Draft

Installation-Wide Work Plan

Fort McClellan
Calhoun County, Alabama

Prepared for:

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1.0 Introduction

This installation-wide work plan (WP) has been prepared by IT Corporation (IT) for the Department of the Army and the U.S. Army Corps of Engineers (USACE), Mobile District for all future work to be performed at Fort McClellan (FTMC) in Calhoun County, Alabama, under Contract No. DACA21-96-D-0018.

This WP, along with the Human Health and Ecological Screening Values and PAH Background Summary Report (IT, 2000a) and the Installation-wide Sampling and Analysis Plan (SAP) (IT, 2002), serve as guidance for field investigations to be conducted at FTMC. The following sections describe the purpose of this WP and the organization of the document.

1.1 Purpose

The WP presents general information regarding FTMC and specifies basic requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process to be conducted at FTMC by IT or others. This document provides the basic requirements and guidance for all investigative and remedial activities at FTMC, and is intended to be used on an installation-wide basis by all parties conducting work associated with the CERCLA process.

Specific requirements for investigative field activities, including environmental sampling and associated activities, are presented in the SAP, which is a necessary companion document to this WP. Information specific to individual investigative sites is presented in site-specific field sampling plan (SFSP) attachments to the SAP, and includes the location and rationale of site samples, site-specific analytical requirements, and site-specific data quality objectives (DQO). Specific requirements of the SAP and SFSPs will supersede those presented in this WP.

1.2 Organization

This WP has been organized to provide general information regarding FTMC and general requirements for components of the CERCLA process that are applicable to all investigations at FTMC sites, as appropriate. The WP is divided into nine chapters, summarized as follows:

- ***Chapter 1.0.*** Presents the introduction, purpose, and document organization.

- ***Chapter 2.0.*** Provides FTMC site background and history, including general discussions of the facility description and history, environmental setting, soils, geology and hydrogeology, hydrology, sensitive environments, and a summary of previous environmental studies.

- ***Chapter 3.0.*** Describes the site investigation process and objectives, including the requirements for development of the conceptual site model (CSM) and DQOs.

- ***Chapter 4.0.*** Describes the remedial investigation (RI) process and objectives, including requirements for development of the conceptual site model, potential source areas and release mechanisms, potential remedial action technologies, preliminary applicable or relevant and appropriate requirements (ARAR), DQOs, data gaps and needs, and a comparison of site and background data.

- ***Chapter 5.0.*** Provides information on streamlined human health and ecological risk assessments, including the processes for identification of chemicals of potential concern (COPC) and for conducting the streamlined human health risk assessment (SRA) and the ecological risk assessment (ERA).

- ***Chapter 6.0.*** Describes feasibility study (FS) approaches, including discussions of the standard FS process and the focused FS process.

- ***Chapter 7.0.*** Describes objectives, content, and format of Proposed Plan (PP) and Record of Decision (ROD) documents.

- ***Chapter 8.0.*** Discusses implementation of remedial actions.

- ***Chapter* 9.0.** Lists the references cited in this WP.

2.0 Site Background

2.1 Facility Description and History

FTMC is a U. S. Army facility under the control of the U. S. Army Training and Doctrine Command (TRADOC) that was closed under the Base Realignment and Closure (BRAC) program in September 1999. FTMC was a U.S. Army training installation located in northeast Alabama, near the city of Anniston in Calhoun County (Figure 2-1). FTMC consisted of three portions of land: Main Post, Choccolocco Corridor, and Pelham Range.

