Draft Comments on the *Final Proposed Plan For LHAAP-16 Longhorn Army Ammunition Plant, Karnack, Texas*, September 2010

George Rice
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These comments are submitted on behalf of the Caddo Lake Institute. They are based on an evaluation of the *Final Proposed Plan For LHAAP-16*[1], as well as supporting documents (see references).

Site history and setting

The Longhorn Army Ammunition Plant (LHAAP) is on the southwestern shore of Caddo Lake, near the towns of Karnack and Uncertain, Texas. It once occupied approximately 8400 acres, but the Army has transferred almost 7000 acres to the U.S. Fish and Wildlife Service for use as a wildlife refuge[2]. Between 1942 and 1997, explosives, pyrotechnic devices (flares, photoflash bombs), and propellants (rocket motors) were manufactured at LHAAP[3].

LHAAP-16 (aka site 16, Old Landfill) occupies approximately 20 acres in the south central portion of the plant[4]. It was operated from 1942 until the 1970s or early 1980s[5]. It received a wide variety of wastes including TNT red water ash, substandard TNT, oil, paint, sulfur, photo flash wastes, barrels of chemicals, solvent wastes, rocket motor casings, construction debris, and scrap metal[6]. The site contained burn pits, a "large bermed depression", and possibly, an artificial pond[7]. The burn pits may have been excavated below land surface and later filled with wastes. Some of the wastes may have been disposed in trenches[8].

The pre-cap height of the landfill was approximately 15 feet above land surface[9]. The landfill was capped in 1998[10]. The cap covers approximately 13 acres[11] and is about two feet thick[12]. From top to bottom, the cap consists of 6 inches of topsoil, an 18-inch soil drainage layer, a 20-mil geomembrane, and a geocomposite clay liner[13].

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[1] US Army, 2010b.
[2] US Army, 2010b, pages 2 and 3.
[3] EPA 2009a, page 3.
[4] US Army, 2010b, page 1.
[5] US Army Corps of Engineers, 1995, pages 1-7 and 1-8.
[6] US Army Corps of Engineers, 1992, pages 3-27 and 3-44.
[7] US Army Corps of Engineers, 1992, page 3-44; US Army Corps of Engineers, 1995 figure 1-2.
[8] Personal communication, Paul Bruckwciki, US Fish and Wildlife Service.
[9] US Army Corps of Engineers, 2000, page 1-4.
[10] US Army, 2010a, page ES-2.
[11] US Army, 2010a, page ES-2.
[12] US Army, 2010a, page 4-1. The geomembrane and geocomposite clay liners are approximately 0.003 feet and 0.02 feet thick, respectively (US Army Corps of Engineers, 1995, appendix A, HELP model data for option 7A). Note: in the HELP model, the soil drainage layer (percolation layer) is 12 inches rather than 18 inches thick.
[13] US Army, 2010a, page 4-1.

The eastern portion of the site is within the floodplain of Harrison Bayou.[14] Harrison Bayou does not flow during extended dry periods[15]. Harrison Bayou discharges to Caddo Lake, approximately 1.8 miles northeast of the site[16].

The materials underlying the landfill consist of unconsolidated sands, silts, and clays[17]. Depth to groundwater ranges from three to 20 feet below ground surface[18]. The Army has divided the groundwater system underlying the site into four zones: shallow[19], intermediate[20], upper deep, and lower deep[21]. The groundwater in all four zones flows toward Harrison Bayou[22].

Groundwater contamination

Groundwater contamination at LHAAP-16 is caused by contaminants being leached from the landfill. The leaching may be due to rainwater and snowmelt infiltrating into the landfill from above, or from the water table rising into the wastes from below[23].

