1.0 PURPOSE.

This report was prepared by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) for the U.S. Army Environmental Command (USAEC) and the Arkansas Army National Guard (ARARNG) to provide site investigation results concerning dioxin and dioxin-like compounds within an area identified as defoliant spray area 1 (DSA 1) on Fort Chaffee resulting from the historic application of tactical grade herbicides to test defoliant efficiency. The site field investigation was conducted 17 – 20 February 2009.

2.0 CONCLUSIONS.

Trace levels of dioxin and dioxin-like compounds were detected in soil, sediment, and surface water samples collected in both the DSA 1 study area and the background sample location. However, no samples contained dioxin or dioxin–like compounds above Federal or State human health risk screening criteria. Trace concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), considered the most toxic of the dioxin compounds, were detected in one surface water, one sediment, and three surface soil samples collected in the DSA 1 study area. A subsequent review of laboratory control sample data found that the trace TCDD concentrations detected in the soil samples may be false positives as dioxins of comparable concentrations were detected in the laboratory method blank sample associated with the soil samples. Additionally, the trace TCDD concentrations detected in the surface water and sediment sample were below the laboratory estimated detection limit (EDL) and were reported as estimated values.

Though laboratory data review suggested that the dioxin concentrations reported may be biased high compared to the true value, the maximum concentration of TCDD reported was compared to the corresponding Federal and State health screening criterion to provide a conservative determination of whether additional study is warranted.
2.1 Soil Sample Results.

Ten surface soil samples, each consisting of a 5-point composite sample, were collected throughout the DSA 1 study area using a systematic random sampling design. Trace concentrations of TCDD were detected in three surface soil samples and the laboratory method blank sample. The maximum concentration TCDD reported (0.46 pg/g) was two orders of magnitude below the U.S. EPA Region 6 Human Health Medium Specific Screening Level (HHMSSL) for industrial soils of 18 pg/g (ppt) (and one order of magnitude below the residential soil HHMSSL of 4.5 pg/g).

2.2 Sediment Sample Results.

Thirteen surface sediment and four subsurface sediment samples were collected for this site investigation. Trace TCDD was detected in one surface sediment sample collected from Stream 1 within the DSA 1 study area. Though an estimated value, the reported concentration was compared to the human health risk screening level to provide a conservative determination of whether additional study is warranted. The reported value (0.11 pg/g) was two orders of magnitude below the U.S. EPA Region 6 HHMSSL of 18 pg/g for industrial soils (and one order of magnitude below the U.S. EPA Region 6 HHMSSL for residential soils).

2.3 Surface Water Sample Results.

Thirteen surface water samples were collected for this site investigation. TCDD was detected in one water sample collected from Stream 1 within the DSA 1 study area (SW-S1-2). Though an estimated value, the reported concentration was compared to the surface water screening level of 1.0 pg/L to provide a conservative determination of whether additional study is warranted. The reported estimated value of 0.53 pg/L (ppq) was below the Arkansas Department of Environmental Quality (ADEQ) water quality human health criteria of 1 pg/L.

2.4 Dioxin-like Compound Results.

The dioxin-like compound, octachlorodibenzo-\textit{p}-dioxin (OCDD), was found at the highest frequency and concentrations in both DSA 1 study area and background samples. This is consistent with other studies involving this compound (U.S. EPA, 2007). Frequent and elevated concentrations of OCDD may be attributed to herbicide use to control weeds and, to some degree, may occur naturally. The highest concentration of OCDD detected (1,153 pg/g) was two orders of magnitude below its HHMSSL of 61,000 pg/g. Trace concentrations of the remaining dioxin-like compounds were detected in the majority of soil and sediment samples. However, the reported concentrations were at least two orders of magnitude below their respective screening criteria. Based on the concentrations of dioxin that were observed, dioxin-like compounds within the DSA 1 were not found to occur at a greater frequency or magnitude than the background sites chosen for this study.
It is not possible to discern the source of trace dioxin and dioxin-like compounds detected in soil, sediment, and surface water samples collected in the western most portion of the DSA 1 study area. Potential sources of these compounds may be attributed to the application of herbicides to control weed growth along roads that access the DSA 1 training area, residuals from the historic application of tactical grade herbicides, or result of natural forest fires or controlled burns. Independent of the source, the concentrations of dioxin and dioxin-like compounds detected in the DSA 1 study area did not exceed Federal or State human health screening criteria.

3.0 RECOMMENDATIONS.

A human health risk assessment is not warranted as the concentrations of dioxin and dioxin-like compounds detected in DSA 1 were below Federal and State human health risk screening criteria. Based on these findings, the USACHPPM recommends no further action with respect to dioxin and dioxin-like compounds within DSA 1.
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1.0 INTRODUCTION.

This report was prepared by the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) for the U.S. Army Environmental Command (USAEC) and the Arkansas Army National Guard (ARARNG) to provide site investigation results concerning dioxin and dioxin-like compounds within an area identified as defoliant spray area 1 (DSA 1) on Fort Chaffee resulting from the historic application of tactical grade herbicides to test defoliant efficiency. The site field investigation was conducted 17 – 20 February 2009.

1.1 References.

A list of references is presented in Appendix A.

1.2 Authority.


1.3 Purpose.

This site investigation was conducted to determine whether dioxin and dioxin-like compounds were present in soil, surface water, and sediment resulting from the historic application of tactical grade herbicides to test defoliant efficiency within the DSA 1 training area. A comparison of sample data collected from the DSA 1 was made to health screening criteria and background levels to determine whether additional study is required to assess potential human health risks to individuals accessing this area.

Readiness thru Health

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1.4 Background.