The majority of FTMC development is in the northwest area of the Main Post. The City of Anniston is located to the south and west of the Main Post; adjoining the Main Post installation to the east are the Choccolocco Mountains of the Talladega National Forest. The Main Post, consisting of 18,929 acres, was purchased by the federal government in March 1917 for the construction of a National Guard camp (Camp McClellan). Pistol and rifle ranges were established north of the camp, automatic rifle and machine gun ranges were established southwest of the camp, and artillery firing ranges were established southeast of the camp toward the Choccolocco Mountains (New South Associates, Inc. [NSA], 1993). Camp McClellan expanded throughout the 1920s and 1930s. The advent of World War II in the 1940s brought continued growth for the installation. Most notably, the 22,245 acres of Pelham Range were purchased to the west of the Main Post in early 1940 for artillery, tank, and heavy mortar firing. Approximately 4,488 additional acres to the east of the Main Post (Choccolocco Corridor) were leased from the state to connect the Main Post to the Talladega National Forest (CH2M Hill, 1994). Historically, Choccolocco Corridor was also used for various range training activities. The lease was terminated in May 1998.

The post-war period initially brought a decline in operations at FTMC. The decrease in military spending placed the installation on inactive status. However, in 1950 the installation was reinstated to active status because of the Korean Conflict. The U.S. Army Chemical School was established at FTMC in 1951; the large outdoor training areas allowed for specialized chemical training involving chemical warfare protection, decontamination procedures, flame throwers, and the operation of smoke generators. The Base hospital was renovated to specialize in chest diseases. The first permanent Women's Army Corps (WAC) training facility was established in 1955, although two WAC detachments had been established during the 1940s at the installation. Radiological training was conducted in the mid-1950s at Iron Mountain, Alpha Field, and