A wide variety of contaminants have been detected in groundwater downgradient of the landfill. These include chlorinated solvents (e.g., TCE, 1,2-DCE, vinyl chloride)[24], SVOCs[25] (e.g., bis(2-ethylhexyl)phthalate)[26], a pesticide (aldrin)[27], dioxins/furans[28], explosives (e.g., RDX, TNT, tetryl)[29], perchlorate[30], and metals (e.g., arsenic, barium, and thallium)[31]. Many of these contaminants are present in concentrations that exceed

[14] US Army Corps of Engineers, 1992, page 3-46.
[15] The author visited site-16 on October 19, 2010. Harrison Bayou was not flowing.
[16] US Army, 2010a, figure 1-1.
[17] US Army Corps of Engineers, 2000, page 3-2.
[18] Jacobs Engineering, 2002a, page 3-2.
[19] The top of the shallow zone is found at depths of three to 20 feet below ground surface (US Army Corps of Engineers, 2000, page 3-2, and Jacobs Engineering, 2002a, page 3-2).
[20] The top of the intermediate zone is found at depths of 30 to 50 feet below ground surface (US Army Corps of Engineers, 2000, page 3-2).
[21] US Army, 2010a, appendix A, page 1-1.
[22] US Army, 2010a, appendix A, page 1-1.
[23] Little is known about the depth of the wastes at site 16. As stated above, the burn pits may have been excavated below land surface and later filled with wastes. Wastes may have been disposed in trenches. The Army states that the water table in the southeastern portion of the landfill may periodically rise above the bottom of the landfill (Jacobs Engineering, 2002a, page 3-14). However, none of the documents examined for this review contained an 'as built' drawing depicting the interface of the wastes and the underlying materials. At a meeting held on October 19, 2010 (either the Restoration Advisory Board meeting or the Public Meeting), Praveen Srivastav of Shaw Engineering and Rose Zeiler of the Army stated they did not know whether any wastes at LHAAP-16 were buried below land surface.
[24] US Army, 2010a, appendix A, table A-2.
[25] SVOC: semi-volatile organic compound.
[26] US Army Corps of Engineers, 2000, page 4-36.
[27] US Army Corps of Engineers, 2000, page 4-36.
[28] US Army Corps of Engineers, 2000, pages 4-29 – 4-32.
[29] US Army Corps of Engineers, 2000, pages 4-25 – 4-28.
[30] US Army, 2010a, appendix A, table A-2.
[31] US Army Corps of Engineers, 2000, pages 4-29 – 4-32.

the limits that have been established to protect human health[32]. Table 1 lists the highest contaminant concentrations most recently found at the site.

Contaminants are present in the shallow and intermediate zones of the aquifer[33]. The contaminant plume in one or both of the zones extends from the landfill to Harrison Bayou, a distance of about 600 feet[34]. Contaminated groundwater is discharging to Harrison Bayou[35].

Table 1
Groundwater Contaminants

Contaminant	Current maximum concentration[36] (ug/L)	MCL[37] or TCEQ GW-Res (ug/L)	Monitor well, date
TCE	29,300	5	16WW36, 3/30/09
1,1-DCE	97.1	7	16WW36, 6/11/07[38]
cis-1,2-DCE	51,800	70	16WW36, 3/30/09
trans-1,2-DCE	1660	100	16WW36, 3/30/09
1,2-DCA	125	5	16WW36, 3/30/09
Vinyl chloride	1700	2	16WW36, 3/30/09
Perchlorate	5990	26[39]	16WW12, 10/11/07
Arsenic	123	10	16WW35, 3/19/09
Barium	9900	2000	16WW09, 6/15/95
Thallium	12	2	16WW30, 10/21/97
OCDD (a form of dioxin)[40]	1.36	0.45	16WW16, 1997? (date not given)

[32] Health based standards are US EPA maximum contaminant levels (MCLs) for drinking water, or, for contaminants without MCLs, the Texas Commission on Environmental Quality (TCEQ) groundwater medium specific concentration for residential use (GW-Res).
[33] US Army, 2010a, appendix A, tables A-2 and A-3.
[34] US Army, 2010a, figures 3-9 and 3-12, and appendix A, table A-2.
[35] US Army, 2010a, figures 3-1 – 3-10, and appendix A, table A-2. Also, see below.
[36] Data from most recent analyses available: US Army, 2010a, appendix A, table A-2, and appendix B; and US Army Corps of Engineers, 2000, pages 4-29 – 4-32.
[37] EPA, 2006a.
[38] 1,1-DCE was not detected in a sample collected on 3/30/09. The detection limit, however, was 250 ug/L.
[39] TCEQ GW-Res (US Army, 2010a, page 2-13).
[40] ATSDR, 2006, page 7.

Contamination of Harrison Bayou

Contaminated groundwater is entering Harrisom Bayou. In 1995 a sample was collected from a seep on a bank above the bayou[41]. It contained high concentrations of TCE (1020 ug/L), cis-1,2-DCE (609 ug/L), and vinyl chloride (65 ug/L)[42]. It appears that this seep was sampled only once.