A 1995 Environmental Baseline Survey (EBS) uncovered documentation indicating that tactical grade herbicides were applied within the Fort Chaffee installation boundary between 1967 and 1968 in an effort to test herbicide defoliant efficiency. Historic documents indicate that a mixture of tactical grade herbicides, labeled Herbicide Orange, Herbicide White, and Herbicide Blue, were reportedly applied to six areas within the Fort Chaffee installation. These documents indicated that a 5 pound mixture, predominantly consisting of Herbicide Orange (commonly referred to as Agent Orange), was applied, via aerial spraying, over an area identified as DSA 1.

According to the Decision Document prepared by the contractor ECC for the U.S. Army Environmental Center (USAEC)\(^1\) addressing the Fort Chaffee Site 41 Defoliant Spray Areas (FTCH-41), a 1963 historical map was uncovered during the 1995 EBS that depicted the six areas that had potentially been used as defoliant spray test locations (See Appendix B Figure 1) (EEC, 2006). The six DSAs were identified as areas of concern requiring a response under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). No further action recommendations were accepted for the two DSAs located in the BRAC Excess Area by the U.S. Environmental Protection Agency (EPA) in 2000 as discussed in the Record of Decision for Five No Further Action Group III-D Environmental Sites, Fort Chaffee, Arkansas (Fort Chaffee, 2000). Based on results of a soil investigation conducted as part of the Preliminary Assessment/Site Investigation (PA/SI) in 2002, the Decision Document determined that the four remaining DSAs, located within the ARARNG Enclave Area (maneuver training area) require no further action for the protection of human health and environment. However, the PA/SI soil investigation analyzed soil samples for chlorinated herbicides using EPA Method 8150 which did not include soil analysis for the chemical compound 2,3,7,8-tetrachlorodibenzo-p-dioxin, a by-product of Herbicide Orange.

Herbicide Orange was made up of an equal mixture of the two chemicals 2,4–D (2,4-dichlorophenoxy acetic acid) and 2,4,5–T (2,4,5-trichlorophenoxy acetic acid). Various formulations of 2,4,5-T have been used extensively for weed control on crops and range lands, and along roadways throughout the world and by the U.S. military during the Vietnam War. The by-product of this manufacturing process, 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), is a halogenated organic compound that has been shown to bioaccumulate in the fatty tissues of humans and wildlife due to its lipophilic properties and is not easily metabolized or excreted. TCDD, referred to simply as dioxin, belongs to a family of chemicals that all share a similar chemical structure and a common mechanism of toxic action. The most toxic of these chemicals, referred to collectively as dioxin and dioxin-like compounds (or congeners), include the seven polychlorinated dibenzo dioxins (PCDDs) and 10 polychlorinated dibenzo furans (PCDFs) analyzed for this site investigation. TCDD, the most studied of these chemicals, is considered to

\(^1\) Presently U.S. Army Environmental Command
have the highest toxicity and has been classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC) and as a probable human carcinogen by the EPA. Other polychlorinated chemicals, like pentachlorophenol (PCP), used to preserve wood, contain some of the more highly chlorinated dioxin compounds (such as octachlorodibenzo-\(p\)-dioxin (OCDD)); TCDD is not usually found with PCP contaminants. Current studies indicate that the toxicity of PCDDs and PCDFs decrease with the increase in the number of chlorine atoms attached to the chemical structure of these compounds. A complete analyte list is provided in Table 1.

2.0 PROPERTY DESCRIPTION.

2.1 Property Location and Description.

The Fort Chaffee MTC lies within Sebastian and Franklin Counties in northwest Arkansas and is located approximately five miles southeast of the city of Fort Smith, Arkansas. The Fort Chaffee MTC encompasses approximately 65,000 acres south of the Arkansas River between the Ozark Mountain Region and the Ouachita Mountain Region within the Arkansas Valley and Ridge physiographic province. This physiographic province consists of Pennsylvanian-age sedimentary rocks that have been compressed into well-developed, east-west trending open folds (anticlines and synclines) and faults split by the wide alluvial bottomlands of the Arkansas River.

The DSA 1 study area lies in the middle of the installation within the central hills region located just south of the Arkansas River floodplain region. The central hills region consists of 10-45 percent slopes and comprises approximately half of the Fort Chaffee MTC land area. The area identified as DSA 1 consists of 720-acres situated east of Highway 96, south of Fort Smith Boulevard, and north of Carnis Auburn Road. This site lies just north of the area known as the Pear Orchard. Appendix B Figure 2 provides an overview of the areas sampled to this site investigation.

2.2 Property History.

Fort Chaffee, initially Camp Chaffee, was established in 1941 to train U.S. soldiers during WWII. Prior to military acquisition, the property land-use was primarily agricultural. Fort Chaffee served as the Joint Readiness Training Center (JRTC) for light combat forces until the JRTC was moved to Fort Polk, Louisiana in 1993. In 1995 the Defense Base Realignment and Closure (BRAC) Commission recommended the permanent closure of Fort Chaffee, AR. The recommendation was approved with the condition that minimum essential ranges, facilities and training areas are maintained as a Reserve Component Training enclave. In late 1995, the federal government declared approximately 6,000 of Fort Chaffee's 72,000 acres to be surplus and the remaining 66,000 acres were turned over to the ARARNG. In September 1997, the installation passed from the U.S. Army to the ARARNG and the installation officially became the Fort Chaffee Maneuver Training Center. The Fort Chaffee MTC is currently utilized by the
ARARNG and the Arkansas Air National Guard to train approximately 50,000 Arkansas National Guardsmen each year. Use and redevelopment of the 6,000 surplus acres was transferred to the local community redevelopment authority and is left to the discretion of local community citizens and leaders. The DSA 1 study area currently serves as a troop maneuver training area.

3.0 PROJECT ROLES AND RESPONSIBILITIES.

3.1.1 Project Officer. Ms. Barbara Vichot, USACHPPM Hazardous and Medical Waste Program, was responsible for developing and implementing the project work plan, performing data assessment, and providing the report of findings for this site investigation.

