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## **Comments on the Final Proposed Plan for LHAAP-29, Former TNT Production Area, Group 2, Longhorn Army Ammunition Plant, Karnack, Texas, March 2011**

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These comments were prepared for the Caddo Lake Institute. They are based on evaluations of the final Proposed Plan for the Longhorn Army Ammunition Plant site 29, and 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. Between 1942 and 1997, explosives (TNT, black powder), pyrotechnic devices (flares, photoflash bombs), and propellants (rocket motors) were manufactured at LHAAP<sup>1</sup>. Materials used to manufacture these products included toluene, acids (hydrochloric, nitric, sulfuric), ammonium perchlorate, powdered metals (e.g., aluminum, magnesium), sodium nitrate, rubber binders, lubricants, PCBs, and solvents (e.g., methylene chloride, TCE)<sup>2</sup>.

LHAAP once occupied approximately 8400 acres. Since 2004 the Army has transferred almost 7000 acres to the U.S. Fish and Wildlife Service for use as a wildlife refuge<sup>3</sup>.

LHAAP-29 (site 29) is a heavily wooded, 85 acre site in the west-central portion of LHAAP<sup>4</sup>. Between 1942 and 1945 approximately 400 million pounds of TNT were produced on six production lines<sup>5</sup>. Between 1959 and the mid-1970s, site 29 was used to “soak out” out-of-specification rocket motors. This process used Turco, a methylene chloride-based solvent<sup>6</sup>.

The site currently contains the production line foundations and underground pipelines used to convey TNT wastewater and cooling water<sup>7</sup>.

The wastewater line is approximately 4000 feet long<sup>8</sup>. It was originally made of wood<sup>9</sup> but was replaced with a transite (cement/asbestos)<sup>10</sup> line in the 1940s<sup>11</sup>. The line is

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<sup>1</sup> EPA 2009a, page 3, and; Shaw Environmental, Inc., 2010a, page 1-3.

<sup>2</sup> Shaw Environmental, Inc., 2010a, pages 1-3, 1-4, and figure 1-3; and Plexus Scientific Corporation, 2005, pages 6-103, 6-104, and 6-108.

<sup>3</sup> US Army, 2011a, pages 2 and 3, and Shaw Environmental, Inc., 2010a, page 1-3.

<sup>4</sup> Shaw Environmental, Inc., 2010a, pages 1-4 and ES-1.

<sup>5</sup> US Army, 2011a, page 3.

<sup>6</sup> Shaw Environmental, Inc., 2010a, pages 1-4 and 1-5.

<sup>7</sup> Shaw Environmental, Inc., 2010a, page 1-4.

<sup>8</sup> Shaw Environmental, Inc., 2010a, page 2-11.

<sup>9</sup> Shaw Environmental, Inc., 2010a, page 1-4.

<sup>10</sup> US Army, 2011a, page 6.

<sup>11</sup> Shaw Environmental, Inc., 2010a, page 1-4. The wooden line was clear-flushed in 1946 (Shaw Environmental, Inc., 2010a, page 1-4).

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buried three to four feet below ground surface<sup>12</sup>. The wastewater was pumped to storage tanks and, presumably, treated<sup>13</sup>.

There are two cooling water lines (north and south)<sup>14</sup> with a combined length of approximately 6700 feet<sup>15</sup>. The cooling water lines are made of vitrified clay and asbestos<sup>16</sup>. They are buried three to eight feet below ground surface<sup>17</sup> and are eight to 18 inches in diameter<sup>18</sup>. The cooling water was neutralized<sup>19</sup> and discharged to an open ditch<sup>20</sup>. The ditch discharges to Goose Prairie Creek<sup>21</sup>.

The northern portion of the site drains to Goose Prairie Creek, the southern portion to Central Creek<sup>22</sup>. Both of these creeks discharge to Caddo Lake, approximately two and a half miles northeast of the site<sup>23</sup>.

The Army has designated three groundwater zones at LHAAP-29: a shallow zone (depth ranges from 17 to 45 feet below ground surface (bgs)), an intermediate zone (extends to approximately 88 feet bgs), and a deep zone (extends to approximately 155 feet bgs)<sup>24</sup>. Groundwater in the shallow and intermediate zones flows to the east-northeast<sup>25</sup>.

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<sup>12</sup> Shaw Environmental, Inc., 2011a, slide 29.

<sup>13</sup> Shaw Environmental, Inc., 2010a, page 1-5

<sup>14</sup> Shaw Environmental, Inc., 2010a, page 1-5

<sup>15</sup> Shaw Environmental, Inc., 2010a, page 2-12.

<sup>16</sup> Shaw Environmental, Inc., 2010a, page 1-5.

<sup>17</sup> Shaw Environmental, Inc., 2011a, slide 30.

<sup>18</sup> Shaw Environmental, Inc., 2010a, page 1-5.

<sup>19</sup> Shaw Environmental, Inc., 2010a, page 1-5.

<sup>20</sup> Shaw Environmental, Inc., 2010a, appendix C, page 1-1.

<sup>21</sup> Shaw Environmental, Inc., 2010a, page 1-5.

<sup>22</sup> Shaw Environmental, Inc., 2010a, page 1-5.

<sup>23</sup> Shaw Environmental, Inc., 2010a, figure 1-2.

<sup>24</sup> Shaw Environmental, Inc., 2010a, page 1-6.

<sup>25</sup> Shaw Environmental, Inc., 2010a, page 1-6.

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## Contamination

Soils, sediment, surface water, and groundwater have been contaminated at site 29. The TNT wastewater and cooling lines also contain contaminants.

In this report, contamination is defined as concentrations of contaminants that exceed the standards established to protect human health or the environment. These standards include US EPA drinking water limits (MCLs)<sup>26</sup> and State of Texas groundwater protection limits (GW-Ind and GWP-Ind).

### Soils and sediment

Soils and sediments at site 29 are contaminated with explosives and perchlorate (table 1).

**Table 1<sup>27</sup>**  
**Contaminants in Soils and Sediment**

<b>Contaminant</b>	<b>Maximum Concentration Detected (mg/kg)</b>	<b>Sample Location (depth)<sup>28</sup></b>	<b>Regulatory Standard<sup>29</sup> (mg/kg)</b>
TNT <sup>30</sup>	26,000	29SD46 (0 – 0.5 ft)	GWP-Ind = 5.1
2,4-DNT <sup>31</sup>	8000	29SD46 (0 – 0.5 ft)	GWP-Ind = 0.042
2,6-DNT <sup>32</sup>	15	29SD46 (0 – 0.5 ft)	GWP-Ind = 0.042
2-amino-4,6-DNT <sup>33</sup>	48	29SD46 (0 – 0.5 ft)	GWP-Ind = 1.7
4-amino-2,6-DNT <sup>34</sup>	16	29SD13 (unknown)	GWP-Ind = 1.7
Perchlorate	8.6	29SB86 (6 - 8 ft)	GWP-Ind = 7.2

<sup>26</sup> See glossary (appendix A) for definition of terms and acronyms.

<sup>27</sup> Shaw Environmental, Inc., 2010a, pages 2-14, figure 2-1; appendix A, tables A-2 and A-3.

<sup>28</sup> 29SD13 and 29SD46 are sediment samples from the cooling water lines outfall ditch. 29SB86 is a soil boring. (Shaw Environmental, Inc., 2010a, figure 2-1.)

<sup>29</sup> Shaw Environmental, Inc., 2010a, table 2-1 and figure 2-5.

<sup>30</sup> TNT: 2,4,6-trinitrotoluene.

<sup>31</sup> 2,4-DNT: 2,4-dinitrotoluene.

<sup>32</sup> 2,6-DNT: 2,6-dinitrotoluene.

<sup>33</sup> 2-amino-4,6-DNT: 2-amino-4,6-dinitrotoluene.

<sup>34</sup> 4-amino-2,6-DNT: 4-amino-2,6-dinitrotoluene.

**TNT wastewater and cooling lines**

Residues<sup>35</sup> in the TNT wastewater lines contain high<sup>36</sup> concentrations of explosives (table 2). The Army does not appear to have sampled liquids in the wastewater lines. In the cooling lines, both liquids and solids contain high concentrations of explosives (tables 3 and 4).

**Table 2<sup>37</sup>  
Contaminants in Residues in TNT Transite Wastewater Line**

<b>Contaminant</b>	<b>Maximum Concentration Detected in Most Recent Sampling Round (mg/kg)<sup>38</sup></b>	<b>Sample Location<sup>39</sup></b>	<b>Regulatory Standard<sup>40</sup> (mg/kg)</b>
1,3-DNB <sup>41</sup>	1.08	29WL13	GWP-Ind = 1.0
TNT	526	29WL13	GWP-Ind = 5.1
2,4-DNT	89	29WL13	GWP-Ind = 0.042
2-amino-4,6-DNT	19 (J) <sup>42</sup>	29WL14	GWP-Ind = 1.7
4-amino-2,6-DNT	13.3	29WL14	GWP-Ind = 1.7

<sup>35</sup> The residues are described as “ ... *thick, viscous, semi-solid* ...” (EPA and TCEQ, 2010(?), page 7).

<sup>36</sup> In this report, high concentrations are concentrations which exceed levels established by the US EPA (MCL) or the State of Texas (GW-Ind, GWP-Ind, EcoPRG) to protect human health or the environment.

<sup>37</sup> Shaw Environmental, Inc., 2010a, page 2-18 and appendix B table B-3.

<sup>38</sup> From most recent sampling data available, September 2006 (Shaw Environmental, Inc., 2010a, figure 2-5).

<sup>39</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

<sup>40</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

<sup>41</sup> 1,3-DNB: 1,3-dinitrobenzene.

<sup>42</sup> “J” indicates that a substance was detected at a concentration greater than the detection limit but less than the reporting limit (aka practical quantitation limit). Reporting limits are typically five times greater than the detection limit.

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**Table 3<sup>43</sup>**  
**Contaminants in Water in Cooling Water Lines**

<b>Contaminant</b>	<b>Maximum Concentration Detected (µg/L)</b>	<b>Sample Location<sup>44</sup></b>	<b>Regulatory Standard<sup>45</sup> (µg/L)</b>
TNT	5200	MH06	GW-Ind = 51
2,4-DNT	15	MH01	GW-Ind = 0.42
2,6-DNT	27	MH09	GW-Ind = 0.42
2-amino-4,6-DNT	220	MH09	GW-Ind = 17
4-amino-2,6-DNT	290	MH09	GW-Ind = 17

**Table 4<sup>46</sup>**  
**Contaminants in Solids in Cooling Water Lines**

<b>Contaminant</b>	<b>Maximum Concentration Detected (mg/kg)</b>	<b>Sample Location<sup>47</sup></b>	<b>Regulatory Standard<sup>48</sup> (mg/kg)</b>
TNT	11	MH02	GWP-Ind = 5.1
2,4-DNT	1.1	MH10	GWP-Ind = 0.042
2,6-DNT	0.30 (J)	MH08	GWP-Ind = 0.042
2-amino-4,6-DNT	9	MH10	GWP-Ind = 1.7
4-amino-2,6-DNT	7.8	MH10	GWP-Ind = 1.7

<sup>43</sup> Shaw Environmental, Inc., 2010a, page 2-20.

<sup>44</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

<sup>45</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

<sup>46</sup> Shaw Environmental, Inc., 2010a, page 2-19.

<sup>47</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

<sup>48</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

**Groundwater**

Groundwater at site 29 is contaminated with explosives, solvents, perchlorate, and metals (table 5). The intermediate zone groundwater contains extremely high concentrations of methylene chloride (10,300,000 µg/L). This concentration is close to the solubility of methylene chloride in water<sup>49</sup> and may indicate that this contaminant is present as a free product (DNAPL)<sup>50</sup>. If so, it may be very difficult to cleanup.

**Table 5<sup>51</sup>  
Contaminants in Groundwater**

<b>Contaminant</b>	<b>Maximum Concentration Detected in Most Recent Sampling Round (µg/L)</b>	<b>Well ID (groundwater zone)</b>	<b>Regulatory Standard<sup>52</sup> (µg/L)</b>
Methylene chloride	10,300,000	29WW16 (intermediate)	MCL = 5
1,2-DCA <sup>53</sup>	5520	29WW15 (shallow)	MCL = 5
TCE <sup>54</sup>	4340 <sup>55</sup>	29WW16 (intermediate)	MCL = 5
Arsenic	141	29WW25 (shallow)	MCL = 10
Mercury	6.1	118 (shallow)	MCL = 2
Selenium	75.3	118 (shallow)	MCL = 50
2-nitrotoluene (o-)	8140	116 (shallow)	GW-Ind = 1000
3-nitrotoluene (m-)	451	116 (shallow)	GW-Ind = 1000
4-nitrotoluene (p-)	1400	116 (shallow)	GW-Ind = 1000
2,4-DNT	50.9	29WW05 (shallow)	GW-Ind = 0.42
2,6-DNT	239	116 (shallow)	GW-Ind = 0.42
Perchlorate	16,800	29WW15 (shallow)	GW-Ind = 72

<sup>49</sup> 13,200,000 µg/L at 20C (J.T. Baker, 2008).

<sup>50</sup> Shaw Environmental, Inc., 2010a, appendix C page 3-13.

<sup>51</sup> Shaw Environmental, Inc., 2010a, pages 2-15 – 2-17, 2-21, figures 2-3 and 2-4, and appendix D, table D-1.

<sup>52</sup> Shaw Environmental, Inc., 2010a, table 2-3 and figure 2-5; and EPA, 2009b.

<sup>53</sup> 1,2-DCA = 1,2-dichloroethane.

<sup>54</sup> TCE = trichloroethene.

<sup>55</sup> Detected in intermediate zone well 29WW16. TCE was not measured in the latest sample collected from this well (October 28, 2008). The latest sample was diluted by a factor of 50,000 and the TCE concentration was reported as < 12,500 µg/L (Shaw Environmental, Inc., 2010a, figure 2-4, appendix C table C-1, and appendix D, table D-1).

**Surface Water**

Surface water samples were collected from two locations: the pond that formed after the soil beneath the former TNT wastewater pump house was excavated<sup>56</sup>, and the cooling water outfall ditch<sup>57</sup>. The samples were analyzed only for explosives (table 6). The ditch contains high concentrations of contaminants<sup>58</sup>.

**Table 6<sup>59</sup>  
Contaminants in Surface Water**

<b>Contaminant</b>	<b>Maximum Concentration Detected in Most Recent Sampling Round (µg/L)<sup>60</sup></b>	<b>Sample Location</b>	<b>Regulatory Standard<sup>61</sup> (µg/L)</b>
TNT	860	Ditch (29SW46)	GW-Ind = 51
2,4-DNT	19	Ditch (29SW46)	GW-Ind = 0.42
2,6-DNT	7.6	Ditch (29SW46)	GW-Ind = 0.42
2-amino-4,6-DNT	20	Ditch (29SW46)	GW-Ind = 17
4-amino-2,6-DNT	48	Ditch (29SW46)	GW-Ind = 17

**Cleanup Alternatives**

The Army developed three cleanup alternatives for site 29<sup>62</sup>.

Alternative 1: No action.

Alternative 2: Excavation and off-site disposal of contaminated soil and sediment, flushing TNT wastewater line, plugging TNT wastewater and cooling lines, monitored natural attenuation (MNA) for groundwater in the shallow zone, in-situ chemical oxidation of contaminated groundwater in the intermediate zone, and land use controls (LUCs). Groundwater in the intermediate zone would be extracted to help distribute the oxidant<sup>63</sup>. The cost of this alternative is estimated to be \$3,028,000<sup>64</sup>.

<sup>56</sup> Shaw Environmental, Inc., 2010a, page 1-5, and appendix A, figure A-1.

<sup>57</sup> Shaw Environmental, Inc., 2010a, appendix A, page A-1 and figure A-1.

<sup>58</sup> Contaminant concentrations in the pond did not exceed standards (Shaw Environmental, Inc., 2010a, appendix A, table A-4).

<sup>59</sup> Shaw Environmental, Inc., 2010a, appendix A, table A-4.

<sup>60</sup> Samples collected in 2004 (Shaw Environmental, Inc., 2010a, appendix A, table A-4).

<sup>61</sup> Shaw Environmental, Inc., 2010a, figure 2-5.

<sup>62</sup> Shaw Environmental, Inc., 2010a, page ES-3.

<sup>63</sup> U.S. Army, 2011a, page 14.

<sup>64</sup> U.S. Army, 2011a, page 15.

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Alternative 3: Same as alternative 2 except instead of in-situ oxidation, groundwater in the intermediate zone would be extracted and treated at the existing groundwater treatment plant. The cost of this alternative is estimated to be \$2,918,000<sup>65</sup>.

## Proposed Cleanup Plan

The Army has chosen cleanup alternative 2.

- Approximately 3900 cubic yards of contaminated soil and sediment will be excavated and disposed off-site<sup>66</sup>.
- The TNT wastewater lines will be flushed and the inlets and outlets will be plugged<sup>67</sup>.
- The need to remediate the cooling water lines will be evaluated during the remedial design (RD)<sup>68</sup>. The evaluation will proceed as follows<sup>69</sup>:
  - The northern line will be sampled for solids and liquids at manholes 8 and 10.
  - If contaminant concentrations do not exceed the levels established to protect human health<sup>70</sup>, or if there is not enough material to sample, the lines will be plugged and abandoned.
  - If contaminant concentrations exceed the levels established to protect human health, the lines will be flushed before they are plugged and abandoned.

At a minimum, the cooling water line manholes will be plugged<sup>71</sup>.

- Four injection wells will be installed around well 29WW16. Well 29WW16 is completed in the most contaminated portion of the intermediate groundwater zone. Approximately 190,000 gallons of persulfate and sodium hydroxide solution will be injected into the four wells. This is intended to oxidize (destroy) the organic contaminants (primarily methylene chloride). The persulfate-treated groundwater will be extracted from well 29WW16. The extracted groundwater will be trucked to the LHAAP groundwater treatment plant. A second round of

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<sup>65</sup> U.S. Army, 2011a, page 15.

<sup>66</sup> U.S. Army, 2011a, page 14; and; Shaw Environmental, Inc., 2010a, figure 2-1.

<sup>67</sup> U.S. Army, 2011a, page 13.

<sup>68</sup> The RD will be prepared after the Army produces the Record of Decision (ROD). The ROD will be produced after the public comment period on the Final Proposed Plan for LHAAP-29 (U.S. Army, 2011a, page 2).

<sup>69</sup> Shaw Environmental, Inc., 2010a, page 5-4.

<sup>70</sup> GW-Ind (water) or GWP-Ind (solids) (Shaw Environmental, Inc., 2010a, page 5-4).

<sup>71</sup> Shaw Environmental, Inc., 2010a, page 5-4.



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persulfate and sodium hydroxide injection may be performed if contaminant concentrations are not sufficiently reduced by the first round<sup>72</sup>.

The oxidizing conditions created by the injection of persulfate may interfere with natural attenuation. Therefore, the Army may inject a carbon source and microorganisms into the treated portion of the intermediate groundwater zone after the in-situ treatment is completed<sup>73</sup>.

The oxidation and accompanying reduction in pH<sup>74</sup> could mobilize metals (e.g., arsenic, selenium). The Army will monitor metal concentrations in the area subjected to in-situ oxidation<sup>75</sup>.

The Army estimates that it will take 70 years<sup>76</sup> for natural attenuation to reduce contaminant concentrations in the shallow groundwater zone to acceptable levels<sup>77</sup>.

The Army has given two different estimates of the duration of in-situ oxidation in the intermediate zone: six months<sup>78</sup> and three years<sup>79</sup>. After in-situ oxidation is completed, natural attenuation will be relied on to reduce contaminant concentrations to acceptable levels. The Army estimates that this will take 90 years<sup>80</sup>.

LUCs would be maintained until contaminant concentrations are reduced to acceptable levels<sup>81</sup>.

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<sup>72</sup> Shaw Environmental, Inc., 2010a, pages 5-4 and 5-5.

<sup>73</sup> Shaw Environmental, Inc., 2010a, pages 5-5 and 5-6.

<sup>74</sup> Shaw Environmental, Inc., 2010a, appendix B, attachment 3, pages 9-13.

<sup>75</sup> EPA and TCEQ, 2010(?), page 2.

<sup>76</sup> Time estimate based on the attenuation of 1,2-DCA (U.S. Army, 2011a, page 14).

<sup>77</sup> Acceptable levels are the Safe Drinking Water Act maximum contaminant levels (MCLs) (U.S. Army, 2011a, page 7). MCLs are established by the U.S. EPA. If there is no MCL for a contaminant, standards established by the State of Texas will be used (e.g., GW-Ind, GWP-Ind) (U.S. Army, 2011a, page 7).

<sup>78</sup> Shaw Environmental, Inc., 2010a, page 6-10.

<sup>79</sup> U.S. Army, 2011a, page 14.

<sup>80</sup> Time estimate based on the attenuation of TCE (U.S. Army, 2011a, page 14).

<sup>81</sup> U.S. Army, 2011a, page 13.

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## Comments

### 1. Remediation of TNT wastewater and cooling water lines

The TNT wastewater and cooling water lines are known to contain contaminants that could contaminate underlying groundwater if the lines leak. Although the Army recognizes this threat<sup>82</sup>, their cleanup plan calls for leaving the lines in-place<sup>83</sup>.

There are several problems with the Army's plan to remediate the lines:

- The Army states that plugging the inlets and outlets will prevent water from infiltrating and transporting contaminants<sup>84</sup>. This is probably incorrect. Almost certainly, the lines will develop leaks, and the seals will eventually fail<sup>85</sup>.
- The Army has not explained how it will determine whether high concentrations of contaminants remain in the TNT wastewater line after it is flushed.
- For the RD evaluation, only two locations along the northern cooling water line will be sampled. This is not sufficient to characterize contamination in the entire northern line. High concentrations of contaminants have been found at other locations along the northern line<sup>86</sup>. Most of the line has not been sampled because it is not accessible through manholes.
- The southern cooling water line will not be sampled for the RD evaluation, even though high concentrations of contaminants have been found in the line<sup>87</sup>. As with the northern line, most of the southern line has not been sampled because it is not accessible through manholes.
- If the cooling water lines are flushed, the Army has not explained how it will determine whether high concentrations of contaminants remain in the lines after flushing.

The Army has not determined the current extent of contamination in either the TNT wastewater line or the cooling water lines. After the planned remediation, the extent of contamination in the lines will remain unknown. Thus, the Army cannot know whether the lines will contaminate groundwater in the future. The Army should either 1) devise a cleanup plan for the lines that can be shown to protect groundwater, or 2) remove the threat to groundwater by removing the lines.

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<sup>82</sup> The Army states the following regarding the cooling lines: "... 2,4-DNT could potentially leach into groundwater at unacceptable concentrations if the pipe deteriorates." (Shaw Environmental, Inc., 2010a, page 3-13).

<sup>83</sup> U.S. Army, 2011a, page 14.

<sup>84</sup> Shaw Environmental, Inc., 2010a, page 5-2.

<sup>85</sup> One of the manholes on the south cooling water line (MH-04) was found to be collapsed in 2005 (Shaw Environmental, Inc., 2010a, appendix A, page A-1).

<sup>86</sup> Manholes 9, 11, and 12 (Shaw Environmental, Inc., 2010a, figure 2-5).

<sup>87</sup> Manholes 1, 2, 5, and 6 (Shaw Environmental, Inc., 2010a, figure 2-5).

## 2. Contaminant releases from wooden TNT wastewater line

The Army claims that “... soil samples collected near the line indicate there has not been a release to the surrounding soil.”<sup>88</sup> This is incorrect. Samples collected from soil borings along the line<sup>89</sup> were found to contain TNT, 2-amino-4,6-DNT, and 4-amino-2,6-DNT<sup>90</sup>.

## 3. Time required to cleanup groundwater

The Army estimates that it will take 90 years for natural attenuation to reduce contaminant concentrations acceptable levels<sup>91</sup>. It is not reasonable to propose a plan that could require the maintenance of LUCs for almost a century<sup>92</sup>.

## 4. No Estimate of time required to cleanup methylene chloride

The most severe groundwater contamination at site 29 is due to the extremely high concentration of methylene chloride in the intermediate groundwater zone<sup>93</sup>. However, the Army has not presented an estimate of the length of time that will be required to reduce methylene chloride concentrations to acceptable levels. The Army should present such an estimate.

## 5. Effectiveness of in-situ oxidation

The Army states that in-situ oxidation will reduce methylene chloride concentrations by approximately 75%<sup>94</sup>. However, in the Army’s treatability study, the concentration of methylene chloride was reduced by less than 50%<sup>95</sup>. The Army should explain this difference.

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<sup>88</sup> Shaw Environmental, Inc., 2010a, page 2-11.

<sup>89</sup> Shaw Environmental, Inc., 2010a, page 2-8.

<sup>90</sup> Shaw Environmental, Inc., 2010a, page 2-19; and appendix A, table A-2.

<sup>91</sup> 70 years in the shallow zone and 90 years in the intermediate zone (U.S. Army, 2011a, page 14).

<sup>92</sup> The Army has not given an estimate of the uncertainty associated with this time estimate, but at other sites they have stated that the uncertainty is an order or magnitude (factor of ten) (US Army, 2010a, page 13). Therefore, the time required for cleanup could be much longer than a century.

<sup>93</sup> The methylene chloride concentration is more than a million times higher than the limit established to protect human health (10,300,000 µg/L vs. 5 µg/L (U.S. Army, 2011a, page 10; EPA, 2009b).

<sup>94</sup> Shaw Environmental, Inc., 2010a, page 5-6.

<sup>95</sup> Shaw Environmental, Inc., 2010a, appendix B, attachment 3, page 14. It should be noted that the conditions in the laboratory were somewhat idealized and are not likely to reflect actual conditions in the field. For example, the aquifer materials used in the treatability study were homogenized (Shaw Environmental, Inc., 2010a, appendix B, attachment 3, page 4). The aquifer is heterogeneous. Therefore, it was probably easier for the oxidant to contact and destroy the contaminants in the laboratory than it would be in the field.

## **6. No plan to deal with DNAPL**

The extremely high concentration of methylene chloride in the intermediate groundwater zone indicates that DNAPL may be present<sup>96</sup>. If so, it may be very difficult to cleanup the groundwater<sup>97</sup>. The Army does not appear to have developed any plans to deal with DNAPL. The Army should explain how it will deal with any DNAPL that may be present.

## **7. Metals in groundwater**

High concentrations of arsenic, mercury, and selenium exist in the shallow groundwater zone<sup>98</sup>. High concentrations of arsenic exist in the deep groundwater zone<sup>99</sup>. The metals are not subject to natural attenuation by biodegradation and the Army has not explained how they will be cleaned up.

The Army should explain how it will cleanup these metals.

## **8. Current distribution of groundwater contaminants not well known**

The current distribution of groundwater contaminants at site 29 is not well known. This is because the Army has not sampled many of the monitor wells (18 of 47) since 2005, and has not sampled any monitor well since 2009 (see table 7). In addition, many of the most recent sample analyses are incomplete. No wells have been analyzed for explosives or perchlorate since February 2007<sup>100</sup>.

The only way to ensure that the current distribution of contaminants is known is to sample all the monitor wells at the site. They should be sampled for solvents (e.g., methylene chloride, TCE), explosives (e.g., TNT, 2,4-DNT), metals (e.g., arsenic, mercury), and perchlorate. The Army should do this before it completes the design of the groundwater cleanup plan.

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<sup>96</sup> Shaw Environmental, Inc., 2010a, page 2-12; and appendix C, page 3-13.

<sup>97</sup> Pools of free product (DNAPL) can slowly dissolve into the surrounding groundwater. These DNAPL pools may act as a source of contaminants for decades (Schwille and Pankow, 1988, page 112).

<sup>98</sup> Monitor wells 116, 118, and 29WW25 (Shaw Environmental, Inc., 2010a, figure 2-3 and appendix D, table D-1).

<sup>99</sup> Monitor well 29WW08 (Shaw Environmental, Inc., 2010a, figure 2-3 and appendix D, table D-1).

<sup>100</sup> Shaw Environmental, Inc., 2010a, appendix B, table B-5; appendix C, tables C-1, C-2, and C-3; and appendix D, table D-1.

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**Table 7<sup>101</sup>**  
**Date Monitor Wells Last Sampled**

Well ID (shallow zone)	Date last sample collected	Well ID (intermediate zone)	Date last sample collected	Well ID (deep zone)	Date last sample collected
114	10/20/2008	29WW13	10/24/2008	29WW04	10/25/2008
115	5/15/2005	29WW14	5/14/2005	29WW08	10/24/2008
116	10/21/2008	29WW16	10/28/2008	29WW40	12/19/2006
117	5/14/2005	29WW21	5/16/2005	29WW41	6/10/2009
118	10/20/2008	29WW24	10/27/2008		
119	5/15/2005	29WW28	5/15/2008		
29WW01	1/21/2009	29WW34	5/16/2005		
29WW02	10/23/2008	29WW35	10/27/2008		
29WW03	5/17/2005	29WW37	2/1/2008		
29WW05	5/16/2005	29WW39	2/1/2008		
29WW06	2/22/2007				
29WW07	10/25/2008				
29WW09	5/15/2005				
29WW10	10/21/2008				
29WW11	5/14/2005				
29WW12	5/15/2005				
29WW15	2/24/2007				
29WW17	5/16/2005				
29WW18	5/14/2005				
29WW19	10/21/2008				
29WW20	5/16/2005				
29WW22	5/16/2005				
29WW23	5/15/2005				
29WW25	1/21/2009				
29WW26	10/24/2008				
29WW27	10/23/2008				
29WW29	1/21/2009				
29WW30	1/21/2009				
29WW31	5/16/2005				
29WW32	5/16/2005				
29WW33	10/25/2008				
29WW36	2/21/2007				
29WW38	2/22/2007				

<sup>101</sup> Shaw Environmental, Inc., 2010a, appendix B, table B-5; appendix C, tables C-1, C-2, and C-3; and appendix D, table D-1.

## **9. Cleanup of contaminated surface water**

The Army's proposed cleanup plan does not address contaminated surface water<sup>102</sup>. The Army should either 1) explain why it is unnecessary to cleanup surface water, or 2) prepare a plan to clean it up.

## **10. Remedial Design**

Major components of the cleanup are yet to be determined. These include the evaluation of the cooling water lines<sup>103</sup>, and details of: the plan to monitor metals near the in-situ oxidation area<sup>104</sup>, the soil excavation plan, the groundwater extraction plan, the LUC implementation plan, the groundwater monitoring plan, and MNA implementation<sup>105</sup>. These components will be presented in the RD, which will be completed after the Record of Decision is published. Given the importance these components, the Army should make the RD available for public review and comment as soon as possible.

## **11. Lack of contingency plan**

The Army has not developed a contingency plan for site 29. There is a great deal of uncertainty associated with in-situ oxidation, MNA, and the presence of DNAPL. The Army should develop a contingency plan to deal with these uncertainties.

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<sup>102</sup> U.S. Army, 2011a, pages 14 and 15.

<sup>103</sup> U.S. Army, 2011a, page 13.

<sup>104</sup> EPA and TCEQ, 2010(?), page 2.

<sup>105</sup> U.S. Army, 2011a, page 19.

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## Appendix A Glossary

**Administrative Record:** a collection of documents that contains all the information used to select a remedial action at a Superfund site.

**Aquifer:** A saturated geologic formation capable of transmitting an economically significant quantity of water.

**Background water quality:** The water quality that would exist if it were not affected by the area in question. Background groundwater quality is usually established by collecting samples immediately up-gradient of the area. Background surface water quality is usually established by collecting samples immediately upstream of the area. It is not necessarily the same as native water quality (see below). Background water quality may be affected by human activity.

**Biodegradation (biologic decay):** The destruction of organic contaminants (e.g., TCE, toluene) by microorganisms. This process may convert one contaminant into another, e.g., TCE biodegrades to DCE, which biodegrades to vinyl chloride.

**Bulk density:** The density of a material, usually soil or rock, including pore spaces. The in-place or undisturbed density. For example, the density of the minerals that make up a soil may be 170 pounds per cubic foot. But the bulk density of the soil; including pore spaces, organic matter and minerals, may be 110 pounds per cubic foot.

**Capillary fringe:** A zone immediately above the water table. The water in this zone is held by capillary forces and cannot flow freely. Portions of the capillary fringe may be saturated.

**COC:** Chemical of concern. A chemical that has the potential to adversely affect human health or the health of other organisms. At contaminated sites, COCs are the contaminants that are to be cleaned-up. That is, the remedial action is designed to reduce COC concentrations to acceptable levels, e.g., MCLs.

**COPC:** Chemical of potential concern.

**Dehalogenation:** The removal of a halogen atom (e.g., chloride, fluoride) from a molecule.

**Discharge:** The movement of water out of a groundwater system. Water may be discharged naturally through springs and evapotranspiration, or through man made structures such as wells and drains.

**Dispersion:** The dilution of a contaminant due to spreading of the contaminant plume. The spreading occurs in all directions; parallel to the flow (longitudinal dispersion) and perpendicular to flow (transverse dispersion). It is caused by variations in groundwater



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flow directions and speeds. An analogous processes is the spreading (dispersion) of a plume of smoke from a smokestack.

**DNAPL:** Dense Non-Aqueous Phase Liquid. Liquids that are more dense than water. Hence, they tend to sink to the bottom of aquifers. Most chlorinated solvents (e.g., TCE, DCE) are DNAPLs. DNAPLs are liquids, sometimes referred to as 'free product' or 'pure product'. They should not be confused with solutes - contaminants that are dissolved in the groundwater. For example, TCE may exist as a free product (DNAPL) or as a solute dissolved in the water.

**EcoPRG:** Ecological preliminary cleanup level.

**Effective porosity (also-see porosity):** The amount of interconnected porosity available for the transmission of fluids. Effective porosity is expressed as a ratio or percentage. In most materials, effective porosity and total porosity are nearly equal. However, some materials, such as clays, have high total porosities but low effective porosities because the pore spaces are too narrow to allow water to flow freely. In other materials, such as volcanic rocks, the pore spaces may not be interconnected.

**Graphical User Interface (GUI):** A computer program. Pre-processor and post-processor tools that allow modelers to automate some aspects of model design (e.g., grid generation, calibration), integrate optimization tools with models, and create maps of model results.

**GW-Ind:** State of Texas health-based standard. Groundwater concentration limit for industrial use.

**GWP-Ind:** State of Texas health-based standard. The concentration limit for soils (industrial use) to prevent unacceptable concentrations of contaminants leaching from soils into underlying groundwater.

**HI:** Hazard index. A measure of the health risk associated with all non-carcinogenic COCs at a site. The HI is the sum of the hazard quotients for all COCs to which an individual is exposed. A HI value of 1.0 or less indicates that no adverse non-cancer human health effects are expected to occur.

**HQ:** hazard quotient. A measure of the health risk associated with a single non-carcinogenic COC at a site. Each HQ is a comparison of an estimated chemical intake (dose) with a reference dose level below which adverse health effects are unlikely. The HQ is expressed as the ratio of the estimated intake (numerator) to the reference dose (denominator). The value is used to evaluate the potential for non-cancer health effects, such as organ damage, from chemical exposures.

**Hydraulic conductivity:** 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

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flow through it. Hydraulic conductivity is expressed as length per unit time (e.g., feet per day, centimeters per second).

**Hydraulic head:** The elevation of water in a well. Groundwater flows from areas of higher hydraulic head to areas of lower hydraulic head. Hydraulic head is a measure of the energy of groundwater and is the sum of two components: elevation head and pressure head.

**LNAPL:** Light Non-Aqueous Phase Liquid. Liquids that are less dense than water. Hence, they float on the water table. Common LNAPLs include oil, gasoline, and diesel fuel. LNAPLs are liquids, sometimes referred to as 'pure product'. They should not be confused with solutes - contaminants that are dissolved in the groundwater. For example, gasoline may exist as a free product floating on the water table. Some of the components of gasoline (e.g., benzene, toluene) may also exist as solutes dissolved in groundwater.

**LUC:** Land use control.

**MCL:** Maximum contaminant level. The US EPA drinking water standard. The maximum concentration of a contaminant allowed in drinking water. MCLs are legally enforceable limits.

**MDL:** Method detection limit). The minimum concentration of an analyte that the laboratory can measure and report with 99% confidence that the analyte concentration is greater than zero. The MDL is determined by the laboratory for each analyte in a given matrix (water, soil, or vapor). It is a measure of the concentration an instrument can detect or 'see' in a given matrix.

**MNA:** Monitored natural attenuation.

**NPL:** National Priorities List. The list of hazardous waste sites eligible for remedial action under the federal Superfund program. US EPA regulations outline a formal process for assessing hazardous waste sites and placing them on the NPL. The list is based primarily on the score a site receives from the Hazard Ranking System. Only sites that are on the NPL may be cleaned-up using money from Superfund.

**NAPL:** Non-Aqueous Phase Liquid. General term that includes DNAPLs and LNAPLs. NAPLs are liquids, sometimes referred to as 'pure product'.

**Native water quality:** Water quality unaffected by affected by human activity. Not necessarily the same as background water quality (see above).

**Organic:** Derived from plant or animal materials.

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**Organic carbon:** Carbon derived from organic sources (e.g., plant material). Distinguished from carbon derived from non-organic sources (e.g., atmospheric carbon dioxide, carbonate minerals). Organic carbon sorbs organic contaminants.

**Oxidation:** The addition of oxygen to an atom or molecule, or the removal of electrons from an atom or molecule.

**Partition coefficient:** A measure of the degree to which a solute is adsorbed. Solute with higher partition coefficients (e.g. TCE) are more strongly adsorbed (i.e., bound to the solid material of the aquifer) and migrate more slowly (are more retarded) than contaminants with lower partition coefficients (e.g., vinyl chloride). For organic contaminants, the partition coefficient increases as the amount of solid organic carbon in an aquifer increases.

**Porosity:** A measure of void space in a material. The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment. Voids may be spaces between sand grains, fractures, or solution cavities. In the saturated zone, the void spaces are completely filled with water. In the unsaturated zone, the voids are filled with water and air.

**Precipitation (chemical):** The combination of solutes to form a solid material. Metals often precipitate, as when dissolved iron and carbonate combine to form the mineral siderite. Precipitation reactions are often not reversible, and the precipitated contaminant is permanently removed from the groundwater.

**Recharge:** The entry of water into a groundwater system. Recharge often occurs along streambeds, mountain fronts, and through the bottoms of playas.

**RA:** Remedial action.

**RD:** Remedial design.

**Reduction:** The addition of electrons to an atom or molecule.

**Retardation:** Due to sorption, most contaminants move more slowly than the groundwater which transports them. Their movement is said to be retarded with respect to the groundwater.

**Retardation coefficient:** A measure of retardation - the rate at which a solute travels through a groundwater system, compared to the velocity of the groundwater. The ratio of the groundwater velocity to the solute velocity. A solute with a retardation coefficient of 2 moves at 1/2 the velocity of the groundwater that is transporting it.

**RI/FS:** Remedial investigation/feasibility study.

**ROD/DD:** Record of decision/decision document.

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**SAI-Ind:** State of Texas health-based standard for soil. Concentration for industrial use based on inhalation, ingestion, and dermal contact.

**Saturated zone:** A zone where the void spaces are completely filled with water or some other liquid.

**SDL:** Sample detection limit (aka SQL: sample quantitation limit). The MDL adjusted to reflect sample-specific actions, such as dilution or use of smaller aliquot sizes than prescribed in the analytical method, and taking into account sample characteristics and sample preparation. It is a measure of the concentration an instrument can detect or 'see' in a given sample.

**Sensitivity study:** A test of a model's response to changes in parameter values or assumptions (e.g., hydraulic conductivity, boundary conditions).

**Sink, groundwater:** See discharge.

**Solute:** A substance dissolved in a liquid.

**Sorption:** A process that binds, usually temporarily, a contaminant to a mineral surface or to organic matter. This temporary binding acts to reduce (retard) the contaminant migration rate with respect to the groundwater. Sorption is a general term used to encompass the processes of absorption and adsorption.

**Source, groundwater:** See recharge.

**SPLP:** Synthetic precipitation leaching procedure. A chemical test in which a liquid (synthetic precipitation) is passed through solid materials (e.g., soils, wastes). The liquid is then analyzed to determine what the concentrations of constituents (e.g., metals, pesticides) it picked up (leached) as it passed through the solids. SPLP tests are often performed to determine whether infiltrating precipitation could carry contaminants in soils to underlying groundwater.

**Storage coefficient:** A measure of the ability of an aquifer to store and release water. The volume of water an aquifer releases from or takes into storage, per unit surface area of the aquifer, per unit change in hydraulic head.

**SVOC:** Semi-volatile organic compound.

**Unsaturated zone:** A zone where the void spaces are not completely filled with water or some other liquid.

**Vadose zone:** The unsaturated zone plus the capillary fringe immediately above the water table. The capillary fringe may be saturated.

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**VOC:** Volatile organic compound.

**Volatilization/Vaporization:** The formation of gasses that may emerge from soil or water as vapors.

**2-D model:** A model that simulates flow or contaminant transport in two space dimensions. The dimensions may be horizontal or vertical (cross section).

**3-D model:** A model that simulates flow or contaminant transport in three space dimensions.