landfill[17].

Bioremediation would be conducted by injecting bacteria and/or bacterial nutrients (e.g., soybean oil) into the contaminated groundwater[18]. If it works as intended, bacteria will consume (biodegrade) the contaminants[19]. The bioremediation would be performed in eight contaminant hot spots[20], i.e., areas with VOC concentrations greater than 1000 µg/L or perchlorate concentrations greater than 20,000 µg/L[21]. At seven of the hot spots the injections would be arranged to form biobarriers. The purpose of the biobarriers would be to 1) reduce contaminant concentrations at hot spots, and 2) reduce the migration of groundwater contaminants to Goose Prairie Creek[22]. Four biobarriers would be created in the shallow and shallow/intermediate zones, and three in the intermediate zone[23]. A direct push investigation (temporary monitor wells) would be performed around hot spots to better define the target areas for bioremediation[24]. The Army would also install five more monitor wells[25].

The effectiveness of the cleanup plan would be monitored by collecting samples from approximately 40 monitor wells[26]. The wells would be sampled quarterly for the first two years, semiannually for the next three years, then annually for the next five years[27]. If monitoring indicates that natural attenuation is not effective, a contingency remedy may be developed and implemented[28].

[14] AECOM, 2012, pages 10 - 13.
[15] Cleanup costs for all alternatives are based on only 30 years of operation. The long term cost will likely be higher (AECOM, 2012, page 11).
[16] AECOM, 2012, page 15.
[17] AECOM, 2012, pages 9 and 15.
[18] AECOM, 2012, page 11.
[19] Primarily VOCs and perchlorate. Metals will not be biodegraded.
[20] Shaw, 2011, figure 5-2.
[21] AECOM, 2012, page 16.
[22] AECOM, 2012, page 11.
[23] Shaw, 2011, figure 5-2.
[24] Shaw, 2011, page 5-4.
[25] AECOM, 2012, page 16.
[26] Shaw, 2011, page 5-5.
[27] AECOM, 2012, page 16.
[28] AECOM, 2012, page 16.

Surface water samples would be collected at three locations on Goose Prairie Creek, one upstream and two downstream of LHAAP-47[29]. The surface water samples would be collected on the same schedule as the groundwater samples[30].

The LUCs would prohibit residential use of the site, and the use of groundwater for potable purposes[31]. LUCs would be maintained until contaminant concentrations were reduced to acceptable levels[32].

The Army estimates that it would take about 30 years to cleanup the aquifer in the areas where bioremediation is performed. However, in other portions of the aquifer, more than 100 years would be required for natural attenuation to reduce contaminant concentrations to acceptable levels[33].

Comments and Recommendations

Time to complete cleanup

All of the alternatives evaluated by the Army have an estimated cleanup time of more than 100 years. It is not possible to determine whether this is a reasonable length of time because the Army did not design an alternative with a significantly shorter cleanup time. Remediation methods that might result in shorter cleanup times include:

- Bioremediation or pump and treat in areas beyond the hot spots.
- Air sparging/vapor extraction in areas beyond the hot spots.
- Horizontal wells or trenches along the axes of contaminant plumes.

Recommendation: The Army should design and evaluate at least one alternative that will result in a cleanup time that is significantly less than 100 years.

Evidence that natural attenuation is occurring

The Army cites reductions in contaminant concentrations in specific wells as evidence that natural attenuation is occurring at LHAAP-47. However, while natural attenuation appears to be reducing perchlorate and PCE concentrations, it is not as effective for TCE.

TCE is the most widespread contaminant at LHAAP-47, but TCE concentrations are decreasing in only about half of the contaminated wells[34]. In the remainder of the wells, TCE concentrations either fluctuate without a clear trend, or are increasing.

Because TCE is so widespread, the overall effectiveness of natural attenuation at this site is questionable.

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[29] The exact locations will be identified in the Remedial Design (Shaw, 2011, page 5-7).
[30] Shaw, 2011, page 5-7.
[31] AECOM, 2012, page 10.
[32] AECOM, 2012, page 7.
[33] AECOM, 2012, page 11.
[34] Contamination is defined as a concentration of TCE greater than the drinking water standard (5 µg/L). TCE concentrations dropped in 13 of 27 wells (Shaw, 2011, appendix A, table A-2).

Recommendation: The Army should not rely on natural attenuation unless it can clearly show that natural attenuation will substantially reduce contaminant concentrations throughout LHAAP-47.

Evaluation of MNA effectiveness

The Army would use several criteria to determine whether natural attenuation is reducing contaminant concentrations at an acceptable rate. However, the Army's primary criterion is vague:

- *Demonstrate that MNA is occurring according to the expectations.* [35]

Recommendation: The Army should use quantifiable criteria to determine whether natural attenuation is reducing contaminant concentrations at an acceptable rate (e.g., a reduction in contaminant concentrations by a given percentage within two years).