Samples collected from Harrison Bayou between 1995 and 2001 contained concentrations of TCE, cis-1,2-DCE, vinyl chloride, and perchlorate that exceeded health based standards[43].

Natural attenuation

Natural attenuation[44] appears to have reduced contaminant concentrations in many, but not all, portions of site 16. For example, perchlorate concentrations have decreased by more than a factor of ten in well 16WW22[45] and TCE concentrations have decreased by more than a factor of ten in well 16WW16[46]. On the other hand, in some wells (e.g., 16WW12[47], 16WW36[48]) perchlorate and TCE concentrations are either increasing or remaining fairly stable.

In should be noted that all of the reductions in contaminant concentrations may not be due to natural attenuation. The Army has been conducting remedial actions at site 16 (see below). These remedial actions may have caused some of the reductions.

[41] Jacobs Engineering, 2002a, page 1-12.
[42] US Army Corps of Engineers, 2000, page 4-24.
[43] Jacobs Engineering, 2002a, pages 1-29 and 1-30. Samples collected at site HBW-1, see figure 1. Maximum concentrations detected: TCE = 282 ug/L (9/23/99), cis-1,2-DCE = 96 ug/L (9/23/99), vinyl chloride = 14 ug/L (9/23/99), perchlorate = 310 ug/L (2/3/00). The author has not found any records of samples collected from Harrison Bayou at site 16 after 2003 (Shaw, 2007, table 6-5.).
[44] Natural attenuation is the reduction in contaminant concentrations that occurs as the result of natural processes. The primary processes are biodegradation and dispersion (dilution caused by the spreading of a contaminant plume).
[45] Perchlorate concentrations decreased from more than 1000 ug/L in 2003 to less than 5 ug/L in 2007 (US Army, 2010a, appendix A, table A-2).
[46] TCE concentrations decreased from 250,000 ug/L in 1997 to 18,900 ug/L in 2009 (US Army, 2010a, appendix A, table A-2).
[47] Perchlorate concentrations increased from 64 ug/L in 2000 to 5990 ug/L in 2007 (US Army, 2010a, appendix A, table A-2). Note: the perchlorate values given for well 16WW12 in table A-2 are different than those given in figure A-5.
[48] TCE concentrations increased from 11,000 ug/L in 1997 to 29,300 ug/L in 2009 (US Army, 2010a, appendix A, table A-2).

Remedial actions

In 1996 and 1997 the Army installed a groundwater pump and treat system to prevent contaminants from the landfill from reaching Harrison Bayou[49]. The system consists of eight extraction wells, four in the shallow zone and four in the intermediate zone[50]. The extracted groundwater is sent to the treatment plant at LHAAP-18/24[51]. The Army considers the pump and treat system to be ineffective because 1) it is extracting only 25% of water it was designed to extract[52], 2) it is allowing high concentrations of TCE to reach *the immediate vicinity* of Harrison Bayou, and 3) it requires excessive maintenance[53].

The landfill was capped in 1998[54]. The purpose of the cap was to reduce infiltration of rainfall and snowmelt into the landfill. The infiltrating water leaches contaminants from the landfill wastes into the underlying groundwater. According to modeling performed by the Army, water is infiltrating through the cap at a rate of approximately 8800 gallons per year[55].

In 2004 the Army installed a semi-passive[56] biobarrier between monitor wells 16WW16 and 16WW36[57] (see figure 1). Perchlorate concentrations in the vicinity of the barrier (within about 60 feet) were reduced[58]. However, farther down gradient (approximately 100 feet) at monitor well 16WW36, concentrations of perchlorate increased[59]. Thus, it is not clear whether the perchlorate was destroyed by the biobarrier, or whether the perchlorate was merely transported farther down gradient of the barrier.