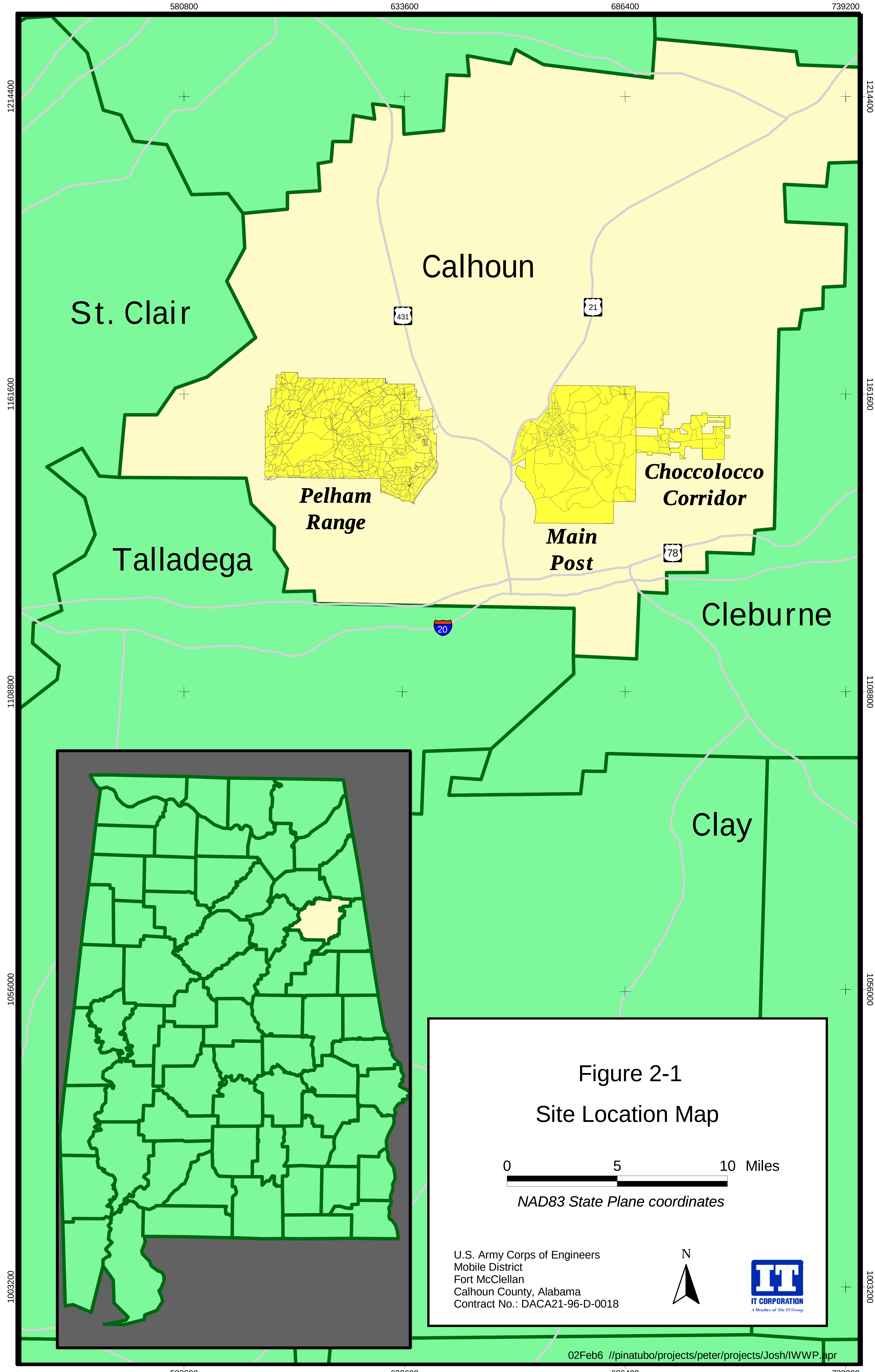


Figure 2-1

Site Location Map

Bromine Field, all located on the Main Post, as well as at Rideout Field on Pelham Range (NSA, 1993).

The mission of the installation was changed in 1966 and it became the U.S. Army School/Training Center. An Advanced Individual Training Infantry Brigade was activated in 1966 to meet requirements for the Vietnam War. The brigade was deactivated in 1970 due to continued force reduction in Vietnam.

In 1973, the Chemical Corps School closed, along with the U.S. Army Combat Developments Command Chemical/Biological Radiological Agency. Five years later, in 1978, the WAC was disbanded and the WAC school closed.

In 1979, the Military Police (MP) School was moved to FTMC. In the same year, the U.S. Army Chemical Corps school was re-established, along with a Brigade for Basic Training. U.S. Army Forces Command units, such as D Company, 46th Engineers, were also garrisoned at the post during the 1970s and 1980s.

The mid-1980s brought additional operations to Pelham Range, which is located approximately 2 miles northwest of Anniston. This area was used for maneuver training and a wide range of activities from small-arms training to tank and artillery training. Pelham Range has also been used for chemical decontamination training and radiological training.

The main missions and support organizations at FTMC have been:

- U.S. Army Chemical School
- U.S. Army Military Police School
- Training Center Command
- Training Brigade
- Directorate of Contracting
- Directorate of Community Activities
- Directorate of Resource Management
- Provost Marshal Office Directorate of Community Safety
- Office of the Staff Judge Advocate
- Safety Office
- Equal Employment Opportunity Office
- Office of the Inspector General
- Internal Review and Audit Compliance
- Public Affairs Office

- Directorate of Engineering and Housing
- Directorate of Environment
- Directorate of Information Management
- Directorate of Logistics
- Directorate of Plans, Training, Mobilization, and Security and Reserve Component Support.

Past tenant activities included the following:

- U.S. Army Medical Department Activity
- U.S. Army Dental Activity
- U.S. Department of Defense Polygraph Institute
- Defense Finance and Accounting Services
- Defense Investigative Service
- Marine Corps Administrative Detachment
- Criminal Investigation Division
- 902nd Military Intelligence Group
- Army National Guard
- U.S. Army Reserves
- TRADOC Manpower Activity
- 722nd Explosive Ordnance Detachment
- Army Air Force Exchange Service
- Defense Commissary Agency
- Defense Reutilization and Marketing Office
- U.S. Department of Defense Security Operation Testing Support
- Fort McClellan Elementary School
- Naval Construction Training Center Detachment
- U.S. Army Corps of Engineers (Mobile District)
- U.S. Air Force Disaster Preparedness School.