Estimation of natural attenuation rates

The Army calculated contaminant half-lives[36] as a means of estimating natural attenuation rates[37]. However, most of the half-life calculations do not satisfy the EPA's requirement for performing the calculations. The EPA states that a decrease in contaminant concentration of at least one order of magnitude[38] is necessary in order to reliably calculate a half-life (rate law)[39]. Only eight of the 21 calculations meet this requirement[40].

Recommendation: The Army should not use any half-lives that do not satisfy the EPA's requirement.

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[35] Shaw, 2011, page 5-6.

[36] A half-life is the time required for the amount of a substance to be reduced by a factor of two. For example, if 100 pounds of TCE was present in water and its half-life was three years, then, in three years only 50 pounds of TCE would be left in the water.

[37] Shaw, 2011, appendix A, page 3-8 and table A-5.

[38] An order of magnitude is a factor of ten.

[39] The EPA directive on MNA states: "*As an example, analysis of natural attenuation rates from many sites indicates that a measured decrease in contaminant concentrations of at least one order of magnitude is necessary to determine the appropriate rate law to describe the rate of attenuation, and to demonstrate that the estimated rate is statistically different from zero at a 95% level of confidence (Wilson, 1998). Due to variability resulting from sampling and analysis, as well as plume variability over time, smaller apparent reductions are often insufficient to demonstrate (with 95% level of confidence) that attenuation has in fact occurred at all.*" EPA, 1999, page 21.

[40] Note: The Army has rejected the use of half-lives that were presented in a report produced in 2007 (AECOM, 2012, page 5; and Shaw, 2007). The half-lives discussed above are from a report produced in 2011 (Shaw, 2011). The Army appears to accept the half-lives in the later report.

Estimating hydraulic conductivity

The Army used slug tests to estimate hydraulic conductivity[41]. However, estimates of hydraulic conductivity based on slug test data are subject to large errors[42]. Slug test data are often affected by a 'skin effect' that is caused by incomplete development[43]. This results in estimates of hydraulic conductivity that are too low. Because calculated groundwater flow rates are directly proportional to the hydraulic conductivity, any groundwater flow rates based on the slug test data will probably be low.

Recommendation: The Army should not rely on data from slug tests to estimate hydraulic conductivity. The Army should use a more reliable method, such as pumping tests[44].

Metals

High concentrations of metals are present in groundwater (e.g., arsenic, cadmium, thallium)[45], but the proposed cleanup plan does not directly address metals. Instead, the Army states: *Monitoring will be performed to track metals concentrations for future potential treatment or elimination as COCs*[46]. This statement does not specify how, or when, the Army would decide to implement cleanup methods designed for metals.

Recommendation: The Army should develop explicit and quantifiable criteria to address the cleanup of metals.

Perchlorate cleanup standard

The Army's cleanup standard for perchlorate in groundwater is a risk-based level of 26 µg/L[47]. However, the EPA has decided to regulate perchlorate under the Safe Drinking Water Act and has established an Interim Drinking Water Health Advisory of 15 µg/L[48]. The EPA and the Army are currently discussing this issue[49].

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[41] Shaw,2011, page 1-4. Hydraulic conductivity is a measure of the ability of a material allow water to flow through it. The higher the hydraulic conductivity of a material, the easier it is for water to flow through it. Hydraulic conductivity is expressed as length per unit time (e.g., feet per day, centimeters per second).

[42] EPA 1993, page 1; and Butler, 1997, pages 4 and 5.

[43] Butler 1997, pages 4 and 5.

[44] The most reliable method of estimating hydraulic conductivity is the pumping test. According to the EPA: "*The most reliable type of aquifer test usually conducted is a pumping test. In addition, some site studies involve the use of short term slug tests to obtain estimates of hydraulic conductivity, usually for a specific zone or very limited portion of the aquifer. It should be emphasized that slug tests provide very limited information on the hydraulic properties of the aquifer and often produce estimates which are only accurate within an order of magnitude. Many experts believe that slug tests are much too heavily relied upon in site characterization and contamination studies. This group of professionals recommends use of slug testing during the initial site studies to assist in developing a site conceptual model and in pumping test design."* EPA 1993, page 1.

[45] AECOM, 2012, pages 7 and 8; and Shaw, 2011, table 2-1.

[46] Shaw, 2011, page 4-2. COCs: chemicals of concern.

[47] Shaw, 2011, table 3-5.

[48] EPA, 2012, page 3.

[49] Inside EPA, 2012.

Recommendation: Pending the outcome of discussions with the EPA, the Army should assume that the perchlorate cleanup level will be 15 µg/L, and plan accordingly.

Note - the purpose of excavating perchlorate contaminated soils would be to protect the underlying groundwater[50]. A more stringent perchlorate groundwater standard may mean that the cleanup standard for soils will also have to be more stringent.

Surface water modeling

The Army recognizes the deficiencies in modeling performed to assess the effect of groundwater contaminants on surface water in Goose Prairie Creek. The Army will re-do the modeling[51]. This is the correct course of action.

References

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[50] AECOM, 2012, page 8.
[51] AECOM, 2012, page 5.