The Army considered seven alternatives for cleaning up contaminated groundwater. These alternatives included the following elements: land use controls (LUCs), monitored natural attenuation (MNA), pump and treat, reactive permeable barriers (biobarriers), in-

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[49] US Army, 2010a, page 1-2. The extraction wells are shown on figure 1: 16EW01 through 16EW08.
[50] US Army, 2010a, figure 1-2; US Army, 2010b, page 5.
[51] US Army, 2010a, page 1-2.
[52] The average extraction rate between June 2000 and June 2007 was approximately 1.3 gallons per minute (US Army, 2010a, appendix A, page 1-1).
[53] US Army, 2010a, page 1-2.
[54] US Army, 2010a, page ES-2.
[55] US Army Corps of Engineers, 1995, appendix A, HELP model data for option 7A. Note: the Army over estimated the infiltration rate because they assumed the cap covered 20 acres. This yielded a total infiltration rate of approximately 13,600 gallons per year. However, the cap covers only 13 acres. Thus, the total infiltration rate is approximately 8800 gallons per year.
[56] The Army may be using the term ‘semi-passive’ because extraction wells were pumped near the barrier until the injection of lactate (to aid biodegradation) was completed (US Army, 2010a, appendix A, page 3-3 and figure A-6).
[57] US Army, 2010a, appendix A, page 3-2.
[58] At monitoring point 16EW148, perchlorate concentrations were reduced from 1000 ug/L to < 4 ug/L between March 2004 and March 2005 (US Army, 2010a, appendix A, page 3-3 and figure A-6).
[59] At monitor well 16WW36, perchlorate concentrations increased from 69.7 ug/L to 441 ug/L between May 2000 and June 2007. The perchlorate concentration then dropped to < 5.5 ug/L in March 2009 (US Army, 2010a, appendix A, page 3-3, and table A-2, page 2 of 19).

situ bioremediation, landfill hot-spot treatment, landfill hot-spot removal, and removal of the entire landfill[60].

The Army's preferred cleanup alternative is Alternative 7[61]. Alternative 7 consists of LUCs, MNA, maintenance of the existing landfill cap, in-situ bioremediation and extraction of groundwater[62], and two passive biobarriers to intercept contaminated groundwater[63] (see figure 1). The in-situ bioremediation would treat both shallow and intermediate groundwater[64]. The passive biobarriers would intercept only shallow groundwater[65]. The cost of this alternative is estimated to be $1,980,000[66].

The Army estimates that natural attenuation will reduce groundwater contaminant concentrations to acceptable levels in 280 years[67]. Within the zone affected by in-situ bioremediation, the Army estimates that contaminant concentrations will be reduced to acceptable levels in 30 to 75 years[68].

Comments

Length of time to achieve acceptable contaminant concentrations

The Army states that it could take 280 years to reduce groundwater contaminant concentrations to acceptable levels[69]. It is not reasonable to propose plans that could require water quality monitoring, maintenance of the landfill cap, maintenance of the biobarriers, and maintenance of LUCs for such a length of time[70].

The Army should take steps to reduce the length of time that will be required to achieve acceptable contaminant concentrations. These steps could include: installation of an effective pump and treat system, modification of the proposed in-situ bioremediation system to cover a greater portion of the site and to operate until acceptable concentrations are achieved, thermal treatment (e.g., steam stripping), and elimination or reduction of the contaminant source by removing the landfill or reducing the mass of contaminants that it contains (see below).

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[60] US Army, 2010b, page 10.
[61] US Army, 2010b, page 1.
[62] The groundwater extraction system will be operated as part of in-situ bioremediation to help draw the carbon source through the contaminant plume (US Army, 2010a, page 4-3).
[63] US Army, 2010b, page 23. The Army may refresh the biobarriers with emulsified oil injections at five year intervals (US Army, 2010a, page 7-1).
[64] US Army, 2010a, page 4-3.
[65] US Army, 2010a, page 4-4.
[66] US Army, 2010b, page 16. This cost assumes 30 years of operation.
[67] US Army, 2010b, page 23; and US Army, 2010a, page 4-8. The Army defines acceptable levels as EPA maximum contaminant levels (MCLs) for drinking water (US Army, 2010b, page 8). However, MCLs have not been established for all contaminants (e.g., perchlorate). For contaminants without MCLs, the acceptable level is the TCEQ Groundwater Medium Specific Concentration for Residential Use (GW-Res) (US Army, 2010b, page 8).
[68] US Army, 2010a, page 4-4.
[69] US Army, 2010b, page 23; and US Army, 2010a, page 4-8.
[70] US Army, 2010a, page 4-8.