FTMC operations were deactivated and missions completed with the installation closure on September 30, 1999.

2.2 Environmental Setting

2.2.1 Physiography

Pelham Range and all but the easternmost portion of FTMC lie within the Valley and Ridge Province of the Appalachian Highlands. The portion of FTMC west of Choccolocco Creek lies within the Piedmont Province. Local relief on FTMC is in excess of 1,320 feet. The lower elevations (700 feet above mean sea level [msl]) occur along Cane Creek, near Baltzell Gate Road, while the maximum elevations (2,063 feet above msl) occur on Choccolocco Mountain, which traverses the area in a north/south direction, with the steep easterly slopes grading abruptly into Choccolocco Valley. The western slopes are more continuous, with the southern extension maintaining elevations up to 900 feet above msl near the western reservation boundary. The northern extension decreases in elevation in the vicinity of Reilly Airfield. The central portion of FTMC is characterized by flat to gently sloping land. The topographic relief at Pelham Range is approximately 445 feet. The minimum elevation is 500 feet above msl, which occurs at the exit of Cane Creek from the range, and the maximum elevation is 945 feet above msl, near the southeastern boundary. The northern sector contains broad, rolling topography capped with isolated round knobs rising 75 to 90 feet above the surrounding terrain. A large, relatively flat area called Battle Drill Area is situated near the western boundary (Science Applications International Corporation [SAIC], 2000).

2.2.2 Climate

FTMC is situated in a temperate, humid climate. Summers are long and hot, and winters are usually short and mild to moderately cold. The climate is influenced by frontal systems moving from northwest to southeast, and temperatures change rapidly from warm to cool due to the inflow of northern air. The average annual temperature is 63 degrees Fahrenheit (°F). Summer temperatures usually reach 90°F or higher about 70 days per year, but temperatures above 100°F are rare. Freezing temperatures are common in winter but are usually of short duration. The first frost may arrive by late October. Snowfall averages 0.5 to 1 inch. On rare occasions, several inches of snow accumulate from a single storm. At Anniston, the average date of the first 32°F temperature is November 6, and the last is March 30. This provides a growing season of 221 days (Environmental Science and Engineering, Inc. [ESE], 1998).

The average annual rainfall is approximately 53 inches and is well distributed throughout the year. The more intense rains usually occur during the warmer months, and some flooding occurs nearly every year. Drought conditions are rare, though the entire southeastern United States has been experiencing drought conditions for the three years previous to this writing. Approximately 80 percent of the flood-producing storms are of the frontal type and occur in the winter and spring, lasting from 2 to 4 days each. Summer storms are usually thunderstorms with intense precipitation over small areas, and these sometimes result in serious local floods. Occasionally, several wet years or dry years occur in series. Annual rainfall records indicate no characteristic order or pattern.

Winds in the FTMC area are seldom strong and frequently blow down the valley from the northeast. However, there is no truly persistent wind direction. Normally, only light breezes or calm prevails, except during passages of cyclonic disturbances, when destructive local wind storms develop, some into tornadoes, with winds of 100 miles per hour or more.

2.2.3 Demographics

FTMC includes 45,679 acres of government-owned and formerly leased land situated in the foothills of the Appalachian mountains of northeast Alabama. The post is located in Calhoun County, approximately 60 miles northeast of Birmingham, approximately 75 miles northwest of Auburn, and approximately 90 miles west of Atlanta, Georgia. The city of Anniston adjoins the Main Post on the south and east. The city of Weaver is located approximately 1 mile northwest of the Main Post, and the city of Oxford is approximately 5 miles south of Anniston. Pelham Range is approximately 5 miles due west of the Main Post and adjoins Anniston Army Depot along its northern boundary (SAIC, 2000).