3.1.2 Project Technical Support. Mr. Mark Farro and Ms. Tracy Merchel, USACHPPM Ground Water and Solid Waste Program, provided additional technical support and assisted in the field sample collection efforts for this site investigation.

3.1.3 Project Site Coordinator. Mr. Gerald Francis, ARARNG Fort Chaffee MTC served as the on-site project coordinator for this site investigation.

3.1.4 Technical Point of Contact. The technical point of contact for this site investigation is Mr. Scott Weber, U.S. Army Environmental Command.

4.0 HUMAN HEALTH RISK SCREENING CRITERIA.

The following human health risk screening criteria were utilized as comparison criteria to determine whether dioxin and dioxin-like compounds detected within the DSA 1 study area require additional study to assess potential unacceptable human health risks.

4.1 U.S. EPA Region 6 Standards.

The U.S. Environmental Protection Agency (EPA) Region 6 has established Human Health Medium-Specific Screening Levels (HHMSSL) for dioxin and dioxin-like compounds in surface soil to address common human health exposure pathways. These HHMSSLs do not represent action levels or cleanup levels but rather are used to determine if potentially significant levels of contamination are present to warrant further investigation. The Fort Chaffee MTC is designated as military/industrial land-use; therefore, the EPA Region 6 HHMSSL of 1.8E-05 mg/kg (18 pg/g) for TCDD in industrial soils is the most appropriate value for comparison to soils and sediment data collected for this site investigation. However, site data was also compared to the HHMSSL for residential soils (i.e., 4.5 pg/g) for a more conservative comparison. A list of the available EPA Region 6 HHMSSL comparison values for dioxins in soil and sediment is provided in Table 1.
4.2 State Regulatory Standards.

The State of Arkansas has primacy for implementation of the EPA National Pollutant Discharge Elimination System (NPDES) requirements. The Arkansas Pollution Control and Ecology Commission is responsible for establishing and updating surface water quality standards while the Arkansas Department of Environmental Quality (ADEQ) is responsible for implementing these standards. Water quality standards for all surface waters, interstate and intrastate, of the State of Arkansas are contained in Regulation No. 2: *Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas* (October 2007). The Toxic Substances Section (Reg.2.508) of this regulation identifies a dioxin human health criterion of 0.001 ng/L for all waterbodies; this human health criterion is based on a lifetime risk factor of $10^{-5}$. TCDD concentrations in surface water sample data collected for this site investigation were compared to the ADEQ water quality human health criterion of 0.001 ng/L, or 1 pg/L.

4.3 Background/Reference Site Data Comparison.

In addition to Federal and State screening criteria, sample data was collected from a background location for comparison to data collected from the DSA 1 study area given the potential for dioxin to be present from sources unrelated to defoliant testing or other U.S. Army activities (i.e., natural or industrial contaminant sources such as forest fires or manufacturing processes). The background sample location chosen for this site investigation was an area within the Fort Chaffee property boundary that was not impacted by the defoliant testing. Background sample collection and comparison is further discussed in Section 5.4.
Table 1. Analytical Parameter List.

<table>
<thead>
<tr>
<th>CONGENERAL</th>
<th>CONGENERAL ABBREVIATION</th>
<th>EPA Method 8290 Battelle Laboratory Level of Quantitation</th>
<th>Screening Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Water pg/L(ppq)</td>
<td>Soil/Sediment pg/g (ppt)</td>
</tr>
<tr>
<td>2,3,7,8-Tetrachlorodibenzo-p-dioxin</td>
<td>2,3,7,8-TCDD</td>
<td>5</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,7,8-Pentachlorodibenzo-p-dioxin</td>
<td>1,2,3,7,8-PCDD</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin</td>
<td>1,2,3,4,7,8-HxCDD</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin</td>
<td>1,2,3,6,7,8-HxCDD</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin</td>
<td>1,2,3,7,8,9-HxCDD</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin</td>
<td>1,2,3,4,6,7,8-HpCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,6,7,8,9-Octachlorodibenzo-p-dioxin</td>
<td>OCDD</td>
<td>50</td>
<td>0.24</td>
</tr>
<tr>
<td>2,3,7,8-Tetrachlorodibenzo-furan</td>
<td>2,3,7,8-TCDF</td>
<td>5</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,7,8-Pentachlorodibenzo-furan</td>
<td>1,2,3,7,8-PCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>2,3,4,7,8-Pentachlorodibenzo-furan</td>
<td>2,3,4,7,8-PCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,7,8-Hexachlorodibenzo-furan</td>
<td>1,2,3,4,7,8-HxCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,6,7,8-Hexachlorodibenzo-furan</td>
<td>1,2,3,6,7,8-HxCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,7,8,9-Hexachlorodibenzo-furan</td>
<td>1,2,3,7,8,9-HxCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>2,3,4,6,7,8-Hexachlorodibenzo-furan</td>
<td>2,3,4,6,7,8-HxCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,6,7,8-Heptachlorodibenzo-furan</td>
<td>1,2,3,4,6,7,8-HpCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,6,7,8,9-Heptachlorodibenzo-furan</td>
<td>1,2,3,4,6,7,8,9-HpCDF</td>
<td>25</td>
<td>0.24</td>
</tr>
<tr>
<td>1,2,3,4,6,7,8,9-Octachlorodibenzo-furan</td>
<td>OCDF</td>
<td>50</td>
<td>0.24</td>
</tr>
</tbody>
</table>

1 Based on Battelle Columbus Laboratory Level of Quantitation (LOQ). LOQ is based on the laboratory low standard; however, the final limit used for quantitation is the estimated detection limit (EDL). This is sample/interference specific (based on the noise in the spectrum for that particular sample).
2 The criteria is below the LOQ for water. However, Battelle typically achieves an estimated detection level (EDL) of 1 pg/L or below.
3 Calculated based on a Carcinogenic Target Risk (TR) of 1E-06.
4 Criteria based on a lifetime risk factor of 10⁻⁶. NA (Not Available)
5.0 SAMPLING RATIONALE, METHODS AND PROCEDURES.

5.1 Sampling and Analysis Plan (SAP) and Site Safety and Health Plan (SSHP).

The USACHPPM prepared a SAP and a SSHP for this sampling event and maintained a copy at the site at all times. The SAP and SSHP for this site investigation is provided in Appendix C. Table 2 provides a summary of the type and number of samples collected for this site investigation.

Table 2. Sample Collection Summary.

<table>
<thead>
<tr>
<th>Media</th>
<th>Number of Samples</th>
<th>Background/Upstream Samples</th>
<th>QA/QC Samples</th>
<th>Composite/Discrete Samples</th>
<th>Analytical Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface soil</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>5 point Composite</td>
<td>17 dioxin compounds</td>
</tr>
<tr>
<td>Surface Sediment</td>
<td>13^2</td>
<td>3</td>
<td>1</td>
<td>10 point Composite</td>
<td>17 dioxin compounds</td>
</tr>
<tr>
<td>Subsurface Sediment</td>
<td>4^2</td>
<td>1</td>
<td>1</td>
<td>5 point Composite</td>
<td>17 dioxin compounds</td>
</tr>
<tr>
<td>Surface water</td>
<td>13^2</td>
<td>3</td>
<td>1</td>
<td>Discrete</td>
<td>17 dioxin compounds</td>
</tr>
<tr>
<td><strong>Total Number of Analytical Samples</strong></td>
<td><strong>49</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 See Table 1 for a list of the 17 dioxin compounds.
2 Number of surface water and sediment samples listed includes background/upstream samples.
Quality Assurance/Quality Control (QA/QC) Samples.

5.2 Surface Soil Sampling Rationale.

Sixteen surface soil samples were collected for this site investigation. Ten surface soil samples (plus two field quality assurance/quality control samples (QA/QC)) were collected throughout the DSA 1 study area. In addition, four surface soil samples were collected from a background sample location for comparison to DSA 1 study area sample data. Surface soil sample locations were determined using a systematic random sample design. The ArcView GIS 9.3 software was used to develop 10 grids of equal dimension to overlie the entire DSA 1 study area. Since the method of herbicide application (i.e., via aerial spraying) would likely have resulted in contaminants being dispersed throughout the site, a composite sampling approach was thought to be the most effective means to assess site conditions.

One surface soil sample, consisting of a 5-point composite sample (5 subsamples), was collected from each of the 10 sample grids overlying the DSA 1 study area. Prior to conducting field activities, the Universal Transverse Mercator (UTM) coordinates for each of the 5 subsamples located within each grid was randomly generated using the ArcView GIS software. To coincide
with installation maps provided by the Fort Chaffee MTC, the UTM coordinates for each sample location generated for this site investigation are based on the WGS 84 datum. Appendix B Figure 3 depicts the 10 sample grids and surface soil sample locations identified for this site investigation. A table containing the UTM coordinates for all sample locations is also provided in Appendix B.

5.2.1 Soil Sample Collection.

Sample personnel used a handheld GPS unit to navigate to the UTM coordinates (easting and northing) for each of the 5 subsamples located within each grid. At each of the 5 subsample locations, one scoop of soil was collected from the top 0 to 6 inches of soil using a disposable plastic scoop and placed in aluminum foil. Once collected, soil from the 5 subsample locations within each sample grid was placed in a stainless steel mixing bowl, thoroughly mixed and placed in the sample jar designated that grid. Surface soil sample identification numbers were based on the following nomenclature: SL-G1 indicates a surface soil collected from Grid 1; SL-G2-D indicates a field duplicate surface soil sample collected from Grid 2; SL-BG1 indicates a surface soil sample collected from the area identified as background location 1.

5.3 Surface Water and Sediment Sampling Rationale.

Surface water and sediment samples were collected from four streams and two creeks to assess dioxin and dioxin-like compound concentrations upstream, downstream and within the DSA 1 study area. Surface water and sediment samples were collected from two streams that originate upstream of the DSA 1 study area and two streams that originate within the DSA 1 study area. For this site investigation these unnamed streams were identified as Stream 1, Stream 2, Stream 3, and Stream 4. Streams 1 and 4 originated upstream of the DSA 1 study area. Stream 1 is located along the western boundary of the DSA 1 study area while Stream 4 is located along the eastern most boundary. Since upstream sample locations are not believed to have been impacted by herbicide testing activities, upstream samples provide background or reference data for comparison to data collected within and downstream of DSA 1 study area. For Streams 2 and 3, no upstream samples were available as both streams originated within the DSA 1 study area. Samples from these two streams were collected to assess dioxin and dioxin-like compounds within and downstream of the central portion of the DSA 1 study area. Surface water and sediment samples were collected from Vache Grasse Creek, located upstream of the DSA 1 study area to serve as a background comparison sample location. Table 4 provides a summary of surface water and sediment sample locations along with the nomenclature used for sample identification. Appendix B Figure 4 depicts the surface water and sediment sample locations identified for this site investigation.

Since up-gradient rocky-bottom streams such as those within the DSA 1 study area primarily transport particulate matter in suspended load to downstream locations, two additional sample locations were selected downstream of the DSA 1 study area to assess transport and deposition...
of contaminants downstream of the DSA 1. A surface water, surface sediment and subsurface sediment sample was collected from the downstream sample locations identified as Flat Rock Creek 1 and Flat Rock Creek 2. Flat Rock Creek, located directly north of the DSA 1 study area, flows east to west and drains to Vache Grasse Creek which empties into the Arkansas River.

5.3.1 Sediment Sampling.

Thirteen surface (0 – 4 inches) sediment and four subsurface (4 – 8 inches) sediment samples were collected for this site investigation. Surface sediment samples were collected upstream (three samples), within (four samples), and downstream (six samples) of the DSA 1 study area. The majority of the sediment sample locations were downstream of the DSA 1 study area due to the potential for historically applied contaminants to be transported and deposited to downstream locations over time. Subsurface sediment samples were collected to assess the deposition of contaminants transported downstream over time. Surface and subsurface sediment samples were collected using the following procedures.

5.3.1.1 Surface Sediment Sample Collection.

Beginning with the most downstream location and moving upstream, 10 subsamples of sediment were scooped from areas having sufficient sediment deposition at various points within 100 feet of the initial sample UTM coordinate location. Surface sediment was collected using a single-use disposable plastic scoop and carefully placed in aluminum foil or in an aluminum foil lined mixing bowl, ensuring that the fines were not lost in the scooping process. Once sufficient sample volume was collected, each sediment sample was thoroughly mixed, removing organic debris and large pebbles. The sediment sample was then placed in the appropriately labeled sample container.

5.3.1.2 Subsurface Sediment Sample Collection.

Six subsurface sediment samples were planned for this site investigation. However, only four subsurface sediment samples were collected due to the lack of sediment associated with upstream streams. Subsurface sediment samples were not collected from upstream or downstream sample locations within Stream 1 and Stream 4 due to the lack of sediment depth associated with rocky bottom streambeds. The inability to collect subsurface sediment samples at these locations does not affect the results of this site investigation since subsurface sediment samples were collected further downstream where sediment deposition is most likely to have taken place over time (i.e., two Flat Rock Creek sample locations).

A hand auger was used to collect subsurface sediment samples. A 8 inch sediment core was extracted from each subsurface sediment sample location. Each subsurface sediment sample consisted of a 5-point composite sample (or subsample) collected at approximately 10 to 15 foot intervals over a 100 linear foot area. At each of the five subsample locations, the bottom 4 - 8
inches of soil was removed from the hand auger and placed in a aluminum lined stainless steel mixing bowl. Once sediment from each subsample location was placed in the mixing bowl, the sediment was thoroughly mixed and placed in the appropriately labeled sample container.

5.3.2 Surface Water Sampling.

Thirteen surface water samples (plus one QA/QC sample) were collected for this site investigation. Four surface water samples were collected from stream sample locations identified within the DSA 1 study area. One surface water sample was collected from each of the following upstream sample locations: Stream 1, Stream 4 and Vache Grass Creek. Six surface water samples were collected from sample locations downstream of the DSA 1 study area.

5.3.2.1 Surface Water Collection.

Two liters of water were collected at each sample location by inverting the sample container and immersing it to mid-depth in the middle of the stream, then filling and capping. The sample container used to collect surface water samples for dioxin analysis was a new, clean, one liter glass jar with a Teflon-lined cap. Samples were preserved immediately after collection by placing on ice. The surface water sample was collected before the sediment sample at each sample location to prevent contamination from the disturbance and resuspension of sediment. Samples collected along a stream reach were collected starting from the farthest point downstream working up to the most upstream sample location to minimize sediment disturbance.

5.4 Background Sample Collection.

5.4.1 Surface Soil Background Samples.

Four surface soil samples were collected in an area that was determined not to have been impacted by the historic defoliant spray activities. The soil types found within this area are consistent with those found within the DSA 1 study area. The soil background sample area is located to the west of the DSA 1 study area and due west of the area identified as the Drop Zone. Appendix B Figure 5 depicts the surface soil background sample location and the Vache Grasse Creek surface water and sediment background sample location.

5.4.2 Surface Water and Sediment Background Samples.

Three surface water and four sediment samples (including one subsurface sediment sample) were collected from stream locations upstream of the DSA 1 study area that were determined not to be impacted by defoliant spray testing. One surface water and one surface sediment sample was collected from the upstream sample location identified within Stream 1 and Stream 4. Subsurface sediment samples were not available at these sample locations due to the lack of sediment depth. One surface water sample and one sediment core sample (consisting of a
surface and subsurface sediment sample) was collected from an area along Vache Grasse Creek upstream of the DSA 1 study area. The Vache Grasse Creek sample location was adjacent to a bridge and track vehicle crossing.

5.5 Field Quality Assurance/Quality Control (QA/QC) Samples.

One field duplicate and one field split sample were collected from both surface soil and sediment sample locations for this site investigation. A field duplicate soil sample was collected from sample Grid 9 (sample identification number SL-G9D). The duplicate soil sample was collected approximately one foot from each of the 5-subsamples within Grid 9 using the same sampling technique used to collect the original sample. A split soil sample was collected from Grid 4 (sample identification number SL-G4S). The split soil sample was collected by placing soil collected and homogenized from this sample location into separate sample containers until each container held an adequate sample volume. A field duplicate sediment sample was collected from the subsurface sediment at the Flat Rock Creek 2 sample location (sample identification number SD-FR2-SSD). Additionally, a split sample was collected from the surface sediment sample collected at this location (sample identification number SD-FR2-SUF2). The field duplicate and field split sediment samples were collected using the same procedures as the original sediment samples. A surface water field duplicate sample was also collected at this location (sample identification number SW-FR2-D).

5.6 Decontamination and Sample Integrity.

Only the subsurface sediment sampling equipment required decontamination. Decontamination of the hand auger used to collect subsurface sediment samples was performed by removing sediment debris for the sample equipment, washing with a Alconox detergent solution and rinsing with distilled water. Surface soil and surface water equipment did not require decontaminations as single-use, disposable plastic scoops and an aluminum lined stainless steel mixing bowl were used to collect surface soil samples and surface water samples were collected directly in their designated sample container. Field personnel wore latex gloves whenever contacting sampling equipment or supplies and donned new gloves for each sample location. All clean, unused sample equipment was placed in clean plastic zip-lock bags or wrapped in aluminum foil to prevent contamination prior to use.

5.7 Sample Labeling, Preservation, Packing, and Chain-of-Custody Procedures.

5.7.1 Sample Labeling.

Sample labels were affixed to each sample container with the appropriate sample number, sample date and time, analyses to be performed, preservative (if required), and sampler’s initials. All information regarding sample collection, including, but not limited to, date and time of collection, name(s) of sampling personnel, sample matrix, sample location, description of
material sampled (including odors or stains), depth of sample, preservatives used, and sampling procedure/equipment used, was recorded in the field log book.

5.7.2 Sample Preservation.

All samples were preserved in accordance with the analytical method and laboratory standard operating procedures requirements. All samples were secured in zip-lock bags, placed in coolers, and cooled to 4 degrees centigrade (4°C) plus or minus 2°C.

5.7.3 Sample Packing and Chain of Custody Procedures.

Samples containers were placed in a structurally sound cardboard box and placed into a cooler. Samples were delivered to the analytical laboratory within appropriate holding times for all samples.

The project officer completed chain-of-custody forms and a copy was included with each sample shipment. The project officer signed, dated, and placed chain-of-custody seals on all coolers when coolers were not within direct control of the project officer or laboratory personnel. The project officers recorded all data regarding shipping and chain-of-custody procedures in the log books. Chain-of-custody procedures followed ASTM D 4840-99 (2004) (ASTM, 2004b).

5.7.4 Log Book.

The project officer maintained a field log book documenting all sampling activities at the site. The field log book and all entries conform to ASTM D 6089-97 (ASTM, reapproved 2003).

6.0 ANALYTICAL METHODS.

Table 3 contains a list of analyses performed and methods used. Laboratory data results are provided in Appendix D.

6.1 Laboratory Accreditation and QA/QC Information.

6.1.1 Accreditation.

All samples were delivered to the USACHPPM Directorate of Laboratory Sciences (DLS), located at Aberdeen Proving Ground, Maryland. Once received, the USACHPPM DLS logged the samples using proper sample management procedures and then submitted samples to the Battelle-Columbus Laboratory for analysis using EPA-approved methodologies. The Battelle Laboratory is accredited by the New Jersey Office of Quality Assurance to perform dioxin analyses. EPA Method 8290 was used for dioxin analysis for each media. All analytical method SOPs are available upon request. The USACHPPM DLS maintains a variety of accreditation/certifications to include the National Environmental Laboratory Accreditation.
Conference (NELAC), now called The NELAC Institute (TNI), the American Association for Laboratory Accreditation (A2LA), and the DOD Clinical Laboratory Improvement Program (CLIP) certification, among other laboratory accreditations and certifications. It should be noted that the Arkansas Department of Environmental Quality requires laboratory certification specific to Arkansas Code Annotated 8-2-201. An ADEQ certified laboratory should be used if additional site investigation is required based on these sample results.

6.1.2 Laboratory QA/QC Procedures.

QA/QC procedures used during sample analysis included laboratory reagent/method blanks, matrix spikes, matrix spike duplicates, laboratory control samples, method detection limit (MDL) samples, instrument performance check samples, and initial calibration and continuing calibration verification checks.

Table 3. Analytical Methods

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<td>Glass container with TeflonTM lined lid</td>
<td>Cool to 4 ± 2°C</td>
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<td>Dioxin/Furan</td>
<td>Surface Water</td>
<td>EPA Method 8290</td>
<td>30 days extraction 45 days analysis</td>
<td>(2) 1 L Glass container with TeflonTM lined lid</td>
<td>Cool to 4 ± 2°C</td>
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7.0 SAMPLE RESULTS.

7.1 Surface Soil Results.

Fourteen surface soil samples were collected for this site investigation. Ten surface soil samples were collected within the DSA 1 study area (plus two QA/QC samples) and four surface soil samples were collected from a background location to serve as comparison samples. Trace concentrations of the dioxin TCDD were detected in three soil samples collected from the DSA 1 study area (collected from Grid 1 (0.25 pg/g), Grid 3 (0.13 pg/g), and Grid 7 (0.46 pg/g)). However, TCDD was also detected in the laboratory method blank sample (0.22 pg/g) that was processed with the soil samples. According to EPA guidelines, sample results reported as less than five times the blank contamination must be flagged as qualified data. Though the blank contamination indicates that data results may be biased high (or false positives), the maximum concentration of TCDD reported (0.46 pg/g) was compared to the human health risk screening level to provide a conservative determination of whether additional study is warranted. The maximum concentration TCDD reported was two orders of magnitude below the EPA Region 6 HHMSSL of 18 pg/g (ppt) for industrial soils (one order of magnitude below the EPA Region 6 HHMSSL for residential soils of 4.5 pg/g).
The dioxin-like compound, octachlorodibenzo-\(p\)-dioxin (OCDD), was found at the highest frequency and concentrations in the soil samples. This is consistent with other studies involving this compound (U.S. EPA, 2007). Frequent and elevated concentrations of OCDD may be attributed to herbicide use to control weeds and, to some degree, may occur naturally. The highest concentration of OCDD detected was at least two orders of magnitude less than its screening criterion. Trace concentrations of the remaining dioxin-like compounds were detected in the majority of the soil samples. However, they were all detected at least two orders of magnitude below their respective screening criteria.

7.2 Surface and Subsurface Sediment Results.

Thirteen surface sediment samples and 4 subsurface sediment samples were collected for this site investigation (plus two QA/QC samples). Trace TCDD was detected in the surface sediment sample collected from Stream 1 within the DSA 1 study area (SD-S1-2SUF). However, the concentration reported was below the laboratory EDL and was flagged as an estimated value. Though an estimated value, the reported maximum concentration was compared to the human health risk screening level to provide a conservative determination of whether additional study is warranted. The reported value (0.11 pg/g) was two orders of magnitude below the EPA Region 6 HHMSSL of 18 pg/g (ppt) for industrial soils (one order of magnitude below the EPA Region 6 HHMSSL for residential soils).

Consistent with soil sample results, OCDD was found at the highest frequency and concentrations within the sediment samples. The highest concentration of OCDD was found in the upstream (background) surface sediment sample collected from Vache Grasse Creek. The higher OCDD concentration in the surface and surface sediment samples collected at this location may be due to the PCP treated wood used in the construction of a nearby bridge. The highest concentration of OCDD detected (1,153 pg/g) was more than an order of magnitude less than the EPA Region 6 HHMSSL of 61,000 pg/g. All other dioxin-like compounds were at least two orders of magnitude below their respective screening levels.

7.3 Surface Water Results.

Thirteen surface water samples were collected for this site investigation. TCDD was detected in one water sample which was collected from Stream 1 within the DSA 1 study area (SW-S1-2). However, the concentration detected was below the laboratory EDL and was reported as an estimated value. Though an estimated value, the reported concentration was compared to the surface water screening level of 1.0 pg/L to provide a conservative determination of whether additional study is warranted. The reported estimated value of 0.53 pg/L (ppq) was below the ADEQ water quality human health criteria of 1 pg/L.

OCDD and 1,2,3,4,6,7,8-HPCDD were the only dioxin-like compounds detected in surface water samples. With the exception sample SW-S4-2, OCDD and HPCDD concentrations detected in
water samples were determined to be nondetects as similar concentrations were detected in the laboratory method blank sample processed with the water samples. The elevated concentrations of these compounds detected in surface water sample SW-S4-2 were determined to be outliers. The ADEQ did not have water quality standards for these compounds available for comparison.

Table 4. Surface Water and Sediment Sample Locations and Sample ID Numbers.

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<tr>
<th>Sample Location</th>
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<th>Downstream</th>
<th>QA/QC Samples</th>
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</tbody>
</table>

Flat Rock Creek = FR; Vache Grasse Creek = VGC; Surface water = SW; Sediment = SD; Surface sediment = S; Subsurface sediment = SS; Duplicate = D
SD-FR1-SUF2 was a surface sediment split sample collected the Flat Rock Creek 1 sample location.
8.0 DATA QUALITY EVALUATION AND ASSESSMENT.

8.1 Data Quality Evaluation.

The accompanying laboratory narrative (Appendix D) contains a complete listing of all analytes, MDLs, Reporting Limits, and analyses performed.

A data quality evaluation was performed on the Fort Chaffee MTC laboratory data to determine data quality and usability. The data quality indicators precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters were assessed to determine data usability. Precision, accuracy and completeness are measured quantitatively. Representativeness and comparability are measured qualitatively.

- **Precision** is the degree of agreement between individual measurements. Precision is measured by the relative percent difference (RPD) between individual measurements with the same characteristic. Field duplicate samples were used to assess laboratory precision. The RPD set for this project was less than 30%. The RPD between original and field duplicate samples for each media were all less than 30%.

- **Accuracy** is the degree of agreement between the measured value and the true value. Accuracy may be assessed by the use of a standard reference material or laboratory matrix spike samples. Accuracy is expressed as a percentage of the ratio of measured value to true value. The laboratory precision limits for analytical method matrix spike sample recovery was used to assess accuracy. Analytical method matrix spike recoveries were met for soil, sediment and surface water samples.

- **Representativeness** reflects the degree to which sample data accurately and precisely portrays the environmental conditions being studied. Representativeness is primarily addressed through designing a sampling plan that will provide data that is most characteristic of site conditions to include ensuring that the number of samples collected and sample locations are sufficient to provide data that is characteristic of site conditions. Sample data was determined to be representative of site conditions.

- **Completeness** is the amount of data obtained for a measurement compared to the expected amount of data required for the measurement. All of the samples planned for this site investigation were collected and analyzed with the exception of four subsurface sediment samples. Subsurface sediment samples were not collected from upstream and downstream sediment sample locations within Stream 1 and Stream 4 due to the lack of sediment depth associated with rocky bottom streams. Prior to sampling collection efforts, it was determined that subsurface samples may not be available from these streams; therefore two alternate sample locations were included to assess contaminant movement downstream (i.e., Flat Rock Creek 1 and Flat Rock Creek 2). The inability to
collect subsurface sediment samples from upstream and downstream sample locations in Stream 1 and Stream 4 did not affect data usability as subsurface sediment samples were collected from the alternate sample locations identified within Vache Grasse Creek (upstream) and Flat Rock Creek 1 and Flat Rock Creek 2 (downstream).

- Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. The degree of comparability is directly related to the precision, accuracy, and representativeness of the data in each set. For this project, comparability was measured through the use of standard field sampling procedures and laboratory analytical methods and by ensuring that the concentration units reported for site data (i.e. pg/L, pg/g) were compared to the appropriate health screening criteria concentration units.

8.2 Data Assessment.

Laboratory data review and validation determined that the data reported for this site investigation was of sufficient quality and quantity for use in the decision-making process. The trace concentrations of TCDD detected in one surface water and one surface sediment sample were below the sample specific estimated detection limit (EDL) and were reported as estimated values or J-qualified data. The J-qualified data does not affect quality or usability of the sample data.

Trace concentrations of TCDD and dioxin-like compounds were detected in the laboratory method blank sample processed with the soil samples. However, the levels detected were less than the method detection level and significantly less than the screening criteria. Laboratory method blank contamination does not affect the quality or usability of data collected for this site investigation.

Due to the large number of nondetects, the maximum concentration of dioxin and dioxin-like compounds reported for each media was qualitatively compared to the corresponding human health risk screening criteria.

9.0 CONCLUSIONS.

Trace levels of dioxin and dioxin-like compounds were detected in soil, sediment, and surface water samples collected in both the DSA 1 study area and the background sample location. However, no samples contained dioxin or dioxin–like compounds above Federal or State human health risk screening criteria. Trace concentrations of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), considered the most toxic of the dioxin compounds, were detected in one surface water, one sediment, and three surface soil samples collected in the DSA 1 study area. A subsequent review of laboratory control sample data found that the trace TCDD concentrations detected in the soil samples may be false positives as dioxins of comparable concentrations were detected in the laboratory method blank sample associated with the soil samples. Additionally, the trace
TCDD concentrations detected in the surface water and sediment sample were below the laboratory estimated detection limit (EDL) and were reported as estimated values.

Though laboratory data review suggested that the dioxin concentrations reported may be biased high compared to the true value, the maximum concentration of TCDD reported was compared to the corresponding Federal and State health screening criterion to provide a conservative determination of whether additional study is warranted.

9.1 Soil Sample Results.

Ten surface soil samples, each consisting of a 5-point composite sample, were collected throughout the DSA 1 study area using a systematic random sampling design. Trace concentrations of TCDD were detected in three surface soil samples and the laboratory method blank sample. The maximum concentration TCDD reported (0.46 pg/g) was two orders of magnitude below the U.S. EPA Region 6 HHMSSL for industrial soils of 18 pg/g (and one order of magnitude below the residential soil HHMSSL of 4.5 pg/g).

9.2 Sediment Sample Results.

Thirteen surface sediment and four subsurface sediment samples were collected for this site investigation. Trace TCDD was detected in one surface sediment sample collected from Stream 1 within the DSA 1 study area. Though an estimated value, the reported concentration was compared to the human health risk screening level to provide a conservative determination of whether additional study is warranted. The reported value (0.11 pg/g) was two orders of magnitude below the U.S. EPA Region 6 HHMSSL of 18 pg/g for industrial soils (and one order of magnitude below the U.S. EPA Region 6 HHMSSL for residential soils).

9.3 Surface Water Sample Results.

Thirteen surface water samples were collected for this site investigation. TCDD was detected in one water sample collected from Stream 1 within the DSA 1 study area (SW-S1-2). Though an estimated value, the reported concentration was compared to the surface water screening level to provide a conservative determination of whether additional study is warranted. The reported estimated value of 0.53 pg/L (ppq) was below the ADEQ water quality human health criteria of 1 pg/L.

9.4 Dioxin-like Compound Results.

The dioxin-like compound, octachlorodibenzo-p-dioxin (OCDD), was found at the highest frequency and concentrations in both DSA 1 study area and background samples. This is consistent with other studies involving this compound (U.S. EPA, 2007). Frequent and elevated concentrations of OCDD may be attributed to herbicide use to control weeds and, to some degree, may occur naturally. The highest concentration of OCDD detected (1,153 pg/g) was two
orders of magnitude below its HHMSSL of 61,000 pg/g. Trace concentrations of the remaining dioxin-like compounds were detected in the majority of soil and sediment samples. However, the reported concentrations were at least two orders of magnitude below their respective screening criteria. Based on the concentrations of dioxin that were observed, dioxin-like compounds within the DSA 1 were not found to occur at a greater frequency or magnitude than the background sites chosen for this study.

It is not possible to discern the source of trace dioxin and dioxin-like compounds detected in soil, sediment, and surface water samples collected in the western most portion of the DSA 1 study area. Potential sources of these compounds may be attributed to the application of herbicides to control weed growth along roads that access the DSA 1 training area, residuals from the historic application of tactical grade herbicides, or result of natural forest fires or controlled burns. Independent of the source, the concentrations of dioxin and dioxin-like compounds detected in the DSA 1 study area did not exceed Federal or State human health screening criteria.

10.0 RECOMMENDATIONS.

A human health risk assessment is not warranted as the concentrations of dioxin and dioxin-like compounds detected in DSA 1 were below Federal and State human health risk screening criteria. Based on these findings, the USACHPPM recommends no further action with respect to dioxin and dioxin-like compounds within DSA 1.

11.0 POINTS OF CONTACT.

For questions or comments regarding this site investigation, please contact Ms. Barbara Vichot at (410) 436-8555 (DSN 584-8555), office (410) 436-3651 or by email at Barbara.Vichot@us.army.mil.

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APPENDIX A
REFERENCES


APPENDIX B
SAMPLE LOCATION MAPS
AND
UTM SAMPLE COORDINATES
### Soil Sample UTM Coordinates

<table>
<thead>
<tr>
<th>Sample Identification Number</th>
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Figure 1
LOCATIONS OF FTCH-41 DEFOLIANT SPRAY AREAS
Fort Chaffee, Arkansas

From PA/SI, Parsons, 2003
Figure 3. DSA 1 Surface Soil Sample Grids and Composite Sample Locations

- **Grid 1**
- **Grid 2**
- **Grid 3**
- **Grid 4**
- **Grid 5**
- **Grid 6**
- **Grid 7**
- **Grid 8**
- **Grid 9**
- **Grid 10**

Legend:
- Yellow circles: Soil composite samples
- Blue lines: Streams
- Red area: Defoliant Spray Area
- Black grid: Soil sampling grid

Scale: 3 125 250 500 750 1,000 Meters
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APPENDIX C
SAMPLE AND ANALYSIS PLAN
AND
SITESAFETY AND HEALTH PLAN

The Sample and Analysis Plan and Site Safety and Health Plan are provided on the enclosed CD-ROM
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APPENDIX D
LABORATORY DATA AND CHAIN-OF-CUSTODY FORMS

Laboratory Data and Chain-of-Custody Forms for the Fort Chaffee MTC DSA 1 Site Investigation are provided on the enclosed CD-ROM