Length of time the landfill will continue to generate contaminants

Groundwater contamination at LHAAP-16 is caused by contaminants being leached from wastes in the landfill. The landfill could continue to generate large amounts of contaminants for decades or centuries[71]. The Army's preferred alternative does not attempt to reduce the length of time that the landfill will generate contaminants.

The Army should attempt to reduce the length of time the landfill will generate large amounts of contaminants. This could be done by 1) removing the landfill, or 2) treating the landfill to reduce the mass of contaminants it contains (e.g., hot-spot removal, flushing with surfactants or solvents, bioremediation, vapor extraction).

Natural attenuation and cleanup time calculations (before implementation of preferred alternative)

The Army's 280 year estimate of cleanup time due to natural attenuation[72] is not based on solid evidence. It appears that the Army chose this number because it was the cleanup time calculated for natural attenuation of TCE at well 16WW16[73]. However, a longer TCE cleanup time (492 years) was calculated for well 16WW12[74]. In addition, contaminant concentrations in some wells are stable or increasing rather than decreasing (e.g., perchlorate in well 16WW12, and TCE in well 16WW36)[75]. The calculated cleanup time due to natural attenuation for these wells would be infinity.

The Army does not address the question of whether the remedial actions it has conducted at the site have affected the cleanup time calculations. That is, are the contaminant reductions seen at the site due to natural attenuation, the remedial actions, or both?

Evaluating the effectiveness of natural attenuation (after implementation of preferred alternative)

The Army intends to evaluate the effectiveness of natural attenuation in a 28 month period following the installation of the biobarriers and the in-situ bioremediation system, and after groundwater extraction has been discontinued[76]. This does not appear to make sense. The effects of the remedial actions will persist for some unknown period of time. How will the Army distinguish between the effects of the remedial actions, and the effects of natural attenuation?

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[71] In addition to the current mass of leachable materials, any intact containers of liquid waste would almost certainly fail within the cleanup period proposed by the Army. Thus, the mass of leachable materials may increase.
[72] US Army, 2010b, page 23; and US Army, 2010a, page 4-8. be
[73] US Army, 2010a, appendix A, table A-6, page 1 of 2.
[74] US Army, 2010a, appendix A, table A-6, page 1 of 2.
[75] US Army, 2010a, appendix A, table A-2, pages 1 and 4 of 19. Note: the perchlorate values given for well 16WW12 in tables A-1 and A-2, are different than those given in figure A-5.
[76] US Army, 2010a, page 7-1.

The Army should clearly explain how it will determine whether natural attenuation is reducing contaminants concentrations at an acceptable rate.

Depth of passive biobarriers

The passive biobarriers will intercept groundwater only in the shallow zone[77]. However, the intermediate zone also contains high concentrations of contaminants[78]. The Army should explain why it chose not to extend the passive barriers into the intermediate zone.

Effect of extraction wells on lateral extent of contaminant plume

The pumping of the extraction wells may be limiting the lateral expansion of the contaminant plume. After the extraction wells are shut down, the plume may expand such that it will flow around the ends of the down gradient biobarrier. The Army should consider this possibility in it's final remedial design.

Extent of groundwater contamination not determined

Groundwater up-gradient of Harrison Bayou is highly contaminated[79], and the contaminant plume emanating from the landfill is discharging to Harrison Bayou[80]. However, there is no reason to believe that Harrison Bayou acts as a complete barrier to groundwater flow. A portion of the contaminant plume may extend beyond the bayou. The Army should install monitor wells to the east of Harrison Bayou to determine the full extent of groundwater contamination[81].

Monitor well network

The proposed monitor well network will not detect contaminants that flow to the southeast of the down gradient barrier (see figure 1). The Army should install at least one shallow and one intermediate monitor well between the southeast end of the barrier and Harrison Bayou.

The proposed monitor well network does not include an intermediate monitor well between the down gradient barrier and Harrison Bayou. The Army should install an intermediate monitor well next to well 16WW40 (see figure 1).

The proposed monitor well network will not detect contaminants that flow thorough the northern portion of the down gradient barrier (see figure 1). The Army should install at

[77] US Army, 2010a, page 4-4.
[78] US Army, 2010a, appendix A, table A-3.
[79] US Army, 2010a, figures 3-1 – 3-12 and 4-1, and appendix A, tables A-2 and A-3.
[80] US Army Corps of Engineers, 2000, page 4-24; and Shaw Environmental, Inc., 2010, page 2.
[81] In 2002 the Army proposed installing monitor wells east of Harrison Bayou (Jacobs Engineering, 2002a, page 4-5). The Army's current cleanup plan does not include monitor wells east of the bayou (US Army, 2010b, figure 4).

least one shallow and one intermediate monitor well between the northern portion of the barrier and Harrison Bayou.