2.3 Soils

The soil associations found at FTMC and Pelham Range (U.S. Department of Agriculture, 1961), include:

- ***Anniston-Allen, Decatur-Cumberland.*** Alluvium, resulting from weathering of older saprolitic soils developed from sandstone, shale, and quartzite; deep, well-drained, level to moderately steep soils in valleys underlain by limestone and shale. Subsoil is dark red sandy clay loam. Cumberland and Decatur soils are dark reddish-brown gravelly loam developed from limestone saprolite source.

- ***Clarksville-Fullerton.*** Well-drained to moderately well-drained stony or cherty soils developed in the residuum of cherty limestone.. This association is limited to the Pelham Range. The soils are generally dark brown to dark gray-brown silt loam.

- ***Rarden-Montevallo-Lehew.*** Moderately deep or shallow soils or ridgetops and steep slopes and in local alluvium in draws. Soils are developed from the residuum of shale and fine-grained, micaceous sandstone; reddish-brown to dark gray brown to yellow-brown silt loam, clay, or silty clay.

- ***Stony Rough Land.*** Shallow, steep, and stony soils formed from the weathering of sandstone, limestone, and Talladega Slate. Infiltration is slow; the soils contain many boulders and fragments with clayey residuum. This association underlies a large portion of the Main Post at FTMC.

In general, the soils are acidic to very strongly acidic (SAIC, 2000).

