

## HAZARD RANKING SYSTEM (HRS) DOCUMENTATION RECORD COVER SHEET

**Name of Site:** National Fireworks

**EPA ID No.:** TNSFN0407047

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### Pathways, Components, or Threats Not Scored

The surface water migration, soil exposure and subsurface intrusion, and air migration pathways were not scored in this HRS documentation record because the ground water migration pathway is sufficient to qualify the National Fireworks (NF) site for the National Priorities List (NPL). These pathways are of concern to the U.S. Environmental Protection Agency (EPA) and may be considered during future evaluation.

**Surface Water Migration:** The listing of the NF site would not be changed by evaluating this pathway. No perennial surface water bodies are nearby (Ref. 13, p. 31) (see Figure 5 of this HRS documentation record).

**Soil Exposure and Subsurface Intrusion:** The listing of the NF site would not be changed by evaluating this pathway. No residences are within known areas of soil contamination (Refs. 9, pp. 2, 3; 29, p. 11, 12) (see Figure 5 of this HRS documentation record). In May 2021, EPA conducted a vapor intrusion study for buildings in the Cordova Industrial Park that overlie a chlorinated volatile organic compound groundwater plume associated with the munitions manufacturing area of the former NF facility (Ref. 94, pp. 7, 15). Analytes of concern detected in the sub-slab soil gas and indoor air samples were found to be at relatively low concentrations (Ref. 94, pp. 11, 19).

**Air Migration:** The listing of the NF site would not be changed by evaluating this pathway. No ambient air samples have been collected and releases to the air migration pathway are not suspected based on available data and observations. The sources are not likely to release to air based on their physical characteristics, as documented in the site description section of this HRS documentation record.

## HAZARD RANKING SYSTEM (HRS) DOCUMENTATION RECORD

Name of Site: National Fireworks

EPA Region: 4

Date Prepared: September 2021

Street Address of Site\*: 9400-9600 Macon Road (Ref. 6, p. 2)

City, County, State, Zip: Cordova, Shelby County, Tennessee 38016 (Ref. 6, p. 2)

General Location in the State: Southwestern portion of state

Topographic Map: Ellendale, TN 2019 (Ref. 3)

Latitude: 35° 09' 36.399" North

Longitude: 89° 45' 05.559" West

The coordinates cited above for National Fireworks (NF) were determined from observed release well NFGW13a, located centrally on the NF property (Refs. 3; 5; 33, p. 1127) (see Figures 1 and 4 of this HRS documentation record).

\* The street address, coordinates, and contaminant locations presented in this HRS documentation record identify the general area in which the site is located. They represent one or more locations EPA considers to be part of the site based on the screening information EPA used to evaluate the site for NPL listing. EPA lists national priorities among the known "releases or threatened releases" of hazardous substances; thus, the focus is on the release, not precisely delineated boundaries. A site is defined as where a hazardous substance has been "deposited, stored, disposed, or placed, or has otherwise come to be located." Generally, HRS scoring and the subsequent listing of a release merely represent the initial determination that a certain area may need to be addressed under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Accordingly, EPA contemplates that the preliminary description of facility boundaries at the time of scoring will be refined as more information is developed as to where the contamination has come to be located.

<b>Pathway</b>	<b>Pathway Score</b>
Ground Water <sup>1</sup> Migration	100.00
Surface Water Migration	NS
Soil Exposure and Subsurface Intrusion	NS
Air Migration	NS
<b>HRS SITE SCORE</b>	<b>50.00</b>

Note:

NS Not scored

<sup>1</sup> "Ground water" and "groundwater" are synonymous; the spelling is different due to "ground water" being codified as part of the HRS, while "groundwater" is the modern spelling.

The Worksheet for Computing HRS Site Score appears below, followed by the Ground Water Migration Pathway Scoresheet.

**Worksheet for Computing HRS Site Score**

	<b>S Pathway</b>	<b>S<sup>2</sup> Pathway</b>
Ground Water Migration Pathway Score ( $S_{gw}$ )	100	10,000
Surface Water Migration Pathway Score ( $S_{sw}$ )	NS	NS
Soil Exposure and Subsurface Intrusion Pathway Score ( $S_{sessi}$ )	NS	NS
Air Migration Pathway Score ( $S_a$ )	NS	NS
$S_{gw}^2 + S_{sw}^2 + S_{sessi}^2 + S_a^2$		10,000
$(S_{gw}^2 + S_{sw}^2 + S_{sessi}^2 + S_a^2) / 4$		2,500
$\sqrt{(S_{gw}^2 + S_{sw}^2 + S_{sessi}^2 + S_a^2) / 4}$		<b>50.00</b>

Note:

NS        =    Not scored

**Table 3-1 – Ground Water Migration Pathway Scoresheet**  
**Aquifer Evaluated: Interconnected Shallow and Memphis Sand**

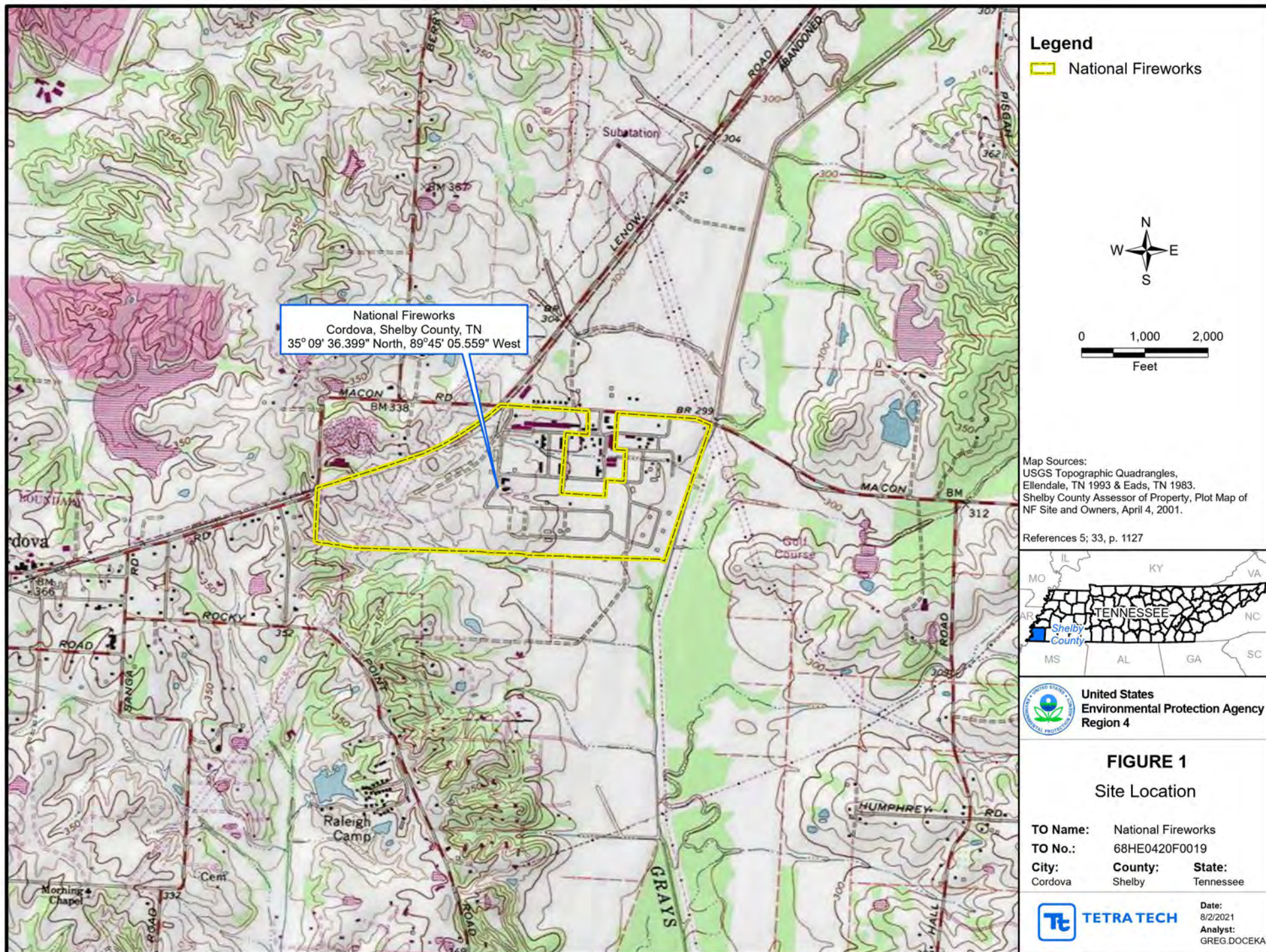
Factor Categories and Factors	Maximum Value	Value Assigned	
<b>Likelihood of Release to an Aquifer:</b>			
1. Observed Release	550	550	
2. Potential to Release:			
2a. Containment	10	NS	
2b. Net Precipitation	10	NS	
2c. Depth to Aquifer	5	NS	
2d. Travel Time	35	NS	
2e. Potential to Release [lines 2a(2b + 2c + 2d)]	500	NS	
3. Likelihood of Release (higher of lines 1 and 2e)	550		550
<b>Waste Characteristics:</b>			
4. Toxicity/Mobility	(a)	10,000	
5. Hazardous Waste Quantity	(a)	10	
6. Waste Characteristics	100		18
<b>Targets:</b>			
7. Nearest Well	50	5	
8. Population:			
8a. Level I Concentrations	(b)	NS	
8b. Level II Concentrations	(b)	NS	
8c. Potential Contamination	(b)	1,192	
8d. Population (lines 8a + 8b + 8c)	(b)	1,192	
9. Resources	5	NS	
10. Wellhead Protection Area	20	5	
11. Targets (lines 7 + 8d + 9 + 10)	(b)		1,202
<b>Ground Water Migration Score for an Aquifer:</b>			
12. Aquifer Score [(lines 3 x 6 x 11)/82,500] <sup>c</sup>	100		100.00
<b>Ground Water Migration Pathway Score:</b>			
13. Pathway Score ( $S_{gw}$ ), (highest value from line 12 for all aquifers valuated) <sup>c</sup>	100		100.00

Notes:

NS = Not scored  
a = Maximum value applies to waste characteristics category  
b = Maximum value not applicable  
c = Do not round to nearest integer

The following Figures 1 to 5 show the location of the former NF facility, the layout of the former NF facility, source sampling locations, monitoring well sampling locations, and a historical layout map, respectively.

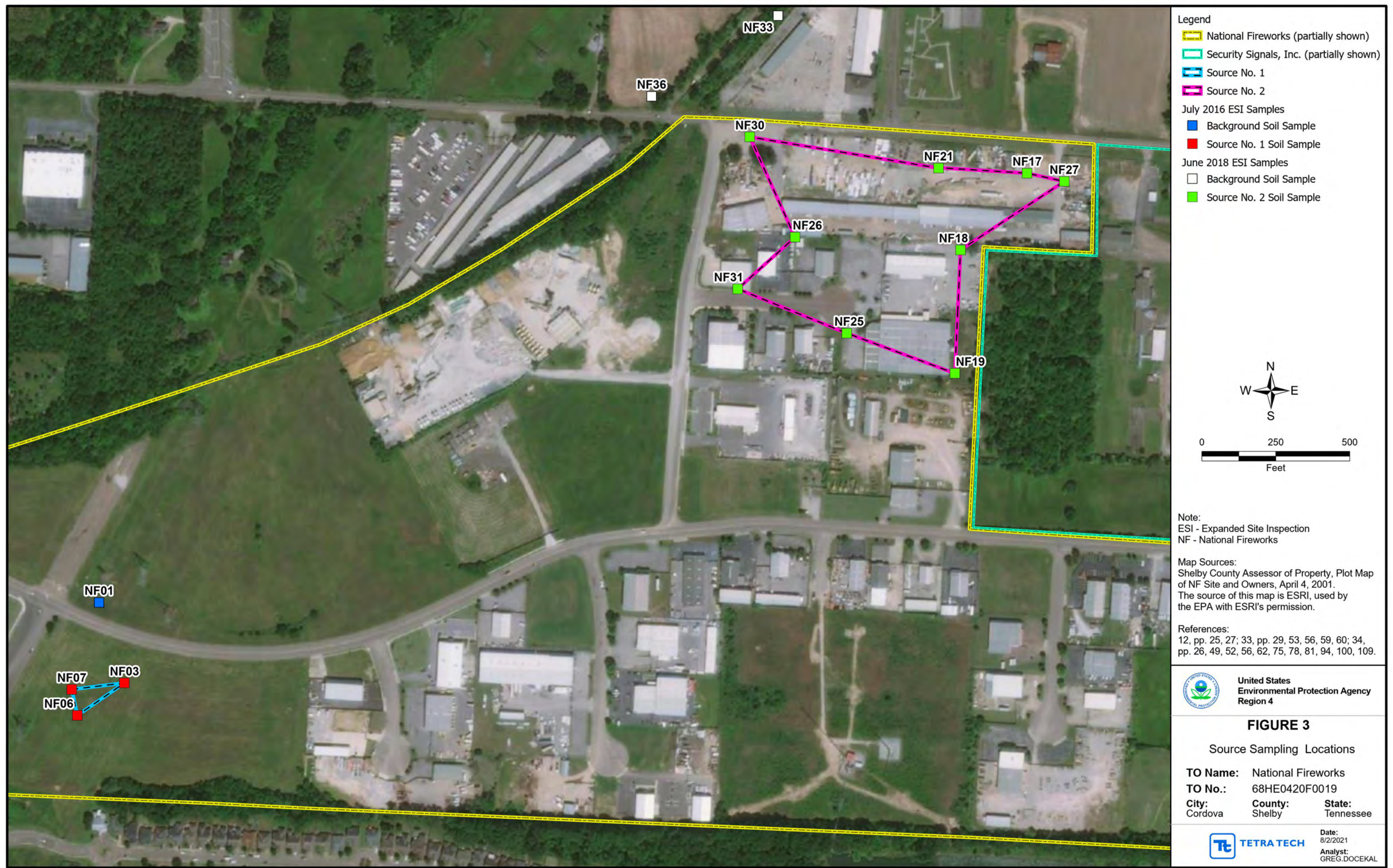




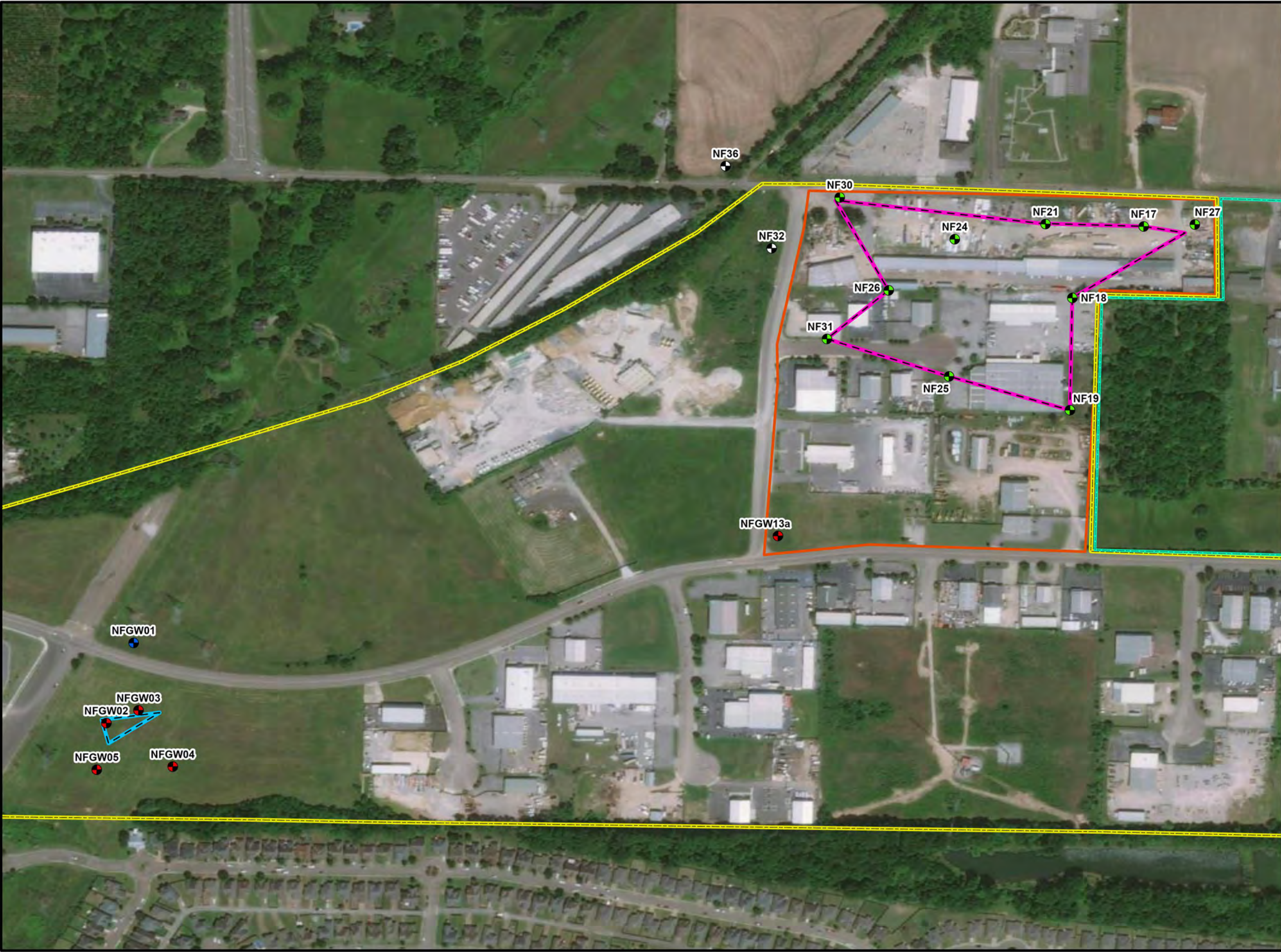












- Legend
- National Fireworks (partially shown)
  - Security Signals, Inc. (partially shown)
  - Former Ammunitions Manufacturing Area
  - Source No. 1
  - Source No. 2
  - July 2016 ESI Samples
    - Background Groundwater
    - Groundwater
  - June 2018 ESI Samples
    - Background Groundwater
    - Groundwater

Note:  
ESI - Expanded Site Inspection  
GW - Groundwater  
NF - National Fireworks

Map Sources:  
Shelby County Assessor of Property, Plot Map of NF Site and Owners, April 4, 2001.  
The source of this map is ESRI, used by the EPA with ESRI's permission.

References:  
12, pp. 25, 27; 33, pp. 29, 61 to 66; 34, pp. 26, 49, 52, 56, 62, 71, 75, 78, 81, 90.



**United States  
Environmental Protection Agency  
Region 4**

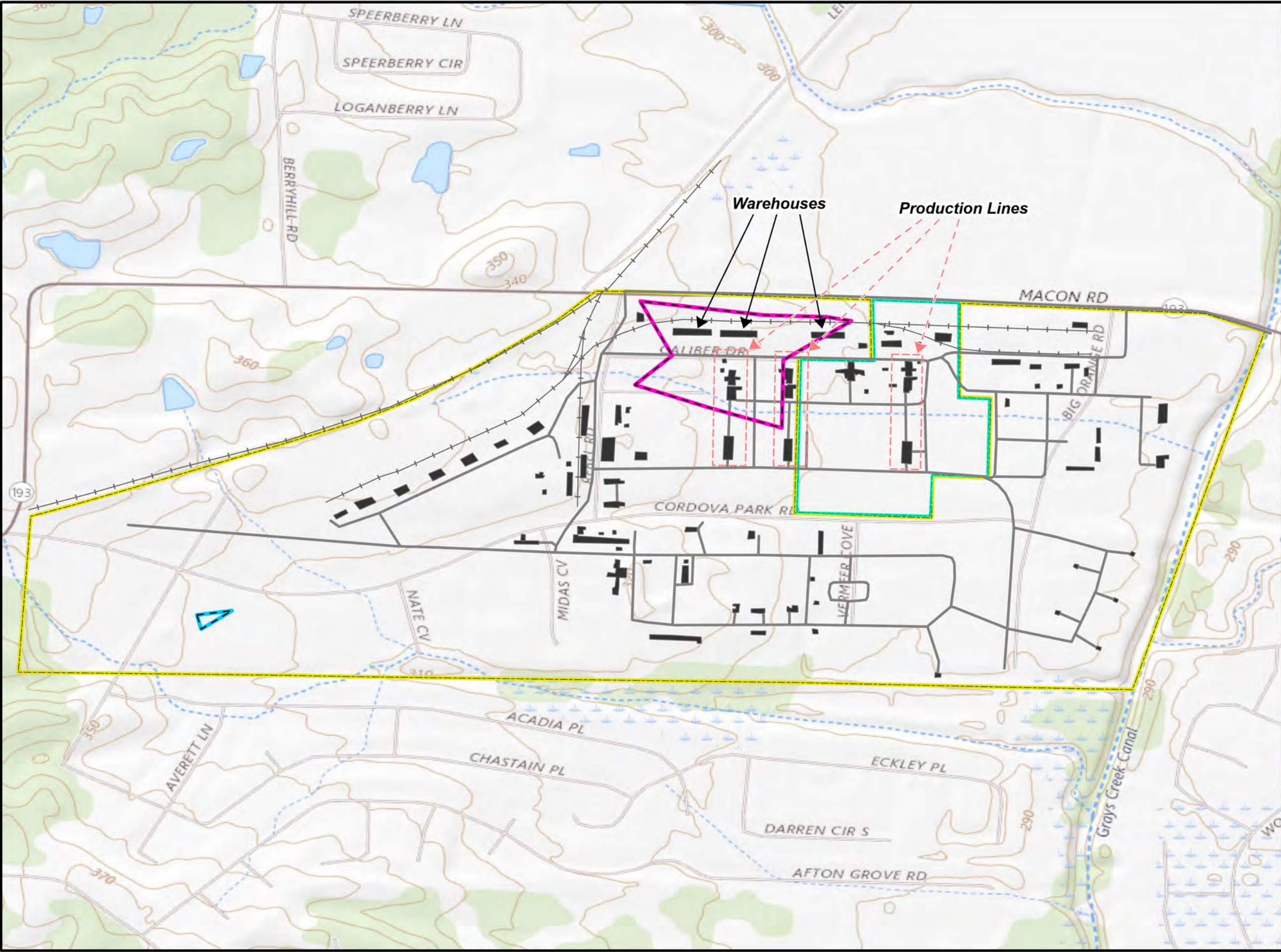
**FIGURE 4**  
Monitoring Well  
Sampling Locations

**TO Name:** National Fireworks  
**TO No.:** 68HE0420F0019  
**City:** Cordova    **County:** Shelby    **State:** Tennessee

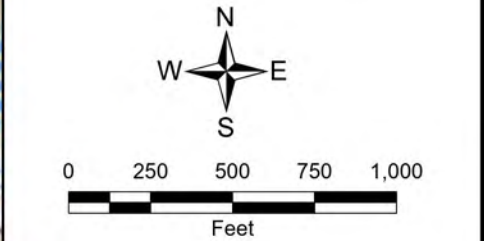


**TETRA TECH**  
Date: 8/2/2021  
Analyst: GREG.DOCKAL



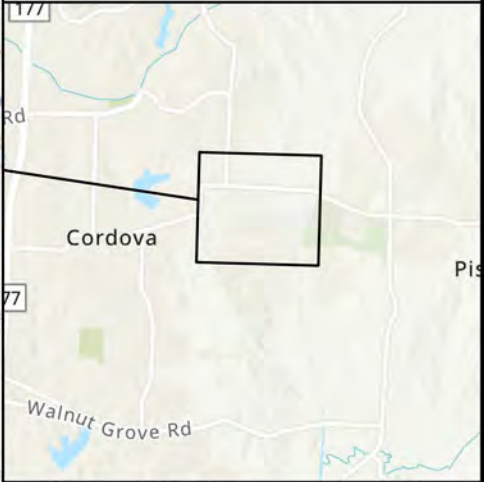


- Legend**
- National Fireworks
  - Security Signals, Inc.
  - Approximate location Source No. 1
  - Approximate location Source No. 2
  - Former Structures
  - Former Paths
  - Former Rail Road Lines



**Map Sources:**  
Shelby County Assessor of Property, Plot Map of NF Site and Owners, April 4, 2001.  
Modified from Tetra Tech ESI Report, April, 2005.  
The source of this map is ESRI, used by the EPA with ESRI's permission.

**References:**  
8, p. 15; 9, p. 6; 28, p. 8; 33, pp. 29, 61 to 66; 34, pp. 26, 49, 52, 56, 62, 71, 75, 78, 81, 90; 78, pp. 1, 3.



 **United States Environmental Protection Agency Region 4**

**FIGURE 5**  
Historical Layout

**TO Name:** National Fireworks  
**TO No.:** 68HE0420F0019  
**City:** Cordova **County:** Shelby **State:** Tennessee

 **TETRA TECH** **Date:** 8/2/2021  
**Analyst:** GREG.DOCKAL



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## SITE DESCRIPTION

The National Fireworks, Inc. (NF) facility, a former munitions manufacturer, operated at 9400-9600 Macon Road, in Cordova, Tennessee (Refs. 6, p. 2; 9, pp. 1, 3) (see Figure 1 of this HRS documentation record). As documented in Sections 2.2.1 and 3.1.1 of this HRS documentation record, the National Fireworks site (NF site) consists of two contaminated soil sources and associated releases to groundwater have been documented at the former NF facility. Source No. 1 is contaminated soil at the former burn pit area within the southwestern portion of the former NF facility, and Source No. 2 is contaminated soil at the former munitions manufacturing area within the northwestern portion of the former NF facility (see Section 2.2, Source Characterization, and Figures 3 and 4 of this HRS documentation record). Hazardous substances—including 2,6-dinitrotoluene (DNT); 1,1-dichloroethane (DCA); cis-1,2-dichloroethene (DCE); trichloroethene (TCE); vinyl chloride; cadmium; lead; and mercury—have been detected in Source Nos. 1 and/or 2 (see Section 2.2, Source Characterization, and Figure 3 of this HRS documentation record). Groundwater underlying Source Nos. 1 and 2 contains some of the same hazardous substances, as well as tetrachloroethene (PCE), at concentrations above background levels, indicating occurrence of a release to the ground water migration pathway, as documented in Section 3.1.1 of this HRS documentation record. Fourteen municipal wells, drawing water from the Memphis Aquifer and serving approximately 64,800 residents, are within 4 miles of Source Nos. 1 and 2 (see Section 3.3, Targets, and Table 18 of this HRS documentation record).

Geographic coordinates at the NF site, as determined from the location of observed release well NFGW13a located within the boundaries of the former NF facility property, are latitude 35° 09' 36.399" north and longitude 89° 45' 05.559" west (Refs. 5; 33, p. 1127) (see Figures 1 and 4 of this HRS documentation record). The U.S. Environmental Protection Agency (EPA) identification number (ID), as recorded in the Superfund Enterprise Management System (SEMS) database, is TNSFN0407047 (Ref. 6, p. 2). (Note: The original parcel owned by NF included the parcel currently occupied by Security Signals, Inc. [SSI]. "Former NF facility" in this document refers to the area of the original parcel minus the area of the SSI parcel.)

### **Current and Former Conditions at the Former NF Facility**

#### General Conditions

The former NF property was sold for development in 1946, and since 1986 through present day, it is the Cordova Industrial Park (CIP), which has been subdivided into privately owned commercial/industrial lots and is surrounded by dense residential areas (Refs. 9, pp. 2, 3; 13, p. 2; 29, pp. 11, 12). Land uses surrounding the former NF facility are predominantly residential, commercial, and industrial (Refs. 7; 8, p. 15) (see Figure 2 of this HRS documentation record). Additionally, several farmed and wooded areas are north of the former NF facility (Refs. 5; 7; 29, p. 11). One private residence is on the north side of Macon Road (Ref. 8, p. 15) (see Figures 2 and 3 of this HRS documentation record).

Before the industrial park was constructed in 1986, the natural topography was rolling hills; these were graded to level land by use of soil and concrete slabs from former NF buildings (Refs. 3; 9, p. 3; 13, pp. 5, 29, 30). Creeks and drainage pathways were diverted through culverts during grading and construction (Ref. 13, pp. 29 to 32, 43).

#### Conditions in the Vicinity of Source Nos. 1 and 2

The area of Source No. 1 is a vacant, open grass area with no structures present (see Figures 2 and 3 of this HRS documentation record). The area of Source No. 2 contains industrial park occupants. Currently, most businesses operating at the industrial park are landscapers, distributors, office spaces, sales, storage, repair, and production facilities (Ref. 89). Specifically, within the area of Source No. 2, buildings formerly used by NF are still present. Currently, commercial buildings formerly used by NF overlying Source No. 2 house a pool and landscape company and a granite and marble company. A masonry company is adjacent to Source No. 2 (Ref. 89) (see Figures 3 and 5 of this HRS documentation record).



## Operable Units

For purposes of previous EPA investigations conducted at the former NF facility, the 260-acre former NF property is divided into two operable units (OU): OU2 is the SSI property in the north-central portion of the former NF facility, and OU1 encompasses the remainder of the original parcel owned by NF, referred to in this document as the former NF facility (see Figure 2 of this HRS documentation record). OU2 is not included in the proposed NPL listing. This HRS documentation record focuses on the source of a chlorinated solvent and mercury groundwater plume beneath OU1 identified during multiple investigations at OU1 and a RI at OU2 (Ref. 8, pp. 82, 83) (see Table 1 of this HRS documentation record).

OU2 is currently addressed as a Superfund Alternative Site under an Administrative Order on Consent (AOC) between SSI and EPA, effective May 18, 2007 (Refs. 8, p. 12; 69, p. 2). In addition, on September 15, 2020, the Department of Justice lodged a Consent Decree with the United States District Court for the Western District of Tennessee in the lawsuit titled *United States and State of Tennessee v. Security Signals, Inc.*, Civil Action No. 2:20-cv-02689-JMP. The Consent Decree resolves the United States and State of Tennessee's claims set forth in the Complaint against SSI ("Defendant") for injunctive relief and cost recovery under Sections 106 and 107(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and injunctive relief under *Tennessee Code Annotated* §§ 68-212-206 and 68-212-227 relating to release or threatened release of hazardous substances into the environment at the OU2 NF Superfund Alternative Site in Cordova, Shelby County, Tennessee (*Federal Register* [FR] Volume 85, Number 184) (Ref. 69, pp. 1, 2). The AOC identifies SSI as the owner, operator, and responsible party for remediation of OU2, and, therefore, OU2 is not included with the NPL listing of NF. OU2 covers the north-central portion of the original parcel owned by NF and consists of approximately 22 acres south of Macon Road, along with the full extent of downgradient contamination from that real property in soil, groundwater, and surface water on, around, and below the NF facility (Ref. 69, p. 3). SSI has owned and operated a portion of OU2 since 1955 and has owned and operated the entire OU2 area since 1993. SSI is the current owner and operator at OU2 (Ref. 69, p. 3).

## Historical NF Facility Operations

From 1942 to 1945, NF manufactured various munitions for the Departments of the Army and Navy, primarily loading flares, blast caps/grenades, incendiary bombs, smoke pots, and anti-aircraft ammunition, including 20-millimeter (mm) and 40-mm rounds. For safety, the buildings were spaced throughout the 260-acre property because of the explosiveness of the products used (Refs. 8, p. 18; 9, p. 3; 10, pp. 3, 5, 6, 7; 70, p. 1; 80, pp. 3, 4, 47). A description of which facility operations occurred specifically in the vicinity of Source No. 1 and Source No. 2 is provided below under Former Layout of NF.

Chemicals possibly mixed and used in munitions production at the former NF facility included TCE; 2,4,6-trinitrophenylmethylnitramine (tetryl); trinitrotoluene (TNT); hexahydro-1,3,5-trinitro-1,3,5-triazine, also termed Research Department Explosive (RDX); ammonium nitrate; fulminated mercury; and white phosphorus (Refs. 9, pp. 8, 9; 10, pp. 6, 8; 11, pp. 2, 3, 4; 70, p. 4). Lead azide and mercury fulminate are types of primary explosives (Ref. 80, p. 17). Munitions manufacturing required a degreasing area for fuse housings, projectiles and the degreasing of machines on production lines (Refs. 71, pp. 9, 11; 78, p. 1). TCE (a degreaser) was known to be used at the former NF facility (Refs. 70, p. 4; 81, p. 2).

Historical operations at the former Cordova NF facility appear to have been similar to those at an NF facility in Hanover, Connecticut that operated during the same time frame as the Cordova NF facility, and manufactured similar products, including fireworks, pyrotechnics, and ammunition (Refs. 8, p. 18; 9, p. 3; 10, pp. 3, 5, 6, 7; 72, pp. 2, 3, 4, 19, 28, 29). Based on affidavits from former employees at the Hanover NF facility, raw products used in manufacturing of munitions included lead azide, freon, mercury fulminate, aluminum fulminate, butyl acetone, amyl acetate, gun powder, lithium chloride, RDX, phosphorous, magnesium, sodium stiftate, tetryl, TNT, TCE, and others (Ref. 71, p. 13). According to reports regarding the Hanover NF facility, lead azide, lead thiocyanate, mercury fulminate, and various solvents and explosives were used in mixing and manufacturing munitions and pyrotechnics. Degreasing was required for fuse housings (Ref. 71, pp. 9, 11).

## **Former Layout of NF and Operations at the Source Areas**

In 2008, the EPA Photographic Interpretation Center (EPIC) prepared an aerial photographic analysis of the former NF facility. The EPIC study reviewed and evaluated property features on aerial photographs dated 1937 to 2004. According to the EPIC study, improvements on the former NF facility were constructed sometime between 1937 and 1957 (Ref. 12, pp. 1, 2, 14). By 1957, a complex of buildings, a railroad spur, unpaved roads, a possible incinerator, possible pipeline, and horizontal tanks were present (Ref. 12, pp. 14, 15). By 1973, new building additions, open storage areas, and two impoundments, or pits, just west of the current SSI property, were present (Ref. 12, pp. 25, 27). Page 11 of Reference 29 shows the historical layout of the facility based on the EPIC study (see Figure 5 of this HRS documentation record). Many buildings associated with NF still exist (Refs. 8, pp. 13, 15; 12, p. 47; 32, p. 22). Both OU1 (the former NF facility) and OU2 (the area occupied by SSI) were part of the original parcel owned by NF. The layouts of Source Nos. 1 and 2 and their vicinities are discussed below.

### **Source No. 1 – Former Burn Pit**

Wastes, such as pallets, debris, and waste pyrotechnical supplies, were burned in the southwestern portion of OU1 at the location of the burn pit (Refs. 9, pp. 6, 8; 12, p. 5; 15, p. 9). The original burn pit dimensions were about 15 by 20 feet (Refs. 9, p. 8; 10, p. 6). Because of construction and grading on the property, some contents of the burn pit were excavated and re-buried in a pit adjacent to the original burn pit (Ref. 13, p. 5). Contaminated soil in the former burn pit is Source No. 1 (see Figure 3 and Table 2 of the HRS documentation record).

### **Source No. 2 – Former Munitions Manufacturing Area**

Figure 5 of this HRS documentation record shows locations of features discussed in this section. The northwestern portion of OU1 is the location of Source No. 2, the former munitions manufacturing area. NF buildings in this area were used as warehouses and offices for facility operations (Refs. 10, p. 6; 28, pp. 6, 8, 9). The long buildings running east-west in this area were receiving docks and warehouses where raw products, chemicals, metals, and other materials were stored (Refs. 12, pp. 14, 15; 78, pp. 1, 3). Transport of raw materials, such as steel stock and machine parts, and all chemicals used in the manufacturing area, to those buildings would have occurred by train via the railroad tracks adjacent to the warehouse (Refs. 12, pp. 14, 15; 28, p. 6; 70, p. 1; 78, pp. 1, 3, 4). Commonly, materials were shipped and packaged in grease to prevent corrosion. After the materials were unloaded in the warehouse area, application of TCE was a preferred way to remove the grease and generally to prepare metal for use (Ref. 78, pp. 1, 3, 4). The incinerator shown in the manufacturing area is likely to have been used to burn packaging used to ship materials via the railroad (Refs. 12, pp. 19, 21; 78, pp. 2, 4).

Three assembly lines appear in the southern half of the manufacturing area on the 1957 aerial photograph. The production lines had a north-to-south orientation (Refs. 12, pp. 14, 15; 78, pp. 1, 4). These production lines can be seen partially within the area of Source No. 2 in Figure 5 of this HRS documentation record. Munitions were assembled at the two buildings on the north end of the assembly line. Fuses were added at the single building at the southern end of the assembly line (Ref. 78, pp. 1, 4). Because of potential for fuse detonation, the assembly area, main explosives filler, and fuse buildings were kept separate. TCE would have been used to clean and maintain the machines utilized on these production lines (Ref. 78, pp. 1, 4).

Reference 8, page 16, shows OU2 and identifies the assembly buildings, including Buildings 7, 8, and 15, and other associated structures such as former chemical storage areas, loading areas, mix area, drum storage area, float room, and press room. These similar structures were within the two production lines in the area of OU1, as evidenced by the 1957 aerial photograph (Ref. 12, p. 15; 78, pp. 1, 2, 4, 5).

Chemicals were processed or pressed in buildings in the southeastern portion OU2 and placed on conveyer belts for transportation between buildings to prevent exposure of the chemicals to the outdoors (Ref. 13, p. 44). Conveyer belts were observed in the southeastern portion of OU2 in 2001 (Refs. 13, p. 45; 78, p. 5).



## PREVIOUS INVESTIGATIONS AND CONTAMINATION DETECTED

Table 1 lists environmental investigations and assessments at the former NF facility property.

<b>TABLE 1: Summary of Previous Investigations and Assessments</b>					
<b>Company/ Agency</b>	<b>Investigation</b>	<b>Field Work Date</b>	<b>Samples Collected</b>	<b>Hazardous Substances Detected</b>	<b>References</b>
Pickering Environmental Consultants for CIP, Ltd.	Environmental Assessment	March 1991	None	ACM	14, pp. 1, 2, 7
Walton for CIP, Ltd.	Phase II ESA	April 1992	Soil	Lead, barium, nitrate-N, TKN, sulfur	15, pp. 1, 3, 7, 24 to 27
EPS for MMD Tower property	Phase I ESA	June 1993	None	None	16, pp. 1, 3, 4, 5, 7
EPS for MMD Tower property	Soil Sampling	July 1993	Soil	Arsenic, barium, cadmium, chromium, lead	17, pp. 1, 3, 4, 17 to 26
TDEC	Preliminary Assessment	December 1999	None	None	9, pp. 1, 6, 14
Tetra Tech for EPA	Site Inspection	September 2001	Soil, groundwater, sediment, surface water	1,3-Dinitrobenzene; 2,4,6-TNT; 2,4-DNT; 2-amino-4,6-DNT; 4-amino-2,6-DNT; nitrobenzene; RDX; tetryl; 4-nitrotoluene; 1,1-DCA; 1,1-DCE; cis- 1,2-DCE; TCE; PCE; pyrene, PCB-1254; arsenic; barium; beryllium; cadmium; chromium; cobalt; copper; lead; mercury, nickel, zinc	28, pp. 1, 5, 8, 21 to 28, 36 to 39, 41, 50, 63, 65, 68, 69, 70, 83 to 86, 91, 93, 94, 96
Walton for EPA	Sampling Tracts 2 and 9	October 2002	Soil	Bis(2- ethylhexyl)phthalate, arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	18, pp. 1, 2, 3, 7, 9
Walton for EPA	Sampling Tract 6	November 2002	Soil	Bis(2- ethylhexyl)phthalate, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, zinc	19, pp. 1, 2, 3, 7, 9
Walton for EPA	Sampling Tract 5	February 2003	Soil	Bis(2- ethylhexyl)phthalate, di- n-butyl phthalate, arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	20, pp. 1, 2, 3, 7, 9

<b>TABLE 1: Summary of Previous Investigations and Assessments</b>					
<b>Company/ Agency</b>	<b>Investigation</b>	<b>Field Work Date</b>	<b>Samples Collected</b>	<b>Hazardous Substances Detected</b>	<b>References</b>
Walton for EPA	Sampling Tract 7	March 2003	Soil	Arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	21, pp. 1, 2, 3, 7
Walton for EPA	Sampling Tract 4	May 2003	Soil	Arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	22, pp. 1, 2, 3, 7
Walton for EPA	Sampling Tract 8	May 2003	Soil	Arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	23, pp. 1, 2, 3, 7
Walton for EPA	Sampling Tract 1	June 2003	Soil	Indeno(1,2,3-cd)pyrene, benzo(ghi)perylene, bis(2-ethylhexyl)phthalate, arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	24, pp. 1, 2, 3, 7, 9
Walton for EPA	Sampling Tract 3	July 2003	Soil	Arsenic, barium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	25, pp. 1, 2, 3, 7
Walton for EPA	Sampling Tract 11	November 2003	Soil	cis-1,2-DCE, bis(2-ethylhexyl)phthalate, PCB-1016, PCB-1264, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	26, pp. 1, 2, 3, 7, 9, 10
Walton for EPA	Sampling Tract 10	December 2003	Soil	Naphthalene, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc	27, pp. 1, 2, 3, 7, 9
Tetra Tech for EPA	ESI	April 2004	Soil, groundwater, surface water, sediment	1,1-DCE; cis-1,2-DCE; TCE; PCE; bis(2-ethylhexyl)phthalate; perchlorate; arsenic; barium; cadmium; chromium; cobalt; copper; lead; manganese; mercury; nickel; zinc	29, pp. 4, 8, 18 to 24, 31, 33, 34, 37 to 40, 51, 53, 58 to 62



<b>TABLE 1: Summary of Previous Investigations and Assessments</b>					
<b>Company/ Agency</b>	<b>Investigation</b>	<b>Field Work Date</b>	<b>Samples Collected</b>	<b>Hazardous Substances Detected</b>	<b>References</b>
Walton for EPA	Soil Sampling and Analysis	August and September 2006	Soil	Benzo(a)pyrene, indeno(1,2,3-cd)pyrene, pyrene, HMX, arsenic, barium, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, zinc, dioxins, and furans	30, pp. 1, 2, 5, 6, 10 to 14, 16 to 20, 24, 26, 30, 32, 39, 44, 45
Walton for EPA	Supplemental Report	June 2007	Soil	Dioxins and furans	31, pp. 1, 2, 3, 5, 6
Tetra Tech for EPA	Final Supplemental Assessment Report	April 2009	Soil, groundwater	PCE, DNT, perchlorate, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, zinc, dioxins, and furans	32, pp. 1, 6, 28, 29, 30, 33, 34, 36 to 41, 43, 44, 46, 47, 49, 50, 52 to 55, 57, 58

Notes:

ACM	Asbestos-containing material
DCA	Dichloroethane
DCE	Dichloroethene
DNT	Dinitrotoluene
EPA	U.S. Environmental Protection Agency
EPS	Environmental Protection Systems, Inc.
ESA	Environmental Site Assessment
ESI	Expanded Site Inspection
HMX	1,3,5,7-Tetranitro-1,3,5,7-tetrazoctane, also termed High Melting Explosive
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
PRP	Principle Responsible Party
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine, also termed Research Department Explosive
TCE	Trichloroethene
TDEC	Tennessee Department of Environment and Conservation
Tetra Tech	Tetra Tech, Inc.
Tetryl	2,4,6-Trinitrophenylmethylnitramine
TKN	Total Kjeldahl nitrogen
TNT	Trinitrotoluene
Walton	Walton Environmental Services, Inc.

### July 2016 Expanded Site Inspection (ESI) – Burn Pit

In July 2016, Tetra Tech, on behalf of EPA, conducted an ESI of the former burn pit area (Source No. 1) on the southwestern portion of the former NF facility (Ref. 33, pp. 1, 4, 29) (see Figure 3 of this HRS documentation record). Tetra Tech collected soil samples within the burn pit area and groundwater samples from existing and newly installed permanent monitoring wells. Tetra Tech also collected background soil and groundwater samples (Ref. 33, pp. 7, 33, 34). Soil samples contained elevated concentrations of 2,6-DNT, cadmium, lead, and mercury, as well as dioxins and furans (Ref. 33, pp. 35, 36, 38, 39) (see Table 2 of this HRS documentation record). Groundwater samples collected hydraulically downgradient of Source No. 1 contained elevated concentrations of mercury, PCE, TCE, vinyl chloride, perchlorate, and dioxins and furans (Ref. 33, p. 42) (see Table 13 of this HRS documentation record).

## **June 2018 ESI – NF**

In June 2018, Tetra Tech, on behalf of EPA, conducted an ESI of the former NF facility (Ref. 34, p. 4). Tetra Tech collected soil and groundwater samples throughout the northwestern portion of the former NF facility in the area that is scored in this HRS documentation record as Source No. 2. Tetra Tech also collected background soil and groundwater samples (Ref. 34, pp. 8, 26, 29, 30) (see Figure 3 of this HRS documentation record). Soil samples contained elevated concentrations of 1,1-DCA; cis-1,2-DCE; trans-1,2-DCE; TCE; vinyl chloride; and mercury (Ref. 34, pp. 31, 32, 33) (see Table 6 of this HRS documentation record). Groundwater samples collected from temporary monitoring wells contained elevated concentrations of 1,1-DCA, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, PCE, TCE, vinyl chloride, and mercury (Ref. 34, pp. 16, 35, 36) (see Table 15 of this HRS documentation record).



## 2.2 SOURCE CHARACTERIZATION

### 2.2.1 SOURCE IDENTIFICATION

Number of Source: 1

Name of Source: Contaminated Soil – Former Burn Pit

Source Type: Contaminated soil

Description and Location of Source (with reference to a map of site):

Source No. 1 is an area of contaminated soil, as characterized by soil samples collected in 2016, within the footprint of the former burn pit in the southwestern portion of the former NF facility near the intersection of Forest Hill Irene Road and Cordova Park Road (Refs. 5; 9, pp. 6, 8; 10, pp. 3, 6; 13, p. 11; 32, pp. 22, 23; 33, pp. 29, 35 to 40) (see Figure 3 of this HRS documentation record). The original burn pit dimensions were about 15 by 20 feet (Refs. 9, p. 8; 10, p. 6; 28, p. 10). Pallets, debris, waste pyrotechnical supplies, and other wastes, as evidenced by soil samples containing metals, dioxins/furans, and explosives, were burned in the pit. Waste ash has been observed on the ground in the area of the pit. Currently, the area encompassed by the former burn pit is an open field (Refs. 9, pp. 6, 8; 10, pp. 3, 6; 12, p. 5; 13, p. 5; 15, p. 9; 28, pp. 14 to 17; 29, pp. 29, 30; 32, p. 25) (see Table 2 of this HRS documentation record). Because of construction and grading on the property, some contents of the burn pit were excavated and re-buried in a pit adjacent to the original burn pit. The original (former) burn pit was filled with construction debris. Any fill in the area of the former burn pit came from the former NF facility (Ref. 13, pp. 2 to 5, 15, 16, 28, 29, 30). Based on the ground penetrating radar (GPR) survey at Source No. 1, estimated depth of the former burn pit is 6 to 7 feet, and its estimated extent is about 44,750 square feet or about 1.02 acres (Refs. 32, pp. 10, 11, 23, 81, 90; 33, p. 6).

Aerial photographic interpretations show the burn pit was active in 1957. The 1963 photographs show disturbed ground in the area of the pit and later photographs starting in 1973 show that the pit is filled, and the area is farmed (Ref. 12, pp. 2, 5, 16, 17, 22, 23, 28, 29).

Wastes disposed of in the former burn pit may have included chemicals mixed and used in ordnance production at the former NF facility, including PCE, TCE, TNT, RDX, tetryl, ammonium nitrate, mercury fulminate, and white phosphorus. Metal scraps were observed in the area of the former burn pit (Refs. 9, pp. 8, 9; 10, pp. 6, 8; 13, pp. 5, 12; 70, p. 4; 81, pp. 2 to 6; 92, pp. 200, 201, 202). Mercury fulminate was used in blasting caps manufactured at the former NF facility (Refs. 9, pp. 8, 9; 10, p. 6). Mercury fulminate explosively decomposes to form mercury, carbon monoxide, and nitrogen (Ref. 37, p. 1). Mercury was detected in soil samples collected from Source No. 1 (Refs. 28, p. 14; 32, p. 25) (see Table 2 of this HRS documentation record).

In 2009, a GPR survey of the former burn pit was completed to determine the pit boundaries and select sampling locations. The pit was determined to be 6 to 7 feet deep (Ref. 32, pp. 10, 11). Additionally, one surface soil sample (0 to 1 foot below ground surface [bgs]) and one subsurface soil sample (6 to 7 feet bgs) were collected at each of 11 discrete sampling locations within the footprint of the former burn pit, avoiding fill material (Ref. 32, p. 11). Elevated concentrations of PCE, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, zinc, 2,4-DNT, and perchlorate, among others, were detected in the soil samples (Ref. 32, pp. 16, 25). Presence of these substances in the former burn pit soils is evidence that waste chemicals used at the former NF facility may have been burned in the former burn pit.

The soil samples collected in 2016 contained cadmium, lead, mercury, and 2,6-DNT at elevated concentrations— 2016 data are used to identify locations of soil contamination in Source No. 1 (Ref. 33, pp. 29, 35).

Soil samples collected to delineate Source No. 1 in July 2016 contained metals and 2,6-DNT above background levels (Ref. 33, pp. 29, 35). These samples were collected in the southwestern portion of the former NF

property in the burn pit. The location of the burn pit was confirmed by GPR and aerial photographs prior to sampling (Refs. 12, pp. 2, 5, 16, 17, 22, 23, 28, 29; 32, pp. 10, 11, 81, 90; 33, p. 29) (see Figure 3 of this HRS documentation record). Table 2 of this HRS documentation record lists data used for evaluating Source No. 1.

## **2.2.2 HAZARDOUS SUBSTANCES ASSOCIATED WITH THE SOURCE**

### **July 2016 ESI – Soil Sampling – Source No. 1**

Table 2 lists surface soil samples (0 to 1-foot bgs) collected during the July 2016 ESI within the footprint of the former burn pit in the southwestern portion of the former NF facility, and one background surface soil sample outside the suspected boundaries of the former burn pit (Ref. 33, pp. 4, 29, 33). At the former burn pit, surface soil samples collected were absent of fill (Ref. 33, pp. 8, 50). Burned material was observed in the former burn pit (Ref. 33, p. 50).

During the ESI, the background soil sample was collected within 0 to 1-foot bgs from a direct-push technology (DPT) borehole at NF01 (the location designated in 2009 as NF16) (about 200 feet north of Source No. 1). NF01 was located outside of the suspected boundaries of the former burn pit but in a similar setting (Refs. 32, pp. 23, 29; 33, pp. 29, 33) (see Figure 3 of this HRS documentation record). Results from the surface soil sample collected at NF01 in 2016 was used to establish background levels at Source No. 1 (see Table 2 of this HRS documentation record). The lithology of each borehole advanced within the burn pit during the 2016 ESI was not recorded at the time of sampling; however, the predominant soil type of samples collected within the burn pit in 2009 was described as brown silty clay (Refs. 32, pp. 23, 97 to 107; 33, p. 29). The 2016 background sample (NF01) was collected at roughly the same location where the 2009 background sample (NF16) was collected, and thus the soil type of these samples is assumed similar (brown silty clay) (Refs. 32, pp. 23, 108; 33, p. 29).

ESI field activities followed the quality assurance project plan (QAPP) dated June 10, 2016 (Refs. 33, p. 7; 38). The background and Source No. 1 surface soil samples were collected during the same sampling event, in accordance with the same sampling procedures, and from the same soil type at corresponding depth intervals (Refs. 32, pp. 23, 97 to 108; 33, pp. 7, 29, 33; 38). A DPT drill rig was used to collect these samples within 0 to 1-foot bgs (Refs. 33, p. 33; 38, p. 5). Soil samples were collected in accordance with the EPA Science and Ecosystem Support Division (SESD) (currently known as Laboratory Services and Applied Sciences Division [LSASD]) Field Branches Quality System and Technical Procedures (FBQSTP) for Soil Sampling (Refs. 33, p. 7; 38, p. 9; 40). Under the EPA Contract Laboratory Program (CLP), ALS Environmental (ALS) analyzed the samples for metals via EPA Method ISM02.3 (Ref. 33, p. 112). EPA SESD reviewed all metals data in accordance with EPA Method ISM02.3 (Ref. 33, p. 112). Katahdin Analytical Services, LLC, procured by Tetra Tech, analyzed the samples for explosives via EPA Method 8330A (Ref. 33, pp. 269, 270). Tetra Tech reviewed all explosives data in accordance with EPA Method 8330A and the EPA National Functional Guidelines (NFG) for Superfund Organic Methods Data Review (August 2014) (Ref. 33, p. 1090). The minimum reporting limits (MRL) for metals and adjusted limits of quantitation (LOQ) for explosives are on the analytical data sheets in Appendix E of Reference 33. The MRLs and adjusted LOQs are equivalent to sample quantitation limits (SQL) as defined in the HRS Rule (Refs. 1, Section 1.1; 41; 90). Table 2 below compares results from the Source No. 1 samples to those from the background sample.

Chain-of-custody forms are in Reference 42. Locations of the background and Source No. 1 samples are depicted on page 29 of Reference 33 and on Figure 3 of this HRS documentation record.



**TABLE 2: Analytical Results from Source No. 1 – July 2016**

Station ID	Sample ID	Hazardous Substance	Hazardous Substance Concentration	SQL	References
Background Surface Soil Sample (0- to 1-foot bgs)					
NF01	NF-01-SF	Cadmium	0.56U mg/kg	0.56 mg/kg	33, pp. 33, 53, 124, 294, 1095; 42, p. 4
		Lead	10 mg/kg	0.56 mg/kg	
		Mercury	0.0063J <sup>1</sup> mg/kg	0.11 mg/kg	
		2,6-DNT	110U µg/kg	110 µg/kg	
Contaminated Surface Soil Samples (0- to 1-foot bgs)					
NF03	NF-03-SF	Cadmium	0.86 mg/kg	0.56 mg/kg	33, pp. 33, 56, 128; 42, p. 4
		Lead	35 mg/kg	0.56 mg/kg	
NF03	NF-03-SF-DUP	Cadmium	0.75 mg/kg	0.55 mg/kg	33, pp. 33, 56, 129; 42, p. 4
		Lead	34 mg/kg	0.55 mg/kg	
NF06	NF-06-SF	Lead	42 mg/kg	0.56 mg/kg	33, pp. 33, 59, 135; 42, p. 5
NF07	NF-07-SF	Cadmium	0.83 mg/kg	0.55 mg/kg	33, pp. 33, 60, 137, 307, 1111; 42, p. 5
		Lead	150 mg/kg	0.55 mg/kg	
		Mercury	0.15 mg/kg	0.097 mg/kg	
		2,6-DNT	220 µg/kg	100 µg/kg	

**Notes:**

<sup>1</sup> The result is qualified as estimated because the detected concentration exceeded or equaled the detection limit but was below the quantitation limit. The associated numerical value is the approximate concentration of the analyte in the sample (Ref. 33, pp. 115, 124). A bias is not associated with this sample concentration; therefore, no adjustment is necessary per the EPA fact sheet *Using Qualified Data to Document and Observed Release and Observed Contamination* (November 1996) (Ref. 45, p. 8).

bgs Below ground surface  
DNT Dinitrotoluene  
DUP Duplicate  
ID Identification  
J Identification of the analyte is acceptable; the reported value is an estimate (Ref. 33, p. 115)  
µg/kg Micrograms per kilogram  
mg/kg Milligrams per kilogram  
NF National Fireworks, Inc.  
SF Surface soil sample  
SQL Sample quantitation limit  
U The analyte was not detected at concentration at or above the reporting limit (Ref. 33, pp. 115, 1094).

Surface soil samples collected at the former burn pit area in July 2016 also contained elevated concentrations of dioxins and furans, including 1,2,3,4,6,7,8-heptachlorodibenzodioxin (up to 130 nanograms per kilogram [ng/kg]), 2,3,7,8-tetrachlorodibenzodioxin (up to 1.6 ng/kg), and 2,3,7,8-tetrachlorodibenzofuran (up to 20 ng/kg), among others (Ref. 33, pp. 11, 33, 36). Subsurface soil samples collected at the former burn pit area contained elevated concentrations of dioxins and furans, including 1,2,3,4,7,8-hexachlorodibenzodioxin (at 12 ng/kg), 1,2,3,6,7,8- hexachlorodibenzodioxin (at 4.7 ng/kg), total heptachlorodibenzofuran (up to 0.36J ng/kg), and total hexachlorodibenzofuran (at 0.27J ng/kg), among others (Ref. 33, pp. 11, 33, 38, 39). The detection of dioxins and furans is evidence that the soil samples were collected within an area used for burning (Refs. 33, pp. 36, 38, 39; 75, p. 2; 76, p. 2).

**Additional Supporting Background Data**

In 2009, during a soil and groundwater investigation of the former burn pit (Source No. 1), background surface and subsurface soil samples were collected and analyzed via the same methods as those applied to collect and analyze the 2016 background samples (Refs. 32, pp. 12, 14, 23, 25, 28, 29; 33, pp. 7, 8, 9, 29, 33). Concentrations detected in the background soil samples in 2009 are summarized in Table 3 below.

TABLE 3: Source No. 1 - Background Soil Concentrations – 2009					
Station ID	Sample ID	Date Collected	Hazardous Substance	Hazardous Substance Concentration (mg/kg)	References
Surface Soil Samples (0 to 1 foot bgs)					
NF01	NF-SS-01	4/7/2009	Cadmium	0.10UJ	32, pp. 68, 316, 323, 388, 495
			Lead	8.4	
			Mercury	0.11U	
			2,6-DNT	2.2U	
NF16	NS-SS-16	4/8/2009	Cadmium	0.51U	32, pp. 74, 317, 361
			Lead	10	
			Mercury	0.036UJ	
Subsurface Soil Sample (1 to 4 feet bgs)					
NF01A	NF-SB-01A	4/7/2009	Cadmium	0.088UJ	32, pp. 68, 316, 319
			Lead	9.4	
			Mercury	0.11U	
Subsurface Soil Sample (6 to 7 feet bgs)					
NF16	NF-SB-16	4/8/2009	Cadmium	0.42U	32, pp. 74, 317, 360
			Lead	8.4	
			Mercury	0.12U	

Notes:

bgs Below ground surface

DNT Dinitrotoluene

ID Identification

mg/kg Milligrams per kilogram

U Analyte was not detected at or above the reporting limit (Ref. 32, p. 318)

UJ Analyte was not detected at or above the reporting limit; the reported value is an estimate (Ref. 32, p. 318)

These background analyte concentrations from 2009 provide corroboration that the 2016 ESI background analyte concentrations listed in Table 2 of this HRS documentation record are representative of background soil conditions.

### Other Evidence of Releases to Source No. 1

A site inspection (SI) of the former NF facility in 2001, on behalf of EPA, involved sampling at the former burn pit. Analytes detected in burn pit soil samples at elevated concentrations included the following: arsenic (up to 36 mg/kg), cadmium (up to 18 mg/kg), chromium (up to 110 mg/kg), cobalt (up to 10 mg/kg), copper (up to 790 mg/kg), lead (up to 34,000 mg/kg), mercury (up to 0.15 mg/kg), nickel (up to 96 mg/kg), zinc (up to 110,000 mg/kg), cyanide (at 1.1 mg/kg), pyrene (up to 7,200 micrograms per kilogram [ $\mu\text{g/kg}$ ]), 1,3-dinitrobenzene (up to 377  $\mu\text{g/kg}$ ), 2,4,6-TNT (up to 1,290  $\mu\text{g/kg}$ ), 2,4-DNT (up to 736  $\mu\text{g/kg}$ ), nitrobenzene (up to 607  $\mu\text{g/kg}$ ), RDX (up to 378  $\mu\text{g/kg}$ ), tetryl (up to 31,300  $\mu\text{g/kg}$ ), 4-nitrotoluene (up to 598  $\mu\text{g/kg}$ ), and dioxins and furans, among others (Ref. 28, pp. 5, 8, 13, 21, 23, 36, 41, 50, 56). The presence of these constituents indicates that the former burn pit was likely used for burning munitions waste.

In April 2009, a Final Supplemental Assessment investigation of the former burn pit was conducted on behalf of EPA. Soil samples were collected in the area of the former burn pit (Source No. 1), and were found to contain the following hazardous substances at elevated concentrations: PCE, 2,4-DNT, arsenic, barium, beryllium, cadmium, chromium, copper, lead, manganese, mercury, nickel, zinc, and dioxins and furans—again indicating that the former burn pit had likely been used for burning munitions waste (Ref. 32, pp. 6, 23, 28, 29, 33, 34, 36 to 41, 43, 44, 46, 47, 49, 50, 52 to 55).



## 2.2.3 HAZARDOUS SUBSTANCES AVAILABLE TO A PATHWAY

Soil samples collected at Source No. 1 contained cadmium, lead, mercury, and 2,6-DNT at elevated concentrations (see Table 2 of this HRS documentation record). Source No. 1 is an area of contaminated soil in the southwestern portion of the former NF facility (Ref. 33, pp. 29, 35 to 40). Logs of soil borings advanced in 2009 for sampling at Source No. 1 do not indicate the presence of a liner (Ref. 32, pp. 92 to 108). Therefore, a containment factor value of 10, as noted in Table 4, was assigned for the ground water migration pathway (Ref. 1, Section 3.1.2.1, Table 3-2).

TABLE 4: Containment Factors for Source No. 1		
Containment Description	Containment Factor Value	References
Gas release to air	NS	NA
Particulate release to air	NS	NA
Release to groundwater: No liner	10	1, Section 3.1.2.1, Table 3-2; 32, pp. 61 to 79, 93 to 108
Release via overland migration and/or flood	NS	NA

Notes:

NA Not applicable  
NS Not scored

## 2.4.2.1 HAZARDOUS WASTE QUANTITY

### 2.4.2.1.1 Hazardous Constituent Quantity (Tier A)

Total hazardous constituent quantity for Source No. 1 could not be adequately determined according to HRS requirements—that is, total mass of all CERCLA hazardous substances in the source and releases from the source is not known and cannot be estimated with reasonable confidence (Ref. 1, Section 2.4.2.1.1). Sufficient historical and current data (manifests, potentially responsible party [PRP] records, State records, permits, waste concentration data, etc.) are not available for trustworthy calculations of total or partial mass of all CERCLA hazardous substances in the source and associated releases from the source. Therefore, information is insufficient to calculate a total or partial Hazardous Constituent Quantity estimate for Source No. 1 with reasonable confidence. Scoring proceeds to the evaluation of Tier B, hazardous wastestream quantity (Ref. 1, Section 2.4.2.1.1).

Hazardous Constituent Quantity Assigned Value: Not scored (NS)

### 2.4.2.1.2 Hazardous Wastestream Quantity (Tier B)

Total hazardous wastestream quantity for Source No. 1 could not be adequately determined according to HRS requirements; that is, total mass of all hazardous waste streams and CERCLA pollutants and contaminants in the source and releases from the source is not known and cannot be estimated with reasonable confidence (Ref. 1, Section 2.4.2.1.2). Sufficient historical and current data (manifests, PRP records, State records, permits, waste construction data, annual reports, etc.) are not available for trustworthy calculations of total or partial mass of all hazardous waste streams and all CERCLA pollutants and contaminants in the source and associated releases from the source. Thus, information is insufficient to evaluate the associated releases from the source in order to calculate the hazardous wastestream quantity for Source No. 1 with reasonable confidence. Scoring proceeds to the evaluation of Tier C, Volume (Ref. 1, Section 2.4.2.1.2).

Hazardous Wastestream Quantity Assigned Value: NS

**2.4.2.1.3 Volume (Tier C)**

Information on the depth of Source No. 1 is not sufficiently documented based on the number of samples collected to support calculation of a volume of contaminated soil with reasonable confidence; therefore, it is not possible to assign a volume (Tier C) in cubic yards (yd<sup>3</sup>) for Source No. 1 (Ref. 1, Section 2.4.2.1.3, Table 2-5). Source No. 1 has been assigned a value of 0 for the volume measure (Ref. 1, Section 2.4.2.1.3). As a result, the evaluation of hazardous waste proceeds to the evaluation of Tier D, area (Ref. 1, Section 2.4.2.1.3).

Volume Assigned Value: 0

**2.4.2.1.4 Area (Tier D)**

Sampling locations for Source No. 1 are depicted on Figure 3 of the HRS documentation record. It is not known whether contamination is present between sampling points; therefore, contamination between sampling points was not inferred.

Sum (square feet [ft<sup>2</sup>]): Undetermined, but greater than zero  
Equation for Assigning Value (Table 2-5): Area (A)/34,000  
(Ref. 1, Section 2.4.2.1.4)

Area Assigned Value: Undetermined, but greater than zero

**2.4.2.1.5 Source Hazardous Waste Quantity Value**

The source hazardous waste quantity (HWQ) value assigned for Source No. 1 is 4.31 (Ref. 1, Section 2.4.2.1.5).

Source HWQ Value: Undetermined, but greater than 0



## 2.2.1 SOURCE IDENTIFICATION

Number of Source: 2

Name of Source: Contaminated Soil – Former Munitions Manufacturing Area

Source Type: Contaminated soil

Description and Location of Source (with reference to a map of site):

Figure 3 of this HRS documentation record shows the location of Source No. 2. Source No. 2, contaminated soil, consists of potentially multiple discrete areas of contaminated soil in the former munitions manufacturing area, as documented by analytical results listed in Table 6 of this HRS documentation record, that are aggregated into a single source for this HRS scoring for the following reasons: the same source type (contaminated soil) affects similar targets, involves the same contaminants of concern, and was contaminated in similar ways (via releases from facility operations).

Mercury and chlorinated volatile organic compounds (VOC) contaminated soil of an undetermined extent on the former NF facility resulted from the migration, deposition, or spillage of hazardous substances associated with the handling, storage, maintenance, and operations at the former munitions area. The probable source of contamination is from the release of chemicals/products used in the manufacturing (mixing) of ammunitions and the transport of products from the adjacent railroad spur to warehouses and manufacturing buildings and from the manufacturing buildings to the railroad spur as evidenced by aerial photographs. Aerial photographs show open bins and storage areas within Source No. 2 where chemicals used in the manufacturing process were stored and may have released to soils in Source No. 2 (Refs. 9, p. 3; 10, p. 6; 12, pp. 14, 15, 19, 21; 34, pp. 26, 31, 32, 33; 78, pp. 1, 2, 4) (see Figures 3 and 5 in this HRS documentation record). Chemicals used in the manufacture of ammunitions were unloaded around the NF railroad spur within the area of Source No. 2 (Refs. 12, pp. 14, 15; 70, p. 1; 78, p. 1). The northern ends of the production lines are located within the area of Source No. 2 and terminate at the assembly building where munitions would have been assembled (Ref. 78, pp. 1, 2, 3) (see Figure 5 of this HRS documentation record).

Former NF operations located in the area of Source No. 2 that may have contributed to soil contamination include:

- An incinerator, open bins, and emissions stack (Refs. 12, pp. 14, 15, 19, 21; 78, p. 2)
- Open storage areas containing crates (Ref. 12, pp. 25, 27, 30, 31)
- Railroad tracks and spur (Ref. 12, pp. 14, 15)
- Assembly building on the north end of the production line (Ref. 78, pp. 1, 3)

It is likely that the incinerator was used for the disposal of waste chemicals and rejected munitions (Refs. 72, pp. 2, 41; 78, p. 2). Materials used in the manufacturing process were likely stored in the open storage areas with no containment and are probable sources of chlorinated VOC and mercury contamination within Source No. 2, as evidenced by soil sample results (see Table 6 of this HRS documentation record). Products possibly stored and used in the munitions manufacturing area included PCE, TCE, DNT, TNT, RDX, tetryl, ammonium nitrate, fulminated mercury, and white phosphorus (Refs. 9, pp. 8, 9; 10, pp. 6, 8; 78, p. 1; 81, pp. 2 to 6; 92, pp. 200, 201, 202). These materials are used in making explosives and smoke agents, such as smoke pots, and in maintaining equipment (Refs. 80, p. 17; 81, pp. 2, 6; 83, p. 1; 84, p. 1; 92, pp. 200, 201, 202).

Soil samples collected from Source No. 2 contained chlorinated VOCs (see Table 6 of this HRS documentation record). TCE was commonly used to clean and maintain the machines used on production lines located within the area of Source No. 2 (Refs. 58; 59; 78, pp. 1, 3; 81, pp. 2, 6). TCE was known to be used at NF and was primarily used in vapor degreasers, which were part of manufacturing lines (Refs. 59; 70, p. 4; 81, p. 6). TCE is a degreasing solvent used to degrease machinery in the manufacturing area and equipment associated with the railroad (Refs. 36, p. 27; 59; 81, p. 6). TCE also was used to degrease fuse houses (Refs. 71, pp. 9, 11; 78, p. 1). Munitions manufacturing required a degreasing area for fuse housings, projectiles, and loading for 20-mm shell

propellants (Ref. 71, pp. 9, 11). The North American Industry Classification System (NAICS) codes associated with the solvent industry include Small Arms Ammunition Manufacturing (332992), Ammunition (except Small Arms) Manufacturing (332993), and Other Ordnance and Accessories Manufacturing (332995) (Refs. 35, pp. 48, 50; 36, p. 7). TCE was detected in Source No. 2 soil samples and Source No. 2 is located in the munitions manufacturing area (see Table 6 and Figures 3 and 5 of this HRS documentation record).

Documents for the main NF facility in Hanover, Massachusetts, for which more complete records exist, show that similar operations took place at both the Hanover NF facility and the Cordova NF facility. At both locations during WWII, manufacture of similar products occurred, including fireworks, pyrotechnics, and ammunition (Refs. 8, p. 18; 9, p. 3; 10, pp. 3, 5, 6, 7; 72, pp. 2, 3, 4, 19, 28, 29; 80, p. 4). Manufacturing areas at both locations included munitions production and degreasing of fuse housings, and a loading area for 20-mm shell propellant (Ref. 71, p. 9). At the Hanover NF facility, manufacturing areas, similar to Source No. 2 at the Cordova NF facility, included operations that may well have involved TCE and mercury (Ref. 71, pp. 9, 11). Also similar to the Cordova NF facility, soil at the Hanover NF facility has been impacted by mercury, methyl mercury, lead, other metals, and chlorinated VOCs generated in the manufacturing process (Ref. 86, p. 2). Based on affidavits with former employees at the Hanover NF facility, raw products used in manufacture of munitions included lead azide, freon, mercury fulminate, gun powder, aluminum fulminate, butyl acetone, amyl acetate, lithium chloride, RDX, phosphorous, magnesium, tetryl, TNT, TCE, and others (Ref. 71, p. 13). Analytical results from soil samples collected during investigations at the Hanover NF facility indicated that lead, mercury, and TCE used in manufacture of munitions had been released to soil (Ref. 71, pp. 6, 21 to 25, 30, 31, 35, 36, 38, 67 to 71). Moreover, locations of TCE in groundwater at the Hanover NF facility corresponded to locations of past manufacturing areas, again indicating use of TCE in the manufacturing areas (Refs. 71, pp. 9, 11, 21 to 25, 39; 74, p. 22).

TCE and its degradation products were detected in Source No. 2 soil samples (see Table 6 of this HRS documentation record). The most significant process for natural biodegradation of the more highly chlorinated solvents, such as TCE, is reductive dechlorination. Typically, reductive dechlorination occurs by sequential dechlorination from TCE to DCE to vinyl chloride to ethene (Ref. 52, p. 23). The full list of daughter products of TCE includes 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, ethene, and ethane (Ref. 52, p. 24). Breakdown of TCE in soil generally proceeds slowly (Ref. 59, p. 1).

## Conditions of Source No. 2

NF buildings within the area of Source No. 2 have remained relatively unchanged since closure of NF operations there—including the complex of warehouse-like buildings in the northwestern portion of the former NF facility where chemicals/products were offloaded from the railroad and stored at outside storage areas. The railroad spur in the area of Source No. 2 has been removed. Aerial photographs show numerous land scars in the area of Source No. 2, indicating much activity in the area (Refs. 12, pp. 14, 15, 19, 21, 25, 27, 30, 31, 34, 35, 39, 42, 43) (see Figures 3 and 5 of this HRS documentation record). Earthwork for construction of Cordova Industrial Park included movement of surface soils from one area to another, which likely began in 1986 when subdivision and sale of individual lots within the industrial park started (Refs. 9, p. 2; 23, p. 2).

Currently occupying the former NF buildings in the area of and adjacent to Source No. 2 are a pool and landscape company, a granite and marble company, and a masonry company (Refs. 66, p. 6; 89) (see Figures 3 and 5 of this HRS documentation record). None of these businesses or other nearby businesses are known or reported to use chlorinated solvents at this time (Refs. 65; 66, pp. 6, 31, 35, 50, 72, 75, 114, 115).

## 2.2.2 HAZARDOUS SUBSTANCES ASSOCIATED WITH THE SOURCE

### June 2018 ESI – Soil Sampling

Source No. 2 samples listed in Table 5 below were collected during the June 2018 ESI throughout the north-central portion of the former NF property (Ref. 34, pp. 8, 26, 29, 30) (see Figures 3 and 5 of this HRS documentation record).

During the 2018 ESI, three background soil samples were collected at various depths (0 to 20 feet bgs) from DPT boreholes at locations designated as NF33 and NF36 (Ref. 34, pp. 11, 26, 34). Presumably, NF33 and NF36 were outside the influence of former NF operations because they were not collected from the former NF facility but in a similar setting, and thus results from samples collected from those boreholes were used to establish background levels at Source No. 2 (see Figure 3 and Table 6 of this HRS documentation record). Results from the surface soil sample (0 to 2 feet bgs) collected at NF33 were selected to represent background levels for comparison to results from surface soil samples (0 to 2 feet bgs) collected at the former NF facility. Results from subsurface soil samples (5 to 7 feet bgs and 16 to 20 feet bgs) collected at NF36 were selected to represent background levels for comparison to results from subsurface soil samples (4 to 10 feet bgs and 12 to 16 feet bgs) collected at the former NF facility. Notably, the two-digit extensions on the sample IDs below (e.g., -01 and -02) do not correspond to any particular depth interval; simply, the first depth interval (-01) and the second depth interval (-02).

Table 5 lists the lithology of each borehole and sample depth noted during soil sampling (Ref. 34, pp. 117, 118, 120 to 123, 127, 128, 139 to 144, 154, 155, 158, 159, 166, 167). Boring logs documenting sample depths and soil descriptions are in Reference 34, Appendix C.

<b>TABLE 5: Source No. 2 Sample Lithology</b>				
<b>Boring ID</b>	<b>Sample ID</b>	<b>Depth (feet bgs)</b>	<b>Lithology</b>	<b>References</b>
<b>Background Sample</b>				
NF33	NF33-SS-01	0 to 2	Brown/dark brown sand, moderate silt, abundant rock fragments, hard, and damp; brown/dark brown silty clay, moderate silt, damp, and slightly to moderately hard	34, pp. 41, 42, 100, 101, 158, 159
<b>Contaminated Samples</b>				
NF17	NF17-SS-01 NF17-SS-01-DUP	0 to 2	Brown silty clay, moderate silt, minor small rock fragments, damp and slightly hard	34, pp. 42, 49, 50, 117, 118
NF19	NF19-SS-01 NF19-SS-01-DUP	0 to 2	Brown silty clay, abundant silt, slightly soft, damp	34, pp. 42, 56, 57, 122, 123
NF26	NF26-SS-01	0 to 2	Brown silty clay, damp, and moderately soft	34, pp. 41, 78, 141, 142
<b>Background Sample</b>				
NF36	NF36-SS-01	5 to 7	Moist brown clay	34, pp. 48, 109, 110, 166, 167
<b>Contaminated Samples</b>				
NF17	NF17-SS-02	4 to 6	Brown silty clay, moderate silt, minor small rock fragments, moist to wet and slightly hard	34, pp. 42, 49, 50, 117, 118
NF25	NF25-SS-01	2 to 4	Brown saturated clay	34, pp. 47, 75, 76, 139, 140
NF26	NF26-SS-02	8 to 10	Brown silty clay, very moist to wet, and moderately soft	34, pp. 41, 78, 79, 141, 142
NF27	NF27-SS-01	2 to 4	Brown silty clay, abundant silt, damp, and slightly hard	34, pp. 42, 81, 82, 143, 144
NF27	NF27-SS-02	4 to 6	Brown/gray brown silty clay, abundant silt, soft to moderately soft, moist throughout, and wet 5-5.75 feet bgs	34, pp. 42, 81, 82, 143, 144



TABLE 5: Source No. 2 Sample Lithology				
Boring ID	Sample ID	Depth (feet bgs)	Lithology	References
<b>Background Sample</b>				
NF36	NF36-SS-02	16 to 20	Saturated light gray clay	34, pp. 48, 109, 110, 166, 167
<b>Contaminated Samples</b>				
NF18	NF18-SS-02	14 to 16	Moist brown/gray mottled clay	34, pp. 48, 52, 53, 120, 121
NF21	NF21-SS-02	13 to 15	Brown/reddish brown sandy clay, abundant fine grain sand, slightly soft, moist, with rock fragments and coarse sand. Also, with rock fragments and coarse sand from 14-14.75 feet bgs.	34, pp. 42, 62, 63, 127, 128
NF25	NF25-SS-02	12 to 14	Brown dry clay	34, pp. 47, 75, 76, 139, 140
NF31	NF31-SS-02	12 to 14	Mottled light brown/gray clay	34, pp. 47, 94, 95, 154, 155

## Notes:

bgs Below ground surface  
 DUP Duplicate  
 ID Identification  
 NF National Fireworks  
 No. Number  
 SS Soil sample

Source No. 2 samples listed in Table 6 below were collected during the June 2018 ESI throughout the north-central portion of the former NF property (Ref. 34, pp. 8, 26, 29, 30) (see Figure 3 of this HRS documentation record).

ESI field activities were conducted in accordance with the QAPP dated May 16, 2018 (Refs. 34, p. 8; 39). The background and Source No. 2 surface and subsurface soil samples were collected during the same sampling event, using the same sampling procedures, and from soil of the same type at corresponding depth intervals (Refs. 34, pp. 8, 26, 29, 30; 39). A DPT drill rig was used to collect these samples at depths between 0 and 20 feet bgs (Refs. 34, pp. 29, 30; 39, p. 5). Soil samples were collected in accordance with the EPA SESD FBQSTP for Soil Sampling (Refs. 34, p. 8; 39, p. 9; 40). The samples were analyzed for VOCs (EPA Method SOM02.4) by Chemtech under the EPA CLP, and for mercury (EPA Method 7473) by EPA SESD Analytical Support Branch (ASB) (Ref. 34, pp. 182, 333). EPA SESD reviewed all VOC data in accordance with EPA CLP Method SOM02.4, and mercury data in accordance with EPA ASB's Laboratory Operations and Quality Assurance Manual (LOQAM) (Ref. 34, pp. 182, 333). MRLs for VOCs and mercury are provided on the analytical data sheets in Appendix E of Reference 34. The MRLs are equivalent to SQLs as defined in the HRS Rule (Refs. 1, Section 1.1; 41). Table 6 below compares results from the Source No. 2 samples to those from background samples collected at corresponding depths. Notably, the two-digit extensions on the sample IDs below (e.g., -01 and -02) do not correspond to any particular depth interval; simply, the first depth interval (-01) and the second depth interval (-02).

Chain-of-custody forms are in Reference 43. Locations of the background and Source No. 2 samples are depicted on page 26 of Reference 34 and on Figure 3 of this HRS documentation record.

TABLE 6: Analytical Results for Source No. 2 – June 2018

Station ID	Sample ID	Hazardous Substance	Hazardous Substance Concentration	MRL	References
Background Surface Soil Sample (0 to 2 feet bgs)					
NF33	NF33-SS-01	cis-1,2-DCE	4.0U µg/kg	4.0 µg/kg	34, pp. 41, 100, 304, 427; 43, pp. 2, 15
		TCE	4.0U µg/kg	4.0 µg/kg	
		Mercury	0.045U mg/kg	0.045 mg/kg	
Contaminated Surface Soil Samples (0 to 2 feet bgs)					
NF17	NF17-SS-01	TCE	28J (13.27) <sup>a</sup> µg/kg	3.7 µg/kg	34, pp. 42, 49, 204, 2789, 2791; 43, p. 4; 44, p. 2; 45, pp. 8, 12
	NF17-SS-01-DUP	cis-1,2-DCE	60J (6.0) <sup>a</sup> µg/kg	3.9 µg/kg	34, pp. 42, 49, 206, 2789, 2792; 43, p. 5; 44, p. 2; 45, pp. 8, 11
NF19	NF19-SS-01	Mercury	0.053 mg/kg	0.044 mg/kg	34, pp. 42, 56, 355; 43, p. 10
	NF19-SS-01-DUP	Mercury	0.046 mg/kg	0.042 mg/kg	34, pp. 42, 56, 357; 43, p. 11
NF26	NF26-SS-01	cis-1,2-DCE	16 µg/kg	4.1 µg/kg	34, pp. 41, 78, 262; 43, p. 1
Background Subsurface Soil Sample (5 to 7 feet bgs)					
NF36	NF36-SS-01	1,1-DCA	4.7U µg/kg	4.7 µg/kg	34, pp. 48, 109, 323, 324; 43, p. 5
		cis-1,2-DCE	4.7U µg/kg	4.7 µg/kg	
		TCE	4.7U µg/kg	4.7 µg/kg	
		Vinyl chloride	4.7U µg/kg	4.7 µg/kg	
Contaminated Subsurface Soil Samples (2 to 10 feet bgs)					
NF17	NF17-SS-02	TCE	730 µg/kg	270 µg/kg	34, pp. 42, 49, 208; 43, p. 4
		Vinyl chloride	4.8 µg/kg	4.3 µg/kg	
NF25	NF25-SS-01	cis-1,2-DCE	5.0 µg/kg	4.7 µg/kg	34, pp. 47, 75, 256; 43, p. 1
NF26	NF26-SS-02	1,1-DCA	5.9 µg/kg	4.1 µg/kg	34, pp. 41, 78, 184, 185, 187, 263, 264; 43, p. 13; 44, p. 2; 45, pp. 8, 11
		cis-1,2-DCE	300J (30) <sup>b</sup> µg/kg	4.1 µg/kg	
NF27	NF27-SS-01	cis-1,2-DCE	100 µg/kg	4.1 µg/kg	34, pp. 42, 81, 268; 43, p. 5
		trans-1,2-DCE	35 µg/kg	4.1 µg/kg	
		TCE	31 µg/kg	4.1 µg/kg	
NF27	NF27-SS-02	cis-1,2-DCE	860 µg/kg	270 µg/kg	34, pp. 42, 81, 270; 43, p. 5
		trans-1,2-DCE	270 µg/kg	270 µg/kg	
		TCE	43 µg/kg	3.9 µg/kg	
Background Subsurface Soil Sample (16 to 20 feet bgs)					
NF36	NF36-SS-02	cis-1,2-DCE	3.9U µg/kg	3.9 µg/kg	34, pp. 48, 109, 326, 444; 43, pp. 5, 16
		TCE	3.9U µg/kg	3.9 µg/kg	
		Mercury	0.040U mg/kg	0.040 mg/kg	
Contaminated Subsurface Soil Samples (12 to 15 feet bgs)					
NF18	NF18-SS-02	TCE	89 µg/kg	4.1 µg/kg	34, pp. 48, 52, 214; 43, p. 4
NF21	NF21-SS-02	TCE	4.3 µg/kg	4.1 µg/kg	34, pp. 42, 62, 234; 43, p. 4
NF25	NF25-SS-02	cis-1,2-DCE	8.8 µg/kg	4.0 µg/kg	34, pp. 47, 75, 258; 43, p. 1
		TCE	20 µg/kg	4.0 µg/kg	
NF30	NF30-SS-02	Mercury	0.074 mg/kg	0.042 mg/kg	34, pp. 48, 90, 414; 43, p. 14
NF31	NF31-SS-02	cis-1,2-DCE	63 µg/kg	6.1 µg/kg	34, pp. 47, 94, 294; 43, p. 2
		TCE	160 µg/kg	6.1 µg/kg	

Notes:

( ) Concentration was adjusted in accordance with References 44 and 45.

<sup>a</sup> Sample result should be considered estimated with a potential unknown bias because the relative percent difference between results from the sample and duplicate exceeds 50 percent (Refs. 34, pp. 204, 206, 2789, 2791, 2792; 44, pp. 1, 2). The value presented parenthetically is the concentration obtained by applying EPA fact sheet *Using Qualified Data to Document and Observed Release and Observed Contamination* (November 1996) (Ref. 45, pp. 8, 11, 12).

<sup>b</sup> Sample result should be considered estimated with a potential unknown bias because the concentration reported is greater than the highest standard on the calibration curve (Refs. 34, pp. 184, 185, 187, 264; 44, pp. 1, 2). The value presented parenthetically is the concentration obtained by applying EPA fact sheet *Using Qualified Data to Document and Observed Release and Observed Contamination* (November 1996) (Ref. 45, pp. 8, 11).

bgs	Below ground surface
DUP	Duplicate
ID	Identification
J	Identification of the analyte is acceptable; the reported value is an estimate (Ref. 34, pp. 187, 337)
µg/kg	Micrograms per kilogram
mg/kg	Milligrams per kilogram
NF	National Fireworks, Inc.
SF	Surface soil sample
U	Analyte not detected at concentration at or above the reporting limit (Ref. 34, pp. 187, 337).

### **Additional Supporting Data for Background Levels**

In 1992, one surface soil sample was collected from each of three parcels that were formerly part of the original parcel owned by NF and analyzed for mercury. A background soil sample (sample identification 30351) was also collected from a field north of Macon Road. Mercury was not detected in the background surface soil sample at a concentration above the detection limit (Ref. 15, pp. 5, 7, 15, 22, 26).

Background surface and subsurface soil samples collected in 2001 as part of an SI at the former NF facility did not contain concentrations of 1,1-DCA, cis-1,2-DCE, trans-1,2-DCE, TCE, vinyl chloride, and mercury at or above their respective detection limits (Ref. 28, pp. 5, 8, 13, 21, 23, 31, 32, 285, 286, 662, 664).

In 2004, during an ESI at the former NF facility, concentrations of 1,1-DCA, cis-1,2-DCE, trans-1,2-DCE, TCE, vinyl chloride, and mercury in the background surface and subsurface soil samples were below detection limits in background surface and subsurface soil samples (Ref. 29, pp. 8, 17, 18, 20, 25, 29, 30, 207, 208, 209, 212, 308, 310, 312, 318).

In 2009, during a soil and groundwater investigation of the former burn pit (Source No. 1), background surface and subsurface soil samples were collected and analyzed via the same methods used for the collection of the 2018 background samples listed below in Table 6 (Refs. 32, p. 14; 34, pp. 9, 10). In background surface and subsurface soil samples concentrations of 1,1-DCA, cis-1,2-DCE, trans-1,2-DCE, TCE, vinyl chloride, and mercury were below the detection limits (Ref. 32, pp. 23, 28, 29, 141 to 148, 149, 150, 224, 225, 226, 319 to 322, 323, 360, 361).

Background surface and subsurface soil samples collected in 2016 during the ESI of OU1 at the former NF facility did not contain concentrations of 1,1-DCA, cis-1,2-DCE, trans-1,2-DCE, TCE, and vinyl chloride above their respective detection limits. Mercury was detected in the background surface and subsurface soil samples at estimated concentrations of 0.0063 and up to 0.019 mg/kg, respectively—below 2018 detection limits (Refs. 33, pp. 7, 11, 29, 33, 120 to 124, 160 to 169; 34, pp. 8, 11, 26, 30, 303 to 306, 323 to 326, 427, 429, 442, 444) (see Table 6 of this HRS documentation record).



## 2.2.3 HAZARDOUS SUBSTANCES AVAILABLE TO A PATHWAY

Soil samples collected at Source No. 2 contained mercury; 1,1-DCA; cis-1,2-DCE; trans-1,2-DCE; TCE; and vinyl chloride at elevated concentrations (see Table 6 of this HRS documentation record). Source No. 2 consists of areas of contaminated soil in the north-central portion of the former NF facility (Ref. 34, pp. 26, 31, 32, 33) (see Figure 3 of this HRS documentation record). During the 2018 ESI, Tetra Tech did not observe a liner during sampling activities (Ref. 34, pp. 47 to 110, 117 to 168). Therefore, a containment factor value of 10, as noted in Table 7 below, was assigned for the ground water migration pathway (Ref. 1, Section 3.1.2.1, Table 3-2).

<b>TABLE 7: Containment Factors for Source No. 2</b>		
<b>Containment Description</b>	<b>Containment Factor Value</b>	<b>References</b>
Gas release to air	NS	NA
Particulate release to air	NS	NA
Release to groundwater: No liner	10	1, Section 3.1.2.1, Table 3-2; 34, pp. 47 to 110, 117 to 168
Release via overland migration and/or flood	NS	NA

Notes:

NA Not applicable  
NS Not scored

## 2.4.2.1 HAZARDOUS WASTE QUANTITY

### 2.4.2.1.1 Hazardous Constituent Quantity (Tier A)

Total hazardous constituent quantity for Source No. 2 could not be adequately determined according to HRS requirements—that is, total mass of all CERCLA hazardous substances in the source and releases from the source is not known and cannot be estimated with reasonable confidence (Ref. 1, Section 2.4.2.1.1). Sufficient historical and current data (manifests, PRP records, State records, permits, waste concentration data, etc.) are not available for trustworthy calculations of total or partial mass of all CERCLA hazardous substances in the source and the associated releases from the source. Therefore, information is insufficient to calculate a total or partial Hazardous Constituent Quantity estimate for Source No. 2 with reasonable confidence. Scoring proceeds to the evaluation of Tier B, hazardous wastestream quantity (Ref. 1, Section 2.4.2.1.1).

Hazardous Constituent Quantity Assigned Value: Not scored (NS)

### 2.4.2.1.2 Hazardous Wastestream Quantity (Tier B)

Total hazardous wastestream quantity for Source No. 2 could not be adequately determined according to HRS requirements—that is, total mass of all hazardous waste streams and CERCLA pollutants and contaminants for the source and releases from the source is not known and cannot be estimated with reasonable confidence (Ref. 1, Section 2.4.2.1.2). Insufficient historical and current data (manifests, PRP records, State records, permits, waste construction data, annual reports, etc.) are available for trustworthy calculations of total or partial mass of the waste stream plus the mass of all CERCLA pollutants and contaminants in the source and the associated releases from the source. Thus, information is insufficient to evaluate the associated releases from the source in order to calculate the hazardous wastestream quantity for Source No. 2 with reasonable confidence. Scoring proceeds to the evaluation of Tier C, Volume (Ref. 1, Section 2.4.2.1.2).

Hazardous Wastestream Quantity Assigned Value: NS

#### 2.4.2.1.3 Volume (Tier C)

Information on depth of Source No. 2 is not sufficiently documented based on the number of samples collected to support calculation of a volume of contaminated soil with reasonable confidence; therefore, it is not possible to assign a volume (Tier C) in cubic yards for Source No. 2 (Ref. 1, Section 2.4.2.1.3, Table 2-5). Source No. 2 has been assigned a value of 0 for the volume measure (Ref. 1, Section 2.4.2.1.3). The evaluation of hazardous waste proceeds to the evaluation of Tier D, area (Ref. 1, Section 2.4.2.1.3).

Volume Assigned Value: 0

#### 2.4.2.1.4 Area (Tier D)

Sampling locations at Source No. 2 are depicted on Figure 3 of the HRS documentation record. It is not known whether contamination is present between sampling points in the various operational areas that comprise Source No. 2; therefore, contamination between sampling points was not inferred. Additionally, a definitive area of contamination cannot be quantified based on the soil sampling locations during the June 2018 sampling. As shown on Figure 3 of this HRS documentation record, large portions of the property are covered by impervious surfaces (e.g., buildings, parking lots). Some of the buildings and foundations have been on the property since the early to mid-1900s (Ref. 12, pp. 21, 27, 31, 35, 39, 43, 47, 53).

Sum (square feet [ft<sup>2</sup>]): Undetermined, but greater than zero  
Equation for Assigning Value (Table 2-5): Area (A)/34,000  
(Ref. 1, Section 2.4.2.1.4)

Area Assigned Value: Undetermined, but greater than zero

#### 2.4.2.1.5 Source Hazardous Waste Quantity Value

The source HWQ value assigned for Source No. 2 is undetermined, but greater than zero (Ref. 1, Section 2.4.2.1.5; see Section 2.4.2.1.4 of this HRS documentation record).

Source HWQ Value: Undetermined, but greater than zero

## SUMMARY OF SOURCE DESCRIPTIONS

Table 8 summarizes source descriptions.

<b>TABLE 8: Summary of Source Descriptions</b>						
<b>Source No.</b>	<b>Source Hazardous Waste Quantity Value</b>	<b>Source Hazardous Constituent Quantity Complete? (Yes/No)</b>	<b>Containment Factor Value by Pathway</b>			
			<b>Groundwater (Ref. 1, Table 3-2)</b>	<b>Surface Water Overland/ Flood (Ref. 1, Table 4-2)</b>	<b>Air</b>	
					<b>Gas (Ref. 1, Table 6-3)</b>	<b>Particulate (Ref. 1, Table 6-9)</b>
1	>0	No	10	NS	NS	NS
2	>0	No	10	NS	NS	NS

Notes:

> Greater than  
 NS Not scored

### Description of Other Possible On-Site Sources

No other possible sources have been identified at the site at this time for HRS scoring purposes.



### 3.0 GROUND WATER MIGRATION PATHWAY

#### 3.0.1 GENERAL CONSIDERATIONS

##### Ground Water Migration Pathway Description

##### **Regional Geology**

NF is in the southern portion of Shelby County, Tennessee, within the Gulf Coastal Plain physiographic province—near the axis of the Mississippi embayment syncline, which plunges southward at a gradient of about 10 feet per mile and generally follows the course of the Mississippi River (Refs. 47, pp. 3, 5; 48, pp. O3, O13; 73, p. 19; 85, p. 15) (see Figure 1 of this HRS documentation record). The Gulf Coastal Plain is characterized by gently rolling to steep topography formed as a result of eroding geologic formations. This topography is broken in many places by the flat-lying alluvial plains of streams crossing the area (Ref. 47, p. 5). Elevations at NF range from about 350 to 290 feet above mean sea level (amsl) (Ref. 3) (see Figure 1 of this HRS documentation record). Geology in the vicinity of Source Nos. 1 and 2 may include, in descending stratigraphic order, some or all of the following units: alluvium of Holocene and Pleistocene age, loess of Pleistocene age, fluvial deposits (terrace deposits) of Pleistocene and Pliocene age, the Jackson-Upper Claiborne confining unit (includes the Jackson, Cockfield, and Cook Mountain Formations) of Eocene age, and the Memphis Sand of the Claiborne Group of Eocene age (Refs. 47, pp. 6, 7; 50, p. 6).

The alluvium occurs beneath the alluvial plains of streams that drain the Gulf Coastal Plain, and consists primarily of sand, gravel, silt, and clay. Thickness of the alluvium ranges from 0 to 175 feet and is commonly less than 50 feet thick beneath the alluvial plains of major streams that drain the Gulf Coastal Plain (Ref. 47, p. 7). Loess is the principal unit at the surface in the upland areas of the Gulf Coastal Plain. Loess deposits consist of silt, silty clay, and minor sand, and range in thickness from about 0 to 65 feet (Ref. 47, p. 6). Fluvial deposits occur beneath the uplands and valley slopes of the Gulf Coastal Plain, and consist primarily of sand, gravel, and minor clay lenses. Thickness of the fluvial deposits ranges from 0 to 100 feet and is highly variable because of erosional surfaces at the top and base of the unit (Refs. 47, p. 7; 50, p. 8).

The Jackson Formation occurs only beneath the higher hills and ridges in the northern part of the Memphis area. The Formation consists of fine sand or sandy clay, with thickness ranging from about 0 to 50 feet (Ref. 47, pp. 7, 13). The Cockfield Formation consists of interfingering fine sand, silt, clay, and local lenses of lignite. In most of the Memphis area, the formation is an erosional remnant, and the original thickness is preserved only beneath the higher hills and ridges in the northern part of the Memphis area. Thickness of the formation ranges from 0 to 250 feet (Ref. 47, pp. 7, 9). The Cook Mountain Formation consists primarily of clay, but locally contains varying amounts of sand. Thickness of the formation ranges from about 30 to 150 feet but is commonly 60 to 70 feet thick (Ref. 47, p. 9). The Jackson, Cockfield, and Cook Mountain Formations comprise the Jackson-Upper Claiborne confining unit (Refs. 47, pp. 6, 7, 9; 50, p. 9).

The Memphis Sand of the Claiborne Group underlies approximately 7,400 square miles in the Gulf Coastal Plain of western Tennessee (Ref. 62, p. 2). The Memphis Sand consists of a thick body of fine to very coarse sand with subordinate lenses of clay and silt at various stratigraphic horizons. Locally, the clay, silt, or sand contains thin lenses of lignite. Thickness of the Memphis Sand ranges from 500 to 890 feet (Ref. 50, p. 8).

##### **Regional Aquifer Description**

The principal aquifers in the Memphis area, in descending order, are: (1) alluvium and fluvial deposits that comprise the shallow aquifer, and (2) the Memphis Sand that comprises the Memphis aquifer (Ref. 47, pp. 7, 8).

The fluvial terrace deposits and the sand and gravel in the lower part of the alluvium comprise the shallow aquifer (Refs. 47, p. 7; 63, p. 389). The base of the shallow aquifer is encountered between 34 and 48 feet bgs (326 feet amsl and 267 feet amsl, respectively) in wells Sh:R-28 (MLGW #755) and Sh:R-29 (MLGW #710), about 1.8 and 1.6 miles from NF, respectively (Refs. 4; 47, p. 15; 53, p. 4). The shallow aquifer is referred to as the shallow water table aquifer, the surficial aquifer, and the shallow fluvial aquifer in regional geological

references (Refs. 47, p. 7; 51; 63, p. 389; 73, p. 16). However, the term shallow aquifer will be used throughout this HRS documentation record.

The Jackson Formation, where present, and the Cockfield and Cook Mountain Formations in the upper part of the Claiborne Group comprise the Jackson-Upper Claiborne confining unit. The unit separates the shallow aquifer and the Memphis aquifer (Refs. 47, pp. 6, 7; 50, p. 9). Thickness of clay beds in the confining unit varies from 1 to 61 meters (about 3 to 200 feet), suggesting that areas of hydrologic connectivity exist between the underlying Memphis aquifer and the overlying shallow aquifer (Ref. 63, p. 389). USGS findings indicate that locally the unit probably consists of discontinuous clay layers or lenses (Ref. 51, p. 1). It should be noted that Reference No. 63 refers to the Jackson-Upper Claiborne confining unit as the Upper Claiborne confining unit (Ref. 63, p. 389). In this HRS documentation record, the term Jackson-Upper Claiborne confining unit will be used.

The Memphis aquifer is a thick, sand-dominated aquifer—its thickness ranges from about 122 to 274 meters (400 to 898 feet) (Ref. 63, p. 389). The aquifer is a thick deposit of fine to very coarse sand with lenses of clay, silt, and lignite at various stratigraphic horizons (Ref. 49, p. 6). The Memphis aquifer provides about 95 percent of the water used for municipal and industrial water supplies in the Memphis area, and is the sole source of water for the City of Memphis (Ref. 50, p. 8).

#### Site Geology/Hydrogeology

The boring log for NF27 within Source No. 2 (elevation of 300 feet amsl) indicates that NF is underlain by brown silty clay, abundant silt, damp and slightly hard from 0 to 4 feet bgs (300 to 296 feet amsl); brown/grey silty clay, abundant silt, soft to moderately soft, moist throughout from 4 to 8 feet bgs (296 to 292 feet amsl); brown/grey silty clay, abundant silt, soft to moderately soft, and very moist to wet from 8 to 16 feet bgs, with increasing sand content with depth (292 to 284 feet amsl); brown sandy silt, moderate to abundant fine grain sand, minor rock fragments and very moist from 16 to 24 feet bgs (284 to 276 feet amsl); light brown/grey brown sandy clay, minor fine grain sand, wet, and soft from 24 to 32 feet bgs (276 to 268 feet amsl); and grey clay, moist, and slightly hard from 32 to 36 feet bgs (268 to 264 feet amsl) (end of boring) (Ref. 34, pp. 144, 145) (see Figures 1 and 3 of this HRS documentation record).

Boring logs are not available for wells within a 2-mile radius of the site. However, in 2016, EPA advanced exploratory borings near Grays Creek, about 1 mile east of Source No. 1 (Ref. 33, pp. 16, 29, 30) (see Figures 2 and 3 of this HRS documentation record). Exploratory boring EXP-03 was advanced to 237 feet amsl (elevation of 290 feet amsl and 53 feet bgs) (Ref. 33, pp. 19, 73, 74, 85 to 88). A 1-foot-thick clay lens was encountered from 246.25 to 245.25 feet amsl (43.75 to 44.75 ft bgs) (Ref. 33, pp. 19, 74). The remainder of the boring consisted of clay silt (245.25 to 244.25 feet amsl) followed by well-sorted, fine-grain sand (244.25 to 237 feet amsl) (Ref. 33, pp. 73, 74). This clay lens is consistent with USGS findings indicating that the confining unit probably consists of discontinuous clay layers or lenses (Ref. 51, p. 1).

Additionally, regional geology references include thicknesses of the Jackson-Upper Claiborne confining unit and Memphis aquifer at USGS wells within a 2-mile radius of NF, as listed in Tables 9 and 10 below. This information, along with the exploratory boring EXP-03 described above, demonstrates that the thickness of the Jackson-Upper Claiborne confining unit varies greatly, with extreme variations over short distances (Refs. 47, pp. 14, 15; 50, p. 9; 61).

According to a 1990 USGS Water-Resources Investigation Report, the base of the shallow aquifer is encountered between 326 and 259 feet amsl and the base of the Jackson-Upper Claiborne confining unit is encountered between 273 and 208 feet amsl, showing that the thickness of the Jackson-Upper Claiborne confining unit ranges from 13 to 66 feet at the well locations in the study area within a 2-mile radius of NF (Ref. 47, pp. 14, 15) (see Table 9 of this HRS documentation record). Of the wells within a 2-mile radius of NF, USGS wells Sh:R-21 and Sh:R-28 are at locations of the thinnest and thickest recorded Jackson-Upper Claiborne confining unit (13 feet and 66 feet, respectively). These wells are about 0.5 mile apart (Ref. 61). Therefore, thickness of the Jackson-Upper Claiborne confining unit varies greatly, again showing extreme variations over short distances (Refs. 47, pp. 14, 15; 50, p. 9; 61).

<b>TABLE 9: Thickness of Jackson-Upper Claiborne Confining Unit</b>					
<b>USGS Well ID</b>	<b>Elevation</b>	<b>Base of WT</b>	<b>Base of UCCU</b>	<b>Thickness</b>	<b>Reference</b>
Sh:R-28	360	34 (+326)	87 (+273)	53	47, p. 15
Sh:R-23	340	48 (+292)	114 (+226)	66	47, p. 15
Sh:R-29	315	48 (+267)	107 (+208)	59	47, p. 15
Sh:Q-7	313	40 (+273)	101 (+212)	61	47, p. 14
Sh:R-21	305	46 (+259)	59 (+246)	13	47, p. 14

Notes:

Elevation is in feet above mean sea level.

Base of WT and Base of UCCU (outside parentheses) are in feet below ground surface.

Values in parentheses are altitudes of bases of units in feet above (+) mean sea level.

Base of the WT is equivalent to the top of the UCCU.

Thickness is in feet.

ID Identification number  
UCCU Upper Claiborne confining unit  
USGS U.S. Geological Survey  
WT Water table aquifer

As presented in Table 10 below, the top of the Memphis aquifer is encountered between 252 and 204 feet amsl; the base is encountered between 449 and 492 feet below mean sea level; and thickness ranges from 696 to 712 feet (Ref. 49, pp. 17, 18).

<b>TABLE 10: Thickness of Memphis Aquifer</b>					
<b>USGS Well ID</b>	<b>Elevation</b>	<b>Top of MS</b>	<b>Base of MS</b>	<b>Thickness</b>	<b>Reference</b>
Sh:R-39	343	108 (+235)	820 (-477)	712	49, p. 18
Sh:R-33	330	78 (+252)	779 (-449)	701	49, p. 18
Sh:R-35	322	118 (+204)	814 (-492)	696	49, p. 18
Sh:Q-7	313	101 (+212)	NR	NA	49, p. 17
Sh:R-21	305	59 (+246)	766 (-461)	707	49, p. 17

Notes:

Elevation is in feet above mean sea level.

Top of MS and Base of MS (outside parentheses) are in feet below ground surface.

Values in parentheses are altitudes of tops and bases of units in feet above (+) or below (-) mean sea level.

Thickness is in feet.

ID Identification number  
MS Memphis Sand aquifer  
NA Not applicable  
NR Not recorded  
USGS U.S. Geological Survey

Groundwater flow in the shallow aquifer is towards the southeast (Refs. 28, pp. 35, 78; 34, pp. 26, 30) (see Table 8 of this HRS documentation record). Groundwater flow in the Memphis aquifer is towards the west (Ref. 47, p. 28, Plate 3).

### **Aquifer Interconnection**

Multiple lines of evidence indicate that the shallow aquifer and the Memphis aquifer are interconnected within a 2-mile radius of Source Nos. 1 and 2. The lines of evidence presented below include: (1) thin and/or absent



Jackson-Upper Claiborne confining unit, (2) historical water level trends in the shallow and Memphis aquifers, and (3) additional supporting research and documentation.

#### Thin and/or Absent Jackson-Upper Claiborne Confining Unit

In 2016, EPA advanced exploratory borings near Grays Creek, about 1 mile east of Source No. 1, to determine whether the confining unit is present, thin, or absent (Ref. 33, pp. 16, 29, 30) (see Figures 2 and 3 of this HRS documentation record). The location of these borings was chosen based on the USGS Water-Resources Investigations Report 90-4092, which indicates that the Jackson-Upper Claiborne confining unit is thin or absent in the area of Grays Creek, and may contain sand “windows” that can provide “pathways” for contaminants to reach the Memphis aquifer (Refs. 33, p. 30; 47, pp. i, 1, 36, Plate 4).

Based on data from wells within a 2-mile radius of NF, the Jackson-Upper Claiborne confining unit is expected to be encountered between 326 and 259 feet amsl (see Table 9 of this HRS documentation record). Exploratory boring EXP-03 was advanced to 237 feet amsl (elevation of 290 feet amsl and 53 feet bgs) (Ref. 33, pp. 19, 73, 74, 85 to 88). A 1-foot-thick clay lens was encountered from 246.25 to 245.25 feet amsl (43.75 to 44.75 ft bgs) (Ref. 33, pp. 19, 74). The remainder of the boring consisted of clay silt (245.25 to 244.25 feet amsl) followed by well-sorted, fine-grain sand (244.25 to 237 feet amsl) (Ref. 33, pp. 73, 74).

The 1-foot-thick clay lens documented at boring EXP-03, about 1 mile east of Source No. 1, is consistent with USGS findings indicating that the confining unit probably consists of discontinuous clay layers or lenses. The unit may be present at a single location but is likely not contiguous within a 2-mile radius of Source Nos. 1 and 2, allowing communication or connection between the shallow and Memphis aquifers (Ref. 51, p. 1).

#### Water Level Trends – Shallow Aquifer and Memphis Aquifer

The USGS National Water Information System (NWIS) database provides hydrogeologic data pertaining to observation wells maintained for Memphis Light, Gas and Water Division (MLGW) in the Shaw wellfield. According to NWIS, water levels in the shallow aquifer mimic Memphis aquifer water levels over time (Ref. 51, p. 2). Water levels in the Memphis aquifer have been continuously dropping at Shaw wellfield (located within a 2-mile radius of Source Nos. 1 and 2) since the withdrawals began in the 1990s, with a rebound starting around 2015. The shallow aquifer also follows these same trends. The recovery seen in water levels in the shallow and Memphis aquifers since 2015 may be the result of increases in rainfall; however, the correlation in long-term water level trends in the two units illustrates that the shallow and Memphis aquifers are interconnected locally (Ref. 51, p. 2).

#### Additional Supporting Research and Documentation

In 2013, a research article was published titled, “*Efficacy of Fuzzy c-Means Cluster Analysis of Naturally Occurring Radioisotope Datasets for Improved Groundwater Resource Management under the Continued Risk of Climate Change.*” The study was conducted in the area of three MLGW wellfields—Shaw, Sheahan, and Morton (Ref. 64, pp. 464, 465). One of the three wells evaluated within the Shaw wellfield (USGS Sh:R-046, MLGW #704) is within a 2-mile radius of Source Nos. 1 and 2 (Refs. 5; 53, p. 4; 61; 64, pp. 471, 472). Samples from the wells were analyzed for uranium and thorium decay series isotopes (10 parameters for each well). The study found that well USGS Sh:R-046 (MLGW #704) was within a localized window in the confining unit that locally serves as an area of recharge to the Memphis aquifer (Refs. 51, p. 2; 61; 64, pp. 464, 470 to 476).

In 2016, a research article was published titled, “*Application of Environmental Tracers in the Memphis Aquifer and Implication for Sustainability of Groundwater Resources in the Memphis Metropolitan Area, Tennessee.*” The study was conducted in the area of 10 MLGW Wellfields. One of the two wells evaluated within the Shaw wellfield (USGS Sh:R-046, MLGW #704) is within a 2-mile radius of Source Nos. 1 and 2 (Refs. 53, p. 4; 61; 88, pp. 79, 88). Environmental tracers were sampled in production wells to evaluate the presence of modern water in the semi-confined Memphis aquifer (Ref. 88, p. 99). The modeling results show that well USGS Sh:R-046, MLGW #704 is affected by modern leakage with mixing proportions between 4 and 7 percent modern

water (Ref. 88, pp. 94, 98). The study found that vertical leakage of modern water from the shallow aquifer occurs at windows in the Jackson-Upper Claiborne confining unit near streams (Ref. 88, pp. 82, 83, 94, 95, 97). Due to the existence of fast recharge pathways and a prominent downward vertical gradient between the shallow and Memphis aquifers, the Memphis aquifer is susceptible to contamination (Ref. 88, p. 97).

Both studies discussed above show that well USGS Sh:R-046, MLGW #704, is located within a localized window in the Jackson-Upper Claiborne confining unit and that the well is affected by modern leakage with mixing proportions between 4 and 7 percent modern water (Refs. 51, p. 2; 61; 64, pp. 470 to 476; 88, pp. 82, 83, 94, 95, 97).

Based on the information discussed above, sufficient lines of evidence indicate the discontinuity of the Jackson-Upper Claiborne confining unit and interconnection of the shallow and Memphis aquifers in the area of the Shaw wellfield and Grays Creek, located within a 2-mile radius of Source Nos. 1 and 2 (Ref. 51, p. 2).

### Aquifer Discontinuity

The shallow aquifer is not continuous within a 4-mile radius of Source Nos. 1 and 2. The Memphis aquifer is continuous within a 4-mile radius of Source Nos. 1 and 2. No surface water bodies or geologic units incise the hydrologic to form a discontinuity (Refs. 1, Section 3.0.1.2.2; 3; 47, pp. 7, 9, Plates 2 and 3; 49, pp. 3, 6).

## SUMMARY OF AQUIFERS UNDER EVALUATION

<b>TABLE 11: Summary of Aquifers Being Evaluated</b>				
<b>Aquifer Name</b>	<b>Is Aquifer Interconnected with Upper Aquifer within 2 Miles? (Yes/No/NA) (Documented Above)</b>	<b>Is Aquifer Continuous within 4-mile TDL? (Yes/No)</b>	<b>Is Aquifer Karst? (Yes/No)</b>	<b>References</b>
Shallow	NA	No	No	4; 47, p. 7, Plate 2
Memphis	Yes	Yes	No	4; 47, pp. 9, Plate 3; 49, pp. 3, 6; 64; 88

Notes:

NA      Not applicable  
TDL     Target distance limit

### **3.1 LIKELIHOOD OF RELEASE**

#### **3.1.1 OBSERVED RELEASE**

Aquifers Being Evaluated: Interconnected shallow and Memphis aquifers

##### Chemical Analysis

An observed release by chemical analysis is established by demonstrating that concentrations of a hazardous substance in release samples are significantly higher than the background level, and by documenting that at least part of that significant difference in concentration is attributable to the site under evaluation. The significant difference can be documented in one of two ways for HRS purposes. If the background concentration of the hazardous substance is undetected, an observed release is established when measured concentration in the sample equals or exceeds the appropriate quantitation limit. If concentration of the hazardous substance in the background sample equals or exceeds the detection limit, an observed release is established when concentration of that substance in the sample is found at three times or more the background concentration and above the appropriate quantitation limit (Ref. 1, Section 2.3, Table 2-3).

Observed releases of 1,1-DCA; 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE; PCE; TCE; vinyl chloride; and mercury to groundwater are documented in the following sections by comparing concentrations of these hazardous substances in samples from monitoring wells to concentrations of these substances in background samples of groundwater collected in similar settings (see Tables 13 and 15 of this HRS documentation record). Samples documenting an observed release were collected during the 2016 and 2018 ESIs (Refs. 33; 34). Samples were collected from the monitoring wells listed in Tables 12 and 14 of this HRS documentation record.

## July 2016 ESI – Source No. 1 Groundwater Investigation

### Monitoring Wells

Tetra Tech, on behalf of EPA, installed the permanent monitoring wells listed in Table 12 in the shallow aquifer in 2004 (NFGW13a), 2009 (NFGW01, NFGW02, NFGW03, NFGW04), and 2016 (NFGW05, previously named NFGW08). These monitoring wells were constructed in the same manner, with similar screened intervals (Refs. 29, pp. 8, 121, 129 to 132; 32, pp. 92 to 95; 33, pp. 8, 34, 50, 51, 52, 65, 68, 69, 78, 79, 80). The sample collected from monitoring well NF-01 (NFGW01) was selected to represent background levels for observed release samples because it is upgradient and outside the influence of Source No. 1. The background monitoring well sample (NF-GW-01) and the release monitoring well samples were collected from the same aquifer within similar depth intervals. Monitoring well construction logs are in References 29, 32, and 33. Monitoring wells listed in Table 12 were sampled in 2016. Monitoring well samples were collected in accordance with the same sampling procedures and during the same sampling event (Refs. 33, pp. 7, 8, 12, 34, 51, 52, 61 to 66; 42, p. 3; 46). See Figure 4 of this HRS documentation record for monitoring well locations.

TABLE 12: July 2016 ESI Monitoring Wells – Shallow Aquifer						
Well ID/ Station ID	Well Depth*		Screened Interval		Location	References
	(ft bgs)	(ft amsl)	(ft bgs)	(ft amsl)		
Background Well						
NF-01/ NFGW01	33	294.07	13 to 33	314.07 to 294.07	About 0.38 mile southwest of NFGW13a	Figure 4; 32, pp. 75, 92; 33, pp. 29, 34, 51, 61, 1127; 79
Release Wells						
NF-02/ NFGW02	36.3	291.38	16.3 to 36.3	311.38 to 291.38	About 0.41 mile southwest of NFGW13a	Figure 4; 32, p. 71, 93; 33, pp. 29, 34, 51, 62, 1127; 79
NF-03/ NFGW03	33	292.05	13 to 33	312.05 to 292.05	About 0.39 mile southwest of NFGW13a	Figure 4; 32, p. 73, 94; 33, pp. 29, 34, 51, 63, 1127; 79
NF-04/ NFGW04	36.5	287.21	16.5 to 36.5	307.21 to 287.21	About 0.39 mile southwest of NFGW13a	Figure 4; 32, pp. 66, 95, 96; 33, pp. 29, 34, 51, 64, 1127; 79
NFGW05	40.91	287.23	20.9 to 40.9	307.24 to 287.24	About 0.43 mile southwest of NFGW13a	Figure 4; 33, pp. 8, 29, 34, 51, 52, 65, 68, 69, 1127; 79
NF-GW-13A/ NFGW13a	35	278.05	15 to 35	298.05 to 278.05	Northeast corner of Cordova Park Road and Rebel Road	Figure 4; 29, p. 121; 33, pp. 29, 34, 51, 66, 1127; 79

Notes:

\* Well depth measurements in feet bgs cited are from the date of installation as recorded on the boring logs (Ref. 29, p. 121; 32, pp. 66, 71, 73, 75, 92 to 95; 33, pp. 51, 52, 68, 69). Well depth measurements in ft amsl cited were derived from subtracting the installation depth in feet bgs from the TOC elevations provided in the well survey dated January 4, 2017 (Refs. 29, p. 121; 32, pp. 92 to 95; 33, pp. 52, 68, 69, 1127).

amsl     Above mean sea level  
bgs       Below ground surface  
ft         Feet  
GW       Groundwater  
ID        Identification number  
NF        National Fireworks, Inc.



## Groundwater Samples

Groundwater samples listed in Table 13 were collected from permanent monitoring wells during the July 2016 ESI sampling event that Tetra Tech conducted on behalf of EPA (Ref. 33, pp. 7, 29, 34) (see Figure 4 of this HRS documentation record). ESI field activities accorded with the QAPP dated June 10, 2016 (Refs. 33, p. 7; 38). Monitoring well samples were collected in accordance with the EPA SEDS FBQSTP for Groundwater Sampling (Refs. 33, p. 7; 38, p. 9; 46). Under the EPA CLP, ALS analyzed the samples for mercury via EPA Method ISM02.3, and Chemtech analyzed the samples for VOCs via EPA Method SOM02.3 (Ref. 33, pp. 112, 146). EPA SEDS reviewed all mercury and VOC data in accordance with EPA Methods ISM02.3 and SOM02.3 (Ref. 33, pp. 112, 146). MRLs for mercury and VOCs are on the analytical data sheets in Appendix E of Reference 33. The MRLs are equivalent to SQLs as defined in the HRS Rule (Refs. 1, Section 1.1; 41). Table 13 compares results from the contaminated samples to those from the background sample collected from the shallow aquifer.

Chain-of-custody forms are in Reference 42. Locations of the background and contaminated samples are depicted on page 29 of Reference 33 and on Figure 4 of this HRS documentation record.

TABLE 13: Analytical Results for Monitoring Well Samples - July 2016						
Station ID	Sample ID	Date Sampled	Hazardous Substance	Concentration (µg/L)	MRL (µg/L)	References
Background Sample						
NFGW01	NF-GW-01	7/13/2016	PCE	0.50U	0.50	33, pp. 51, 61, 138, 197; 42, pp. 3, 5
			TCE	0.50U	0.50	
			Vinyl chloride	0.50U	0.50	
			Mercury	0.20U	0.20	
Contaminated Samples						
NFGW02	NF-GW-02	7/13/2016	PCE	0.82	0.50	33, pp. 51, 62, 199; 42, p. 3
NFGW03	NF-GW-03	7/13/2016	Mercury	0.55	0.20	33, pp. 51, 63, 140, 201; 42, pp. 3, 5
	NF-GW-03-DUP	7/13/2016	Mercury	0.51	0.20	33, pp. 51, 63, 141, 203; 42, pp. 3, 5
NFGW04	NF-GW-04	7/13/2016	PCE	42	2.0	33, pp. 51, 64, 205; 42, p. 3
			TCE	1.8	0.50	
NFGW05	NF-GW-05	7/15/2016	PCE	6.7	0.50	33, pp. 52, 65, 207; 42, p. 3
NFGW13a	NF-GW-13a	7/14/2016	TCE	0.61	0.50	33, pp. 52, 66, 209; 42, p. 3
			Vinyl chloride	0.85	0.50	

### Notes:

DUP Duplicate  
 GW Groundwater  
 ID Identification  
 µg/L Micrograms per liter  
 NF National Fireworks  
 PCE Tetrachloroethene  
 TCE Trichloroethene  
 U The analyte was not detected at concentration at or above the reporting limit (Ref. 33, pp. 115, 149).

Groundwater samples collected from monitoring wells during previous events contained contaminants at similar concentrations to the above wells. PCE, TCE, vinyl chloride, and mercury were not detected in background monitoring wells in 2001, 2004, and 2009 (Refs. 28, pp. 5, 26, 307, 690; 29, pp. 8, 184, 266; 32, pp. 30, 239, 371). Groundwater samples collected from monitoring wells in 2004 and 2009 in and near Source No. 1 contained elevated concentrations of PCE, TCE, and mercury (Refs. 29, pp. 8, 15, 50, 53; 32, pp. 23, 30, 57).

## June 2018 ESI – Source No. 2 Groundwater Investigation

### Monitoring Wells

Tetra Tech, on behalf of EPA, installed the temporary monitoring wells listed in Table 14 in the shallow aquifer in 2018. These monitoring wells were constructed in the same manner, with similar screened intervals (Refs. 34, pp. 12, 13, 34, 42, 43, 47, 48, 51, 54, 58, 64, 73, 77, 80, 83, 92, 96, 99, 111). The samples collected from monitoring wells NF32 and NF36 were selected to represent background levels for observed release samples because these wells are upgradient and outside the influence of the contaminated monitoring wells. The background monitoring well samples and the release monitoring well samples were collected from the same aquifer at similar depth intervals. Monitoring well construction logs are in Reference 34. Monitoring wells listed in Table 14 were sampled in 2018. Monitoring well samples were collected in accordance with the same sampling procedures and during the same sampling event (Refs. 34, pp. 12, 13, 29, 30; 46). Elevations were calculated based on an average ground elevation of 310 feet amsl in the north-central portion of the former NF facility (Refs. 3; 34, p. 26) (see Figures 1 and 4 of this HRS documentation record). Figure 4 of this documentation record depicts the monitoring well locations.

TABLE 14: June 2018 ESI Monitoring Wells – Shallow Aquifer						
Station ID	Well Depth *		Screened Interval		Location**	References
	(ft bgs)	(ft amsl)	(ft bgs)	(ft amsl)		
Background Wells						
NF32	10.05	299.95	5 to 10	305 to 299.95	About 0.21 mile north of NFGW13a	Figure 4; 3; 34, pp. 34, 99
NF36	25.09	284.91	20 to 25	290 to 285	About 0.26 mile northwest of NFGW13a	Figure 4; 3; 34, pp. 34, 111
Release Wells						
NF17	24	286	19 to 24	291 to 286	About 0.30 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 51
NF18	16.2	293.8	11 to 16	299 to 294	About 0.24 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 54
NF19	22.92	287.08	17.92 to 22.92	292.08 to 287.08	About 0.19 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 58
NF21	23.1	286.9	18.1 to 23.1	291.9 to 286.9	About 0.22 mile north of NFGW13a	Figure 4; 3; 34, pp. 34, 64
NF24	25	285	20 to 25	290 to 285	About 0.23 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 73
NF25	20	290	10 to 20	300 to 290	About 0.15 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 77
NF26	20.05	289.95	15.05 to 20.05	294.95 to 289.95	About 0.18 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 80
NF27	27.5	282.5	22.5 to 27.5	287.5 to 282.5	About 0.32 mile northeast of NFGW13a	Figure 4; 3; 34, pp. 34, 83
NF30	20.8	289.2	16 to 21	294 to 289	About 0.24 mile north of NFGW13a	Figure 4; 3; 34, pp. 34, 92
NF31	20.05	289.95	10 to 20	300 to 290	About 0.14 mile north of NFGW13a	Figure 4; 3; 34, pp. 34, 96

Notes:

\* Well depth measurements are provided in feet bgs and feet amsl are provided based on an average elevation of 310 ft amsl in the vicinity of Source No. 2 (see Figure 1 and 4 of this HRS documentation record).

\*\* Because observed release well NFGW13a is located approximately mid-way between Source Nos. 1 and 2 and is used to identify the site coordinates, it was also used in Table 14 as the reference point from which the distance to the other observed release wells were measured (Refs. 3; 5; 33, p. 1127) (see Table 13 of this HRS documentation record).

amsl Above mean sea level

bgs Below ground surface

ft Feet

ID Identification number

NF National Fireworks, Inc.

## Groundwater Samples

Groundwater samples listed in Table 15 were collected from temporary monitoring wells during the June 2018 ESI sampling event that Tetra Tech conducted on behalf of EPA (Ref. 34, pp. 8, 26, 29, 30) (see Figure 4 of this HRS documentation record). ESI field activities accorded with the QAPP dated May 16, 2018 (Refs. 34, p. 8; 39). Monitoring well samples were collected in accordance with the EPA SESD FBQSTP for Groundwater Sampling (Refs. 34, p. 8; 39, p. 9; 67). The EPA Region 4 Laboratory analyzed the samples for mercury via EPA Method 245.1, and Chemtech, under the CLP, analyzed the samples for VOCs via EPA Method SOM02.4 (Ref. 34, pp. 182, 333). EPA SESD reviewed all mercury and VOC data in accordance with EPA Methods 245.1 and SOM02.4 (Ref. 34, pp. 182, 333). MRLs for mercury and VOCs are on the analytical data sheets in Appendix E of Reference 34. The MRLs are equivalent to SQLs as defined in the HRS Rule (Refs. 1, Section 1.1; 41). Table 15 compares results from the contaminated samples to those from the background samples collected from the shallow aquifer.

Chain-of-custody forms are in Reference 43. Locations of the background and contaminated samples are depicted on page 26 of Reference 34 and on Figure 4 of this HRS documentation record.

TABLE 15: Analytical Results for Monitoring Well Samples - June 2018						
Station ID	Sample ID	Date Sampled	Hazardous Substance	Concentration (µg/L)	MRL (µg/L)	References
Background Samples						
NF32	NF32-GW-01	6/21/2018	1,1-DCA	0.50U	0.50	34, pp. 48, 295, 296, 421; 43, p. 8
			1,1-DCE	0.50U	0.50	
			cis-1,2-DCE	0.50U	0.50	
			PCE	0.50U	0.50	
			trans-1,2-DCE	0.50U	0.50	
			TCE	0.50U	0.50	
			Vinyl chloride	0.50U	0.50	
			Mercury	0.10U	0.10	
NF36	NF36-GW-01	6/21/2018	1,1-DCA	0.50U	0.50	34, pp. 48, 321, 322, 441; 43, p. 8
			PCE	0.50U	0.50	
			TCE	0.50U	0.50	
			Mercury	0.10U	0.10	
Contaminated Samples						
NF17	NF17-GW-01	6/20/2018	1,1-DCA	1.8	0.50	34, pp. 42, 199, 200; 43, p. 7; 44, p. 2; 45, pp. 8, 11
			1,1-DCE	14J (5.95) <sup>a</sup>	0.50	
			PCE	2.6	0.50	
			TCE	1,200	50	
			Vinyl chloride	2.7	0.50	
	NF17-GW-01-DUP	6/20/2018	1,1-DCA	1.9	0.50	34, pp. 42, 201, 202, 342; 43, p. 9; 44, p. 2; 45, pp. 8, 11
			1,1-DCE	14J (5.95) <sup>a</sup>	0.50	
			PCE	2.7	0.50	
			TCE	1,200	50	
			Vinyl chloride	2.8	0.50	
NF18	NF18-GW-01	6/21/2018	TCE	420	13	34, p. 48, 210; 43, p. 7
NF19	NF19-GW-01	6/20/2018	cis-1,2-DCE	37	13	34, pp. 42, 43, 216, 354; 43, p. 7
			TCE	470	20	
NF21	NF21-GW-01	6/20/2018	cis-1,2-DCE	68	20	34, pp. 42, 230, 366; 43, p. 7; 44, p. 2; 45, pp. 8, 18
			TCE	2,900	200	
			Mercury	0.81J (0.54) <sup>b</sup>	0.10	

TABLE 15: Analytical Results for Monitoring Well Samples - June 2018						
Station ID	Sample ID	Date Sampled	Hazardous Substance	Concentration (µg/L)	MRL (µg/L)	References
NF24	NF24-GW-01	6/20/2018	cis-1,2-DCE	11	0.50	34, pp. 48, 248, 381; 43, p. 7; 44, p. 3; 45, pp. 8, 18
			PCE	0.66	0.50	
			TCE	110	5.0	
			Vinyl chloride	1.0	0.50	
			Mercury	0.17J (0.11) <sup>b</sup>	0.10	
NF25	NF25-GW-01	6/19/2018	cis-1,2-DCE	48	4.0	34, pp. 47, 254, 386; 43, p. 7
			trans-1,2-DCE	0.54	0.50	
			TCE	12	0.50	
			Vinyl chloride	3.1	0.50	
			Mercury	0.52	0.10	
NF26	NF26-GW-01	6/20/2018	1,1-DCA	1,100	1,000	34, pp. 43, 259, 260; 43, p. 7
			1,1-DCE	1,500	1,000	
			cis-1,2-DCE	2,800	1,000	
			PCE	150	20	
			TCE	28,000	1,000	
			Vinyl chloride	150	20	
NF27	NF27-GW-01	6/21/2018	1,1-DCA	1.5	0.50	34, pp. 43, 265, 266; 43, p. 8; 44, p. 3; 45, pp. 8, 11, 12
			1,1-DCE	24J (10.31) <sup>a</sup>	0.50	
			cis-1,2-DCE	3,800	500	
			PCE	18	0.50	
			trans-1,2-DCE	780	500	
			TCE	27,000	2,500	
			Vinyl chloride	100J (10) <sup>b</sup>	0.50	
NF30	NF30-GW-01	6/20/2018	Mercury	0.47J (0.31) <sup>b</sup>	0.10	34, p. 48, 411; 43, p. 8; 44, p. 3; 45, pp. 8, 18
NF31	NF31-GW-01	6/21/2018	cis-1,2-DCE	510	20	34, p. 48, 290; 43, p. 8
			TCE	1,800	100	
			Vinyl chloride	80	20	

Notes:

( ) Concentration was adjusted in accordance with References 44 and 45.

<sup>a</sup> Sample result should be considered estimated with a potential high bias because the surrogate recovery was higher than established control limits (Refs. 34, pp. 187, 199, 201, 265; 44). The value presented parenthetically is the concentration obtained by applying EPA fact sheet *Using Qualified Data to Document and Observed Release and Observed Contamination* (November 1996) (Ref. 45, pp. 8, 11).

<sup>b</sup> Sample result should be considered estimated with an unknown bias (calibration check standard less than method control limits or concentration reported is greater than the highest standard on the calibration curve) (Refs. 34, pp. 187, 266, 337, 366, 381, 411; 44). The value presented parenthetically is the concentration obtained by applying EPA fact sheet *Using Qualified Data to Document and Observed Release and Observed Contamination* (November 1996) (Ref. 45, pp. 8, 12, 18).

DCA Dichloroethane

DCE Dichloroethene

DUP Duplicate

GW Groundwater

ID Identification

J The identification of the analyte is acceptable; the reported value is an estimate (Ref. 34, pp. 187, 337)

µg/L Micrograms per liter

NF National Fireworks, Inc.

PCE Tetrachloroethene

TCE Trichloroethene

U The analyte was not detected at concentration at or above the reporting limit at the left (Ref. 34, p. 187, 337).



## Attribution

The hazardous substances detected in the groundwater samples are attributed to operations at the former NF facility, as documented in the subsections below and summarized as follows:

- Although documentation of historical operations at the former NF facility has not been identified, explosives, which are unique to munitions manufacturing, have been detected in soil collected from Source No. 1 (the burn pit)—indicating that materials used at the former NF facility were not contained and were released to the environment (see Table 3 of this HRS documentation record).
- Disposal of wastes occurred at Source No. 1 (the burn pit) during its operation (Refs. 9, p. 12; 10, pp. 6; 70, p. 2).
- Mercury was detected in both source soil and groundwater samples—likely from use of mercury fulminate in blasting caps that decomposes to form mercury, carbon monoxide, and nitrogen (Refs. 37, p. 1; 80, p. 17) (see Tables 3, 6, 13, and 15 of this HRS documentation record).
- The same hazardous substances detected in source soil samples were detected in groundwater samples collected hydrologically downgradient of the sources (see Tables 3, 6, 13, and 15 of this HRS documentation record).
- PCE, TCE, and/or associated breakdown products were detected in one or both sources based on either current or historical samples and current groundwater samples. PCE and TCE are known to have been used for degreasing at WWII munitions manufacturing facilities. Additionally, PCE was used to produce hexachloroethane (HC), HC was used in smoke producing devices such as smoke pots during WWII, and smoke pots were manufactured at the former NF facility. Further evidence indicates that PCE is a known byproduct of smoke pot smoke (Refs. 32, pp. 23, 158, 184, 188, 208; 52, p. 24; 70, p. 4; 81, pp. 2 to 6; 92, pp. 200, 201, 202; 93, p. 9, 11) (see Tables 1, 3, 6, 13, and 15 of this HRS documentation record).
- With the exception of the SSI facility, which is not hydrologically upgradient of Source No 1, Source No. 2 and the documented groundwater observed releases at the NF site, no other sources of chlorinated VOCs and mercury have been identified within 1 mile of the former NF facility (Refs. 28, pp. 35, 78; 34, pp. 26, 30; 65, pp. 3 to 60; 66, pp. 3 to 122) (see Figures 3 and 4 of this HRS documentation record).
- A groundwater plume underlying the SSI facility has been documented as being a separate plume from the groundwater plume associated with the NF site, which is upgradient of the SSI facility (Refs. 8, pp. 72, 74, 75, 76, 82, 83, 112, 113, 223, 344; 28, pp. 35, 78; 34, pp. 26, 30) (see Figures 3 and 4 of this HRS documentation record and the discussion below regarding other possible sites in the area).
- The chlorinated VOCs detected in groundwater and soil samples are not naturally occurring (Refs. 60, p. 9; 68, p. 9; 77, p. 2).
- Mercury is not ubiquitous in the Cordova, Tennessee area, as documented in Tables 3 and 6 of this HRS documentation record and was not detected in background samples.

## Materials Used in Manufacturing and Released to Soil and Groundwater

NF was a munitions manufacturer in Cordova, Tennessee. From 1942 to 1945, NF manufactured various munitions for the Departments of the Army and Navy, although records regarding NF operations during the World War II era are not available (Refs. 3; 8, p. 20; 9, pp. 1, 3; 80, pp. 3, 4, 47 – the date of 1942 is taken from Reference 80) (see Figure 1 of this HRS documentation record). The munitions NF manufactured included flares, grenades, smoke pots, 20-mm and 40-mm rounds, and incendiary bombs (Refs. 9, p. 3; 10, pp. 5, 6, 7; 70, pp. 1, 4; 80, p. 47). Chemicals possibly handled in ordnance production areas such as Source No. 2 and disposal areas such as Source No. 1 at the former NF facility included PCE, TCE, TNT, RDX, tetryl, ammonium nitrate, mercury fulminate, and white phosphorus (Refs. 9, pp. 8, 9; 10, pp. 6, 8; 70, p. 4; 81, pp. 2 to 6; 92, pp. 200, 201, 202). Some of the same substances (and related breakdown products), including cadmium, mercury, lead, TCE, cis-1,2-DCE, 1,1-DCA, trans-1,2-DCE, vinyl chloride, and 2,4-DNT, were documented in soil within Source Nos. 1 and 2 (Ref. 52, p. 24) (see Tables 3 and 6 of this HRS documentation record). Source No. 1 is contaminated soil in an area where munitions and waste were burned, and Source No. 2 is contaminated soil that resulted from migration, deposition, or spillage of hazardous substances associated with handling, storage, maintenance, and operations at the former munitions manufacturing area (including degreasing of metal and fuses) (Refs. 9, pp. 6, 8; 10, pp. 3, 6; 12, p. 5; 13, p. 5; 15, p. 9; 78, p. 1). TCE was used as a metal degreasing solvent at the former NF facility (Refs. 36, pp. 27, 28; 59; 70, p. 4; 81, p. 2). The same hazardous substances in the source soil samples were detected in groundwater samples hydrologically downgradient of sources—including 1,1-DCA, cis-1,2-DCE, trans-1,2-DCE, TCE, vinyl chloride, and mercury at concentrations exceeding background, indicating the sources released these substances to groundwater (see Tables 3, 6, 13, and 15 of this HRS documentation record). (PCE breaks down into TCE, 1,1-DCE, cis-1,2-DCE, trans-1,2-DCE, and vinyl chloride [Ref. 52, p. 24].) Although PCE was not detected in source soil samples collected at the former NF facility in 2016 and 2018 at concentrations meeting observed release criteria, PCE was detected in source soil samples collected in 2001 and 2009 (Refs. 28, pp. 5, 63; 32, pp. 16, 33, 36, 38, 43, 46, 54). PCE evaporates quickly in soil or may filter through the soil and into the groundwater below (Ref. 58). This may be the reason PCE was not detected in the more recent soil samples.

Typically, TCE was used as a solvent to remove grease and prepare metals for use (Refs. 36, pp. 27, 28; 59; 81, pp. 2 to 6). During WWII, weapons manufacturers used TCE primarily in vapor degreasers that were usually part of manufacturing lines producing ammunition. Carbon tetrachloride, TCE, and PCE were three of the most widely used cleaning and degreasing solvents in the United States during WWII (Ref. 81, pp. 2 to 6). The NAICS codes associated with the solvent industry include Small Arms Ammunition Manufacturing (332992), Ammunition (except Small Arms) Manufacturing (332993), and Other Ordnance and Accessories Manufacturing (332995) (Refs. 35, pp. 48, 50; 36, p. 7). Use of TCE at the former NF facility is known—commonly to remove grease and generally prepare metals for use after materials were unloaded in the warehouse area (Ref. 78, pp. 1, 3, 4, 5). Presence of TCE in source soils and groundwater at concentrations exceeding background levels indicates a release of chlorinated VOCs has occurred from the sources to the shallow aquifer underlying the NF site.

## Historical Sampling

As documented in Table 1 of this HRS documentation record, the same hazardous substances have been detected consistently in soil and groundwater samples collected at the former NF facility, as have other substances unique to the manufacture of munitions, including 1,3-dinitrobenzene, 2,4,6-TNT; 2,4-DNT; 2-amino-4,6-DNT; 4-amino-2,6-DNT; and RDX (Refs. 11, pp. 1, 3, 4; 28, p. 80; 82, p. 1; 83, p. 1; 84, pp. 1, 2). Presence of these explosives in environmental samples collected at the former NF facility indicates that materials used in the NF munitions manufacturing process were not contained and were released to the environment.

## Source and Groundwater Samples Contained the Same Substances

Soil samples collected within Source Nos. 1 and 2 contain PCE breakdown products TCE; 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE; and vinyl chloride; as well as 1,1-DCA and mercury (see Tables 3 and 6 of this HRS documentation record).

Mercury and PCE historically have been documented at Source No. 1, contaminated soil in the southwestern portion (former burn pit area) of the former NF facility (see Tables 1 and 3 and Section 2.2 of this HRS documentation record). In 2009, soil samples were collected within and surrounding the former burn pit area (Ref. 32, pp. 23, 28, 29). Soil samples contained elevated concentrations of mercury (up to 0.73 mg/kg) and PCE (up to 12 µg/kg) (Ref. 32, pp. 16, 33, 36, 38, 43, 46, 54). Soil samples collected at Source No. 1 during the July 2016 ESI contained elevated concentrations of mercury (up to 0.15 mg/kg) (see Table 2 of this HRS documentation record). Mercury, PCE, TCE, and vinyl chloride were detected in groundwater samples collected hydraulically downgradient of Source No. 1 (see Table 13 of this HRS documentation record).

Moreover, though not presented as part of this HRS scoring, these same groundwater samples collected downgradient of Source No. 1 contained elevated concentrations of perchlorate and dioxins and furans, indicating Source No. 1 as the likely source of these constituents as well (Ref. 33, pp. 31, 42).

Mercury and vinyl chloride (a PCE breakdown product) have been documented in Source No. 2, contaminated soil in the north-central portion of the former NF facility (Ref. 52, p. 24) (see Figure 5 and Table 6 of this HRS documentation record). These same hazardous substances were detected in groundwater samples collected hydraulically downgradient of Source No. 2 (see Figure 4 and Table 15 of this HRS documentation record).

PCE, its breakdown products, and mercury have been detected at concentrations significantly above background levels in groundwater in the vicinity of Source Nos. 1 and 2 (Ref. 52, p. 24) (see Section 3.1.1, Observed Release, of this HRS documentation record). Analytical results from monitoring wells in the vicinity of Source Nos. 1 and 2 indicate that a release has occurred or is occurring at the former NF facility (see Section 3.1.1 of this HRS documentation record). Groundwater samples collected from monitoring wells contained concentrations of 1,1-DCA (up to 1,100 µg/L); 1,1-DCE (up to 1,500 µg/L); cis-1,2-DCE (up to 3,800 µg/L); trans-1,2-DCE (up to 780 µg/L); PCE (up to 150 µg/L); TCE (up to 28,000 µg/L); vinyl chloride (up to 150 µg/L); and mercury (up to 0.55 µg/L) (see Tables 13 and 15 of this HRS documentation record). PCE and its breakdown products are not naturally occurring, and based on its absence in background samples, it is not ubiquitous in the area (Refs. 52, p. 24; 58; 59; 60, p. 9; 68, p. 9; 77, p. 2) (see Tables 13 and 15 of this HRS documentation record).

## Other Possible Non-Site Sources

### SSI

SSI housed screw machine parts buildings, including a pack-out building (Building SSI-13B), former degreaser building (Building SSI-13A), machine shop (Building SSI-10A), warehouse (Building SSI-10B), cafeteria/brazing building (Building SSI-9), and fuel storage/boiler (Building SSI-14) (Ref. 8, pp. 16, 17). World War II-vintage buildings associated with ammunition and pyrotechnic productions, including those in warehouse, mixing, and assembly areas, were demolished. A PCB-transformer station in the northern portion of SSI also has been removed. The southern portion of SSI is an undeveloped, approximately 3.75-acre field formerly used for loading powder magazines, small-scale waste burning, vehicle parking, and product testing (Ref. 8, p. 17).

Between 2008 and 2013, a remedial investigation (RI) was conducted at SSI. Phase I was completed in 2008, Phase II was completed in 2009, Phase III was completed in 2011, and supplemental sampling occurred in 2012 and 2013 (Ref. 8, pp. 24, 26, 27). The RI identified two TCE groundwater plumes (A and B) along the western boundary of the SSI property (Ref. 8, pp. 82, 83). During the 2018 ESI,

chlorinated VOCs were detected at elevated concentrations in SSI monitoring wells MW-7 and SS-GW-01 (Ref. 34, pp. 16, 17, 26, 29, 36).

SSI is east and hydrologically downgradient of Source No. 2 as supported by the discussion below, and SSI is underlain by a chlorinated VOC groundwater plume. TCE and PCE are the two primary contaminants at SSI, with daughter products 1,1-DCE, cis-1,2-DCE, trans-1,1-DCE, and vinyl chloride (Refs. 8, p. 112; 52, p. 24). Based on data acquired at SSI, PCE contamination appears to move to the east and south-southeast away from Source No. 2. Results from groundwater samples collected in the area of SSI confirmed the direction of PCE plume movement to the east (Refs. 8, p. 112; 34, p. 26).

Groundwater data from the western/northwestern portion of SSI indicated elevated levels of TCE, with little to no PCE detected. Because soil sampling within this area did not indicate residual soil source mass, and groundwater flows to the southeast across the property line into SSI, the contamination appears to be originating from an upgradient source, probably Source No. 2. Lack of PCE presence in groundwater within this area of SSI, with PCE the contaminant of concern associated with the SSI degreaser, also supports the assertion of an upgradient source of the TCE contamination (Ref. 8, pp. 72, 74, 75, 76, 112, 113, 344).

Movement of the TCE contamination/groundwater from west/northwest (upgradient) to southeast (downgradient) appears to be influenced by the structural high observed in the top of the Jackson Clay in the western/central portion of the former NF facility. Groundwater flows around this structural high and then continues on a southeasterly flow direction across the former NF facility until reaching the point at which the TCE contamination/plume begins to co-mingle with the PCE contamination/plume associated with the former SSI degreaser source area (Ref. 8, pp. 72, 74, 75, 76, 112, 113, 344).

#### Other Facilities at and within 1 Mile of the Former NF Facility

Nine EPA-regulated facilities are within 1 mile of the former NF facility, and eight EPA-regulated facilities are within the former the NF facility property boundaries (Refs. 65, pp. 1, 3; 66, pp. 1, 3). None of these facilities are known or reported to use, produce, or release solvents or mercury based on evidence available at this time (Refs. 65, pp. 3 to 60; 66, pp. 3 to 122). Most businesses operating at the industrial park are landscapers, distributors, office spaces, sales, storage, repair, and production facilities (Ref. 89). Within the area of Source No. 2, buildings formerly used by NF are still present. Currently, commercial buildings formerly used by NF at Source No. 2 house a pool and landscape company and granite and marble company. A masonry is adjacent to Source No. 2 (Ref. 89) (see Figure 3 and 5 of this HRS documentation record).

#### Hazardous Substances in the Release

1,1-DCA  
1,1-DCE  
cis-1,2-DCE  
trans-1,2-DCE  
PCE  
TCE  
Vinyl chloride  
Mercury

Groundwater Observed Release Factor Value: 550

### **3.1.2 POTENTIAL TO RELEASE**

Potential to release was not evaluated because an observed release to the interconnected shallow and Memphis aquifers has been documented (Ref. 1, Section 3.1.1).



## 3.2 WASTE CHARACTERISTICS

### 3.2.1 TOXICITY/MOBILITY

Table 16 summarizes toxicity and mobility factor values for the hazardous substances detected in source and observed release samples with containment factor values exceeding 0. The combined toxicity and mobility factor values are assigned in accordance with Reference 1, Section 3.2.1. Hazardous substances detected in the observed release to groundwater are assigned a mobility factor value of 1 (Ref. 1, Section 3.2.1.2).

TABLE 16: Groundwater Toxicity/Mobility						
Hazardous Substance	Source No./OR	Toxicity Factor Value	Mobility Factor Value <sup>b</sup>	Does Hazardous Substance Meet Observed Release? (Yes/No)	Toxicity/Mobility (Ref. 1, Table 3-9)	Reference
2,6-DNT	1	Not listed	1	No	Not listed	Not listed
1,1-DCA	2, OR	10	1	Yes	10	2, p. 2
1,1-DCE	OR <sup>a</sup>	10	1	Yes	10	2, p. 3
cis-1,2-DCE	2, OR	1,000	1	Yes	1,000	2, p. 4
trans-1,2-DCE	2, OR	100	1	Yes	100	2, p. 5
PCE	OR <sup>a</sup>	100	1	Yes	100	2, p. 8
TCE	2, OR	1,000	1	Yes	1,000	2, p. 9
Vinyl chloride	2, OR	10,000	1	Yes	10,000	2, p. 10
Cadmium	1	10,000	0.01	No	100	2, p. 1
Lead	1	10,000	0.01	No	100	2, p. 6
Mercury	1, 2, OR	10,000	1	Yes	10,000	2, p. 7

Notes:

<sup>a</sup> 1,1-DCE and PCE were not detected in source samples; however, the chlorinated volatile organic compounds detected in Source No. 2 are breakdown products of PCE (Ref. 52, p. 24) (see Table 6 of this HRS documentation record). Although 1,1-DCE and PCE were not detected in Source Nos. 1 and 2 soil samples collected at the NF site in 2016 and 2018, these substances were documented in the groundwater at concentrations meeting observed release criteria. Furthermore, PCE was detected in historical source soil samples collected in 2001 and 2009 (Refs. 28, pp. 5, 63; 32, pp. 16, 33, 36, 38, 43, 46, 54).

<sup>b</sup> Hazardous substances documented in the observed release are assigned a default mobility factor value of 1 per HRS Section 3.2.1.2.

DCA Dichloroethane  
DCE Dichloroethene  
DNT Dinitrotoluene  
No. Number  
OR Observed Release  
PCE Tetrachloroethene  
TCE Trichloroethene

Toxicity/Mobility Factor Value: 10,000  
(Ref. 1, Table 3-9)

### 3.2.2 HAZARDOUS WASTE QUANTITY

TABLE 17: Hazardous Waste Quantity		
Source No.	Source Type	Source Hazardous Waste Quantity
1	Contaminated soil	>0
2	Contaminated soil	>0

The approximate area of Source No. 1 has been estimated (see Section 2.1), and the area of Source No. 2 is undetermined, but greater than zero (see 2.4.2.1.4 Area (Tier D) – Source No. 2). A hazardous waste quantity default value of 10 is assigned in accordance with Reference 1—namely the hazardous constituent quantity is not adequately determined, no targets are subject to Level I or Level II, and no removal actions have occurred at the former NF facility (Ref. 1, Section 2.4.2.2).

Hazardous Waste Quantity Factor Value: 10  
(Ref. 1, Section 2.4.2.2)

### 3.2.3 WASTE CHARACTERISTICS FACTOR CATEGORY VALUE

The waste characteristics factor category was obtained by multiplying the toxicity, mobility, and HWQ factor values, subject to a maximum product of  $1 \times 10^8$  (Ref. 1, Section 2.4.3.1). Based on this product, a value was assigned in accordance with Reference 1, Table 2-7. Mercury and vinyl chloride yield the highest toxicity/mobility factor value of 10,000 (Ref. 2, pp. 7, 10).

Toxicity/Mobility Factor Value: 10,000  
Hazardous Waste Quantity Factor Value: 10

Toxicity/Mobility Factor Value  $\times$   
Hazardous Waste Quantity Factor Value: 100,000

Waste Characteristics Factor Category Value: 18  
(Ref. 1, Table 2-7)

### 3.3 TARGETS

MLGW provides municipal water to the City of Memphis and surrounding areas. MLGW maintains eight water treatment plants and wellfields supplied by 130 wells, which are part of a blended system (Ref. 53, pp. 1, 2). Of the eight wellfields, the MLGW Shaw Wellfield is within a 4-mile radius of Source Nos. 1 and 2 (Refs. 4; 53, pp. 1, 2, 5). The MLGW Shaw Wellfield consists of 17 wells, nine of which are within a 1- to 2-mile radius of Source Nos. 1 and 2; seven are within a 2- to 3-mile radius of Source Nos. 1 and 2; and one is within a 3- to 4-mile radius of Source Nos. 1 and 2 (Refs. 4; 53, pp. 4, 5). Fourteen of the 17 wells are completed in the Memphis aquifer at depths ranging from 355 to 899 feet bgs. Three wells (751, 755, 761) are completed in the Fort Pillow Sand aquifer at depths ranging from 1,161 to 1,225 feet bgs and underlie the interconnected shallow and Memphis aquifers being evaluated. These wells (two from the 1- to 2-mile radius and one from the 2- to 3-mile radius) are not evaluated in this HRS documentation record because the Fort Pillow Sand aquifer is separated from the Memphis aquifer by the Flour Island Formation confining unit (Refs. 4; 49, pp. 5, 18; 53, p. 4). Water from the Shaw Wellfield is blended with water from the other wellfields before it is distributed, and none of the wells in the water supply system, including Shaw Wellfield wells, produces more than 40 percent of the total water supply. MLGW serves about 229,683 residential customers (residential connections) (Refs. 53, p. 2; 57, pp. 1, 2, 3; 91). According to the U.S. Bureau of the Census, the persons per household value for Shelby County, Tennessee (2014 to 2018), is 2.62 (Ref. 54). Therefore, MLGW serves approximately 601,769.46 people (229,683 residential connections  $\times$  2.62 persons per household). Each well serves approximately 4,628.99 people (601,769.46 people  $\div$  130 wells) (Refs. 53, p. 2; 54; 91). Information obtained from MLGW does not indicate a surface water drinking water source. It is not known whether private wells are present within a 4-mile radius of Source Nos. 1 and 2.

The population served by these wells per distance ring is distributed as follows: > 0 to 0.25 mile, 0 people; > 0.25 to 0.50 mile, 0 people; > 0.50 to 1 mile, 0 people; > 1 to 2 miles, 32,402.93 people; > 2 to 3 miles, 27,773.94 people; > 3 to 4 miles, 4,628.99 people (Refs. 4; 53, p. 2; 54; 57, pp. 1, 2, 3; 91).

Table 18 below summarizes the MLGW municipal supply wells in the Shaw Wellfield screened in the Memphis Sand Aquifer.

TABLE 18: MLGW Municipal Supply Wells – Shaw Wellfield Memphis Sand Aquifer									
Distance Ring (Miles)	No. of Wells	Well No. (MLGW No.)	Total Depth (feet bgs)	Screen Depth (feet bgs)	Level I Cont. (Y/N)	Level II Cont. (Y/N)	Potential Cont. (Y/N)	Population Served	References
0 to 0.25	0	NA	NA	NA	NA	NA	NA	NA	4; 53, p. 4
> 0.25 to 0.5	0	NA	NA	NA	NA	NA	NA	NA	4; 53, p. 4
> 0.5 to 1	0	NA	NA	NA	NA	NA	NA	NA	4; 53, p. 4
> 1 to 2	7	703	636	430 to 636	No	No	Yes	32,402.93	4; 53, p. 4; 54; 91
		704	355	250 to 355					
		706	514	408 to 514					
		708	448	300 to 448					
		709	443	323 to 443					
		710	589	484 to 589					
		728	780	675 to 780					
> 2 to 3	6	702	799	695 to 799	No	No	Yes	27,773.94	4; 53, p. 4; 54; 91
		722-A	616	510 to 616					
		723	627	513 to 627					
		724	844	738 to 844					
		725	758	653 to 758					
		726	889	760 to 889					
> 3 to 4	1	721	682	578 to 682	No	No	Yes	4,628.99	4; 53, p. 4; 54; 91

Notes:

> Greater than  
 bgs Below ground surface  
 Cont. Contamination  
 MLGW Memphis Light, Gas, and Water Division  
 NA Not applicable  
 No. Number

### 3.3.1 NEAREST WELL

The closest municipal drinking water well to Source Nos. 1 and 2 is MLGW Shaw Wellfield Well 709. This well is about 1.42 miles southeast of Source No. 2 (Refs. 4; 53, p. 4).

Well ID: MLGW Shaw Wellfield Well 709

Level of Contamination (I, II, or potential): Potential

If potential contamination, distance from source in miles: about 1.42 miles southeast of Source No. 2 (Refs. 4; 53, p. 4).

In accordance with Section 3.3.1 and Table 3-11 of the HRS rule, a nearest well factor value of 5 is assigned (Ref. 1, Section 3.3.1).

Nearest Well Factor Value: 5  
(Ref. 1, Section 3.3.1, Table 3-11)

### 3.3.2 POPULATION

#### 3.3.2.1 Level of Contamination

No Level I or Level II concentrations attributable to the NF sources have been documented.

#### 3.3.2.2 Level I Concentrations

Not Scored.

#### 3.3.2.3 Level II Concentrations

Not Scored.

#### 3.3.2.4 Potential Contamination

Table 19 lists distance-weighted population values pertaining to targets potentially exposed to contaminated groundwater, considering the interconnected shallow and Memphis Sand aquifers.

<b>TABLE 19: Distance-Weighted Population Values – Other than Karst</b>			
<b>Distance Category (Miles)</b>	<b>Population</b>	<b>Distance-Weighted Population Value (Ref. 1, Table 3-12)</b>	<b>References</b>
Greater than 0 to 0.25	0	0	4
Greater than 0.25 to 0.5	0	0	4
Greater than 0.5 to 1	0	0	4
Greater than 1 to 2	32,402.93	9,385	4; 53, pp. 2, 4; 54; 57, p. 1; 91
Greater than 2 to 3	27,773.94	2,122	4; 53, pp. 2, 4; 54; 57, p. 1; 91
Greater than 3 to 4	4,628.99	417	4; 53, pp. 2, 4; 54; 57, p. 1; 91



Calculations:

Sum of Distance - Weighted Population Values: 11,924

Sum of Distance - Weighted Population Values ÷ 10: 1,192.4, rounded to 1,192

Potential Contamination Factor Value: 1,192  
(Ref. 1, Section 3.3.2.4)

### **3.3.3 RESOURCES**

Resources were not evaluated because they do not significantly contribute to the overall site score.

Resources Factor Value: NS  
(Ref. 1, Section 3.3.3)

### **3.3.4 WELLHEAD PROTECTION AREA**

The Federal Safe Drinking Water Act Amendments of 1986 established the initial step toward prevention of contamination of public water supplies. Each state was required to develop a wellhead protection program to protect the water source of public water systems relying on groundwater (Ref. 55, p. 5). EPA approved Tennessee's Wellhead Protection Program on July 27, 1994 (Ref. 56, pp. 93, 94). The Safe Drinking Water Act was amended in 1996 (Section 1453 of the 1996 Safe Drinking Water Act) to require all states to establish Source Water Assessment Programs detailing how each state would delineate source water protection areas, inventory significant contaminants in these areas, and determine susceptibility of each public water supply to contamination. EPA approved Tennessee's Source Water Assessment Program in November 1999 (Ref. 55, p. 5).

MLGW municipal wells and thus their wellhead protection areas are within a 4-mile radius of Source Nos. 1 and 2. Two wellhead protection zones are established for each well—an inner fixed radius zone (Zone 1) around the well to protect the immediate area from spills, and a larger management zone (Zone 2) that takes into account the wide variety of geologic conditions across Tennessee to provide for long-term management of the well and wellfield (Refs. 4; 53, pp. 4, 5; 55, pp. 5, 7, 77).

Wellhead Protection Area Factor Value: 5  
(Ref. 1, Section 3.3.4)