The extent of the contaminant plume in the shallow aquifer north of well 16WW22, and in the intermediate aquifer north of well 16WW41, is unknown[82]. The Army should install at least one shallow well and one intermediate monitor well to the north of these wells (see figure 1).

Floodplain

The Army Corps of Engineers determined that the eastern portion of the site is within the floodplain of Harrison Bayou[83]. It is not clear, however, whether any portion of the landfill itself is in the floodplain. The Army should determine whether any portion of the landfill is within the floodplain. If it is, steps should be taken to protect the landfill from the effects of flooding.

Sampling of Harrison Bayou

The Army is proposing only one sampling point on Harrison Bayou near site 16 (see figure 1). Thus, if contaminants are detected, the Army will not be able to determine whether they are coming from site 16 or from an upstream source. In addition, this single sampling point will not detect any site 16 contaminants that enter Harrison Bayou downstream of the point. That is, it will not detect contaminants that may flow around the northern end of the biobarrier, or through the barrier if it fails to function as intended.

The Army should monitor at least two additional sampling points near site 16. One point should be immediately upstream of the site, and one should be immediately downstream of the site.

Pooled water and seeps

The author visited site 16 on October 19, 2010[84]. Although Harrison Bayou was not flowing, there was a pool of standing water in the streambed. This pool was about 30 feet upstream of well 16WW40, and in the same area as the seep that was sampled in 1995[85]. The pool was approximately 20 feet long, three feet wide, and a few inches deep.

This pooled water may be groundwater that has discharged to the streambed. During periods when Harrison Bayou is not flowing, the Army should monitor the streambed for pools of water. If they are present, they should be sampled. The Army should also

[82] Each of these wells contains high concentrations of contaminants (US Army, 2010a, appendix A, tables A-2 and A-3).

[83] US Army Corps of Engineers, 1992, page 3-46. The document did not report the recurrence period associated with the floodplain, e.g., 10 year, 25 year, 100 year, etc.

[84] The author was accompanied by Dawn Orsak of the Caddo Lake Institute, and Paul Bruckwciki and Mark Williams of the US Fish and Wildlife Service.

[85] US Army Corps of Engineers, 2000, pages 2-1 and 4-24.

monitor the banks of Harrison Bayou for seeps and should attempt to sample any that are discovered.

Landfill-derived contaminants in Harrison Bayou – human health risk

The Army performed a ‘streamlined’ Human Health Risk Assessment for Harrison Bayou at site 16[86]. This risk assessment found that the excess lifetime cancer risk for dermal contact with Harrison Bayou surface water was 1.62×10^{5}. This is higher than the lower bound (1.0×10^{-6}) of the EPA target risk range[87]. The streamlined assessment did not estimate the human health risk from drinking the water, nor did it estimate the effects that the water could have on Caddo Lake. The Army stated that a *full risk assessment of Harrison Bayou* would be conducted as part of the Group 2 risk assessment. However, site 16 does not appear to have been included in the Group 2 risk assessment[88].

The Army should perform a full Human Health Risk Assessment for Harrison Bayou at site 16.

Antimony and thallium

Concentrations of antimony and thallium that exceed the EPA MCL are commonly detected in groundwater at site 16[89]. However, the Army has not included antimony or thallium as contaminants of concern (COC)[90]. The Army should either include antimony and thallium as a COCs for groundwater at site 16, or explain why they are omitted.

Thallium reporting limit

The Army is using reporting limits for thallium in groundwater that are higher than the EPA MCL[91]. Thus, concentrations of thallium that exceed the MCL may be undetected or unreported. The Army should use a thallium reporting limit that is less than the MCL.

Dioxins and furans

High concentrations[92] of dioxins and/or furans have been detected in surface water[93] and groundwater[94] at site 16. However, neither dioxins or furans are included as COCs

[86] Jacobs Engineering Group Inc., 2002a, appendix A.
[87] Jacobs Engineering Group Inc., 2002a, appendix A, page A-8 and table A-4.
[88] The Group 2 risk assessment was published approximately six months after the streamlined risk assessment (Jacobs Engineering Group Inc., 2002b).
[89] Between 2003 and 2004, antimony was detected in 17 of 44 shallow groundwater samples at site 16. Thallium was detected in eight of 44 shallow groundwater samples. The highest concentration of antimony was 11.1 µg/L (well 16WW36). The highest concentration of thallium was 19.1 µg/L (well 16WW30). See US Army Corps of Engineers, 2007, appendix A, Site 16. The EPA MCLs for antimony and thallium are 6 µg/L and 2 µg/L, respectively (EPA, 2006a).
[90] US Army, 2010a, pages 2-12 and 2-13.
[91] The Army uses reporting limits of 10 µg/L and 3.14 µg/L (US Army Corps of Engineers, 2007, appendix A, Site 16). The EPA MCL for thallium is 2 µg/L (EPA, 2006a).

for surface water or groundwater[95]. The Army should either include dioxins and furans as COCs, or explain why they are omitted.

Perchlorate cleanup level

The Army's cleanup level for perchlorate is 26 µg/L[96]. This is TCEQ's groundwater medium specific concentration for residential use (GW-Res)[97]. However, the EPA's Health Advisory (HA) level for perchlorate is 15 µg/L[98]. Although the HA is not an enforceable MCL, it is reasonable to assume that when it is finally established, the perchlorate MCL will be similar to the HA. The Army should explain why it did not use the HA level as the cleanup level.

Remedial Design and contingency plans

The final details of the remedial action will be presented in a Remedial Design (RD)[99]. The Army should make the RD available for public review and comment as soon as it is developed.

The Army's Proposed Plan does not mention the development of a contingency plan to be invoked if the remedial actions are not performing satisfactorily. A contingency plan should be included in the RD.

Note: calculation of groundwater speeds

The Army reported an average groundwater speed in the shallow zone of 36.7 ft/yr[100]. However, groundwater speeds in the shallow zone range from 0.44 ft/yr – 990 ft/yr[101].

The higher values may be associated with paleochannels, while the lower values may be associated with ancient overbank deposits that border the paleochannels.

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[92] High concentrations are concentrations above the medium specific concentration (MSC) established by TCEQ.

[93] US Army Corps of Engineers, 2000, page 4-21. Note, the Army reports concentrations for dioxins/furans but claims that they were not *positively identified*. The Army does not explain the basis for this claim.

[94] US Army Corps of Engineers, 2000, pages 4-29 – 4-32. Note, the Army reports concentrations for dioxins/furans but claims that some of them were not *positively identified*. The Army does not explain the basis for this claim.

[95] US Army, 2010a, pages 2-12 and 2-13.

[96] US Army, 2010a, page 2-13.

[97] US Army, 2010a, page 2-11.

[98] Interim lifetime health advisory level (EPA, 2008, page 1).

[99] United States Army, 2008b, page 25.

[100] Based on a hydraulic conductivity of 8.5 x 10^{-4} cm/s, a hydraulic gradient of 0.0104, and an effective porosity of 0.25 (US Army Corps of Engineers, 2000, page 3-9).

[101] Based on a hydraulic conductivities of 1.02 x 10^{-5} cm/s and 2.30 x 10^{-2} cm/s, a hydraulic gradient of 0.0104, and an effective porosity of 0.25 (US Army Corps of Engineers, 2000, page 3-9 and table 3-1. Note: some of the hydraulic conductivity values in table 3-1 are not legible).

When evaluating the transport of contaminants in groundwater, we are usually more concerned with the contaminants that flow most rapidly, rather than those that flow at average or lower speeds.

Note: documents misfiled or not included in Administrative Record

At least one document related to site 16 was not included in the Administrative Record, and at least one document was misfiled[102].

The following document was not included in the Administrative record:

> Sverdrup Inc., 1996, *Design Analysis Report for the Site 16 (Old Landfill) Critical Removal Action at Longhorn Army Ammunition Plant, Karnack, Texas*, May, 1996.

The following document was misfiled:

> Jacobs, 2002, Feasibility Study for Site 16, *Longhorn Army Ammunition Plant, Karnack, Texas,* Final, Oak Ridge, Tennessee, March[103].

The Army should ensure that the Administrative Record is complete and accurate.

[102] US Army, 2008a.
[103] Filed with documents published in 2007 instead of 2002.

References

Agency for Toxic Substances and Disease Registry (ATSDR), 2006, ToxFAQs: CABS™/Chemical Agent Briefing Sheet, Dioxins, March 2006.

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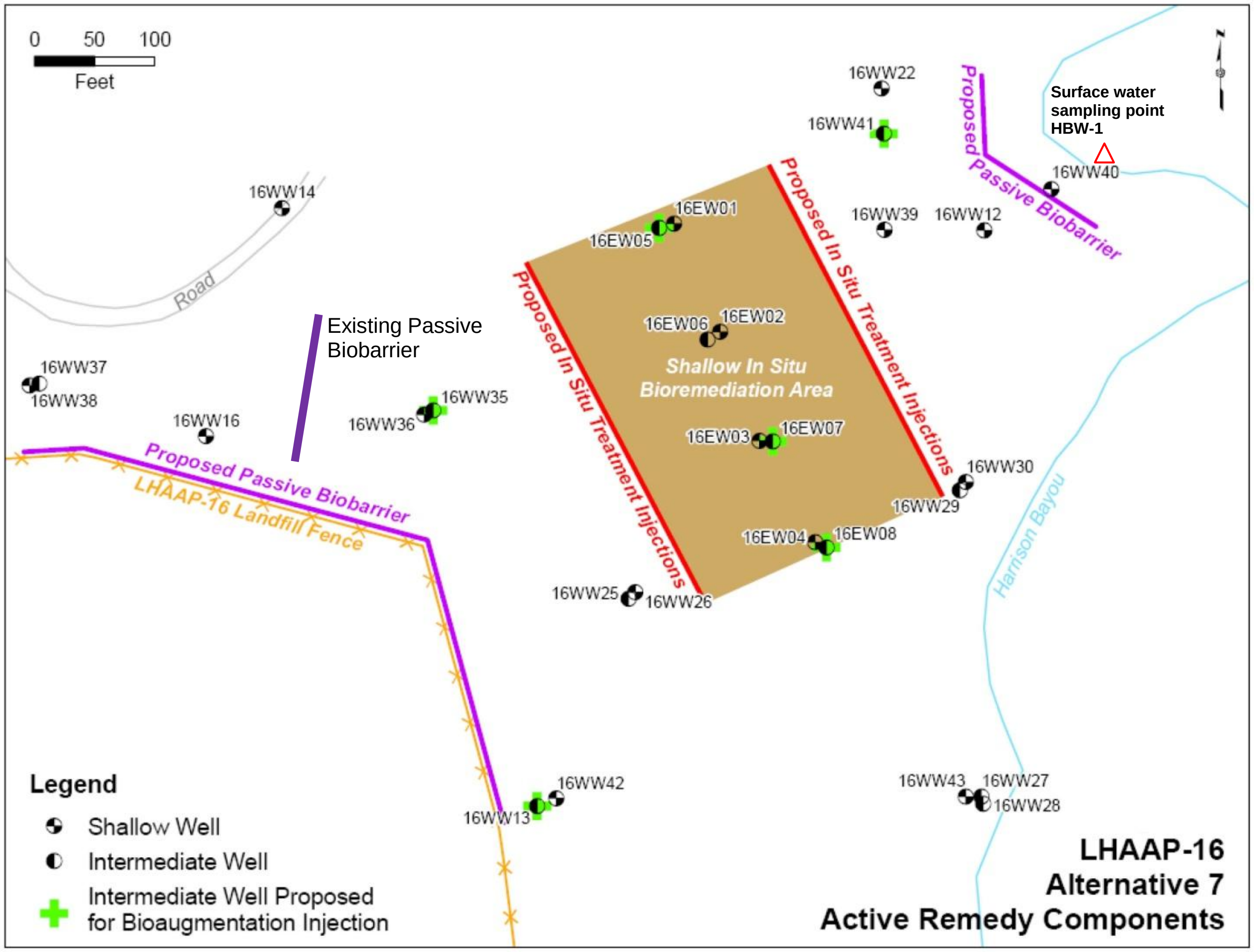

Figure 1

(adapted from US Army, 2010a, figure 4-1; and US Army 2010b, figure 4)