2.4 Geology and Hydrogeology

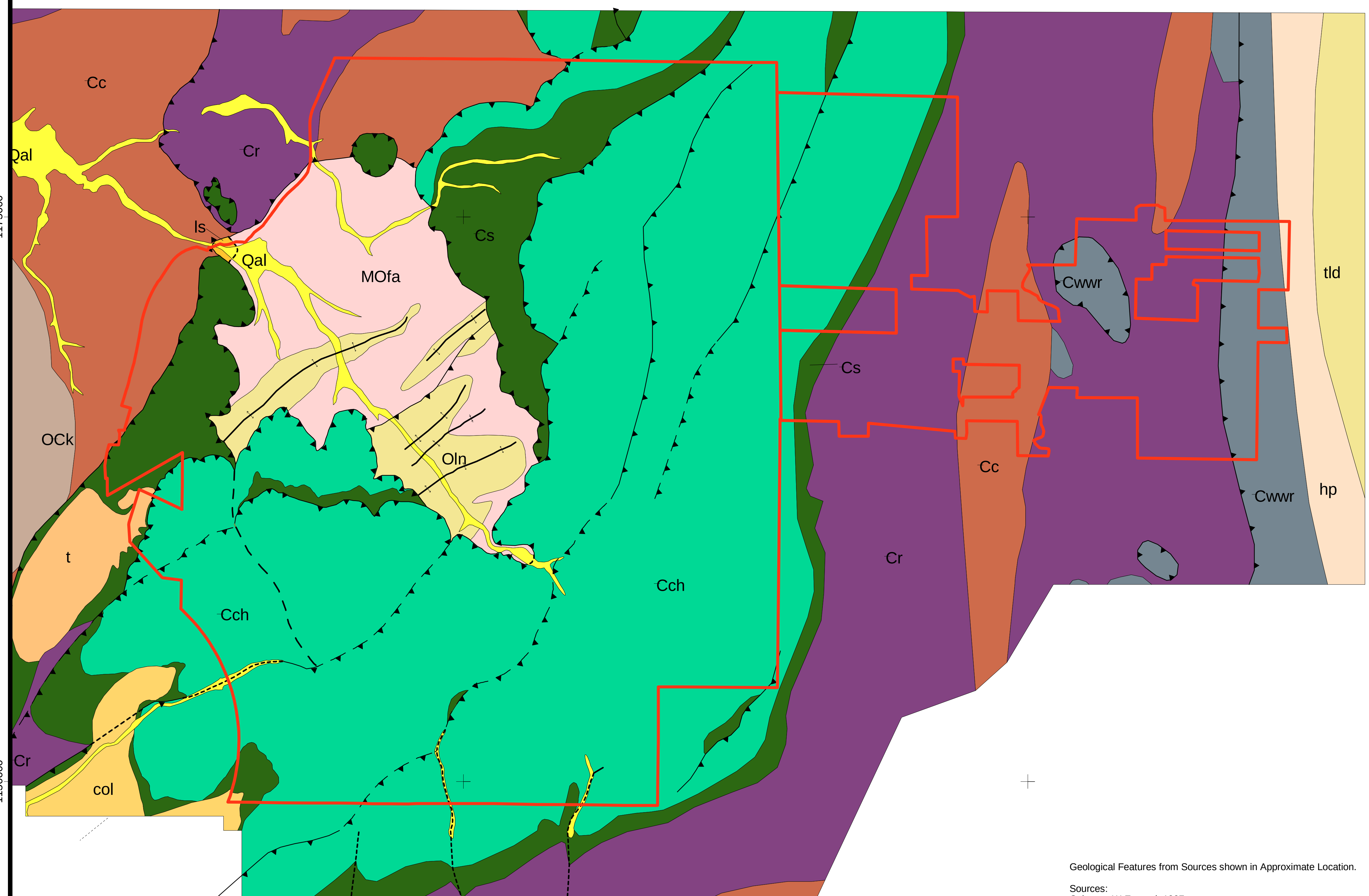
2.4.1 Geology

Calhoun County includes parts of two physiographic provinces, the Piedmont Upland Province and the Valley and Ridge Province. The Piedmont Upland Province occupies the extreme eastern and southeastern portions of the county and is characterized by metamorphosed sedimentary rocks. The generally accepted range in age of these metamorphics is Cambrian to Devonian.

The majority of Calhoun County, including the Main Post of FTMC, lies within the Appalachian fold-and-thrust structural belt (Valley and Ridge Province) where southeastward-dipping thrust faults with associated minor folding are the predominant structural features. The fold-and-thrust belt consists of Paleozoic sedimentary rocks that have been asymmetrically folded and thrust-faulted, with major structures and faults striking in a northeast-southwest direction.

Northwestward transport of the Paleozoic rock sequence along the thrust faults has resulted in the imbricate stacking of large slabs of rock referred to as thrust sheets. Within an individual thrust sheet, smaller faults may splay off the larger thrust fault, resulting in imbricate stacking of rock units within an individual thrust sheet (Osborne and Szabo, 1984). Geologic contacts in this region generally strike parallel to the faults, and repetition of lithologic units is common in vertical sequences. Geologic formations within the Valley and Ridge Province portion of Calhoun County have been mapped by Warman, et al. (1960), Osborne and Szabo (1984), and Moser and DeJarnette (1992) and vary in age from Lower Cambrian to Pennsylvanian. The geologic maps of the Main Post and Choccolocco Corridor is provided in Figure 2-2. The geologic map of Pelham Range is shown in Figure 2-3.

The basal unit of the sedimentary sequence in Calhoun County is the Cambrian Chilhowee Group. The Chilhowee Group consists of the Cochran, Nichols, Wilson Ridge, and Weisner Formations (Osborne and Szabo, 1984) but in Calhoun County is either undifferentiated or divided into the Cochran and Nichols Formations and an upper, undifferentiated Wilson Ridge and Weisner Formation. The Cochran is composed of poorly sorted arkosic sandstone and conglomerate with interbeds of greenish-gray siltstone and mudstone. Massive to laminated, 675000 700000



1175000 1150000

Geological Features from Sources shown in Approximate Location.

Sources:
Osborne, W.E., et al, 1997,
Preliminary Geologic Map of the Anniston 7.5' Quadrangle,
Calhoun County, Alabama, Geologic Survey of Alabama, overlaying:

Osborne, W.E., et al, 1988, Geologic Map of Alabama,
Northeast Sheet, Alabama Geological Survey Special Map 220,
scale 1:250K 5 sheets.

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675000 700000

Figure 2-2

Geologic Map - Main Post and Choccolocco Corridor

Legend

- Boundary
- Fault (direction of movement is unknown)
- Thrust Fault (dashed where inferred)
- Geologic Contact
- Concealed Fault
- Syncline
- Anticline

Geology

Qal	Quaternary - alluvium
col	Colluvium - age unknown
t	Terrace Deposit - age unknown
ls	Limestone - age unknown
MOfa	Mississippian/Ordovician - Floyd & Athens Shale, Undifferentiated
Oln	Ordovician - Little Oak and Newala Limestones
OꞒk	Cambrian/Ordovician - Knox Group, Undifferentiated
Ꞓc	Cambrian - Conasauga Formation
Ꞓr	Cambrian - Rome Formation
Ꞓs	Cambrian - Shady Dolomite
Ꞓch	Cambrian - Chilhowee Group
Ꞓwwr	Cambrian - Weisner and Wilson Ridge Formations, undifferentiated
hp	Cambrian? - Heflin Phylite
tld	Silurian/Devonian? - Lay Dam Formation

0 5000 10000

NAD83 State Plane coordinates

N

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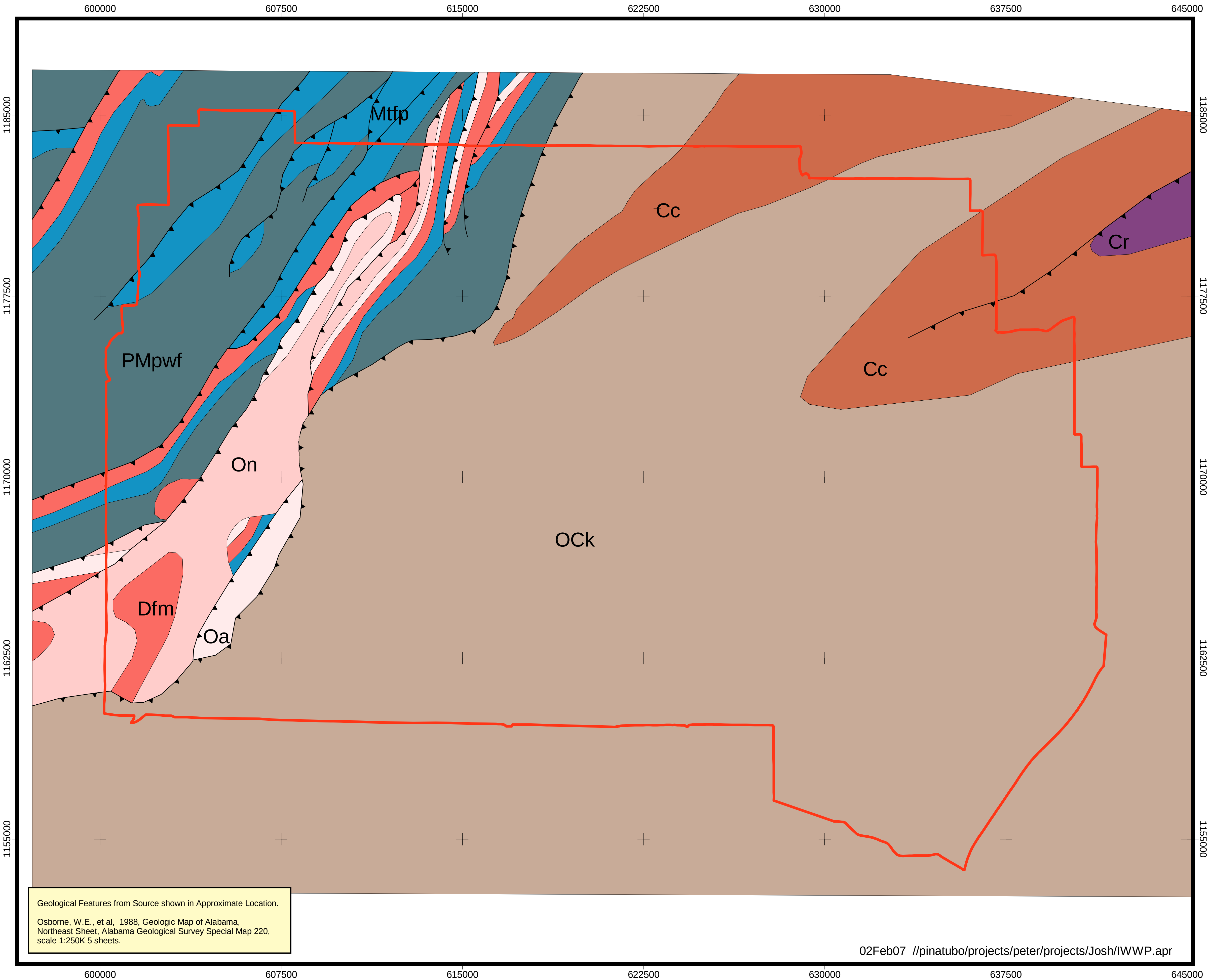

Figure 2-3

Geologic Map - Pelham Range

Legend

- Fault (direction of movement is unknown)
- Thrust Fault (dashed where inferred)
- Geologic Contact
- Boundary

Geology

PMpwf	Pennsylvanian/Missispipian - Parkwood Formation and Floyd Shale undifferentiated
Mtfp	Mississippian - Tuscumbia Limestone and Fort Payne Chert, undifferentiated
Dfm	Devonian - Frog Mountain Sandstone
Oa	Ordovician - Athens Shale
On	Ordovician - Newala Limestone
OCk	Cambrian/Ordovician - Knox Group, Undifferentiated
Cc	Cambrian - Conasauga Formation
Cr	Cambrian - Rome Formation

0 4000 8000

NAD83 State Plane coordinates

N

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greenish-gray and black mudstone makes up the Nichols Formation, with thin interbeds of siltstone and very fine-grained sandstone (Szabo et al., 1988). These two formations are mapped only in the eastern part of the county.

The Wilson Ridge and Weisner Formations are undifferentiated in Calhoun County and consist of both coarse-grained and fine-grained clastics. The coarse-grained facies appears to dominate the unit and consists primarily of coarse-grained, vitreous quartzite and friable, fine- to coarse-grained, orthoquartzitic sandstone, both of which locally contain conglomerate. The fine-grained facies consists of sandy and micaceous shale and silty, micaceous mudstone, which are locally interbedded with the coarse clastic rocks. The abundance of orthoquartzitic sandstone and quartzite suggests that most of the Chilhowee Group bedrock in the vicinity of FTMC belongs to the Weisner Formation (Osborne and Szabo, 1984).

The Cambrian Shady Dolomite overlies the Weisner Formation northeast, east, and southwest of the Main Post and consists of interlayered bluish-gray or pale yellowish-gray, sandy dolomitic limestone and siliceous dolomite with coarsely crystalline, porous chert (Osborne et al., 1989). A variegated shale and clayey silt have been included within the lower part of the Shady Dolomite. Material similar to this lower shale unit was noted in core holes drilled by the Alabama Geologic Survey on FTMC (Osborne and Szabo, 1984). The character of the Shady Dolomite in the FTMC vicinity and the true assignment of the shale at this stratigraphic interval are still uncertain (Osborne, 1999).

The Rome Formation overlies the Shady Dolomite and locally occurs to the northwest and southwest of the Main Post as mapped by Warman, et al. (1960) and Osborne and Szabo (1984). The Rome Formation consists of variegated, thinly interbedded grayish-red-purple mudstone, shale, siltstone, and greenish-red and light gray sandstone, with locally occurring limestone and dolomite. The Conasauga Formation overlies the Rome Formation and occurs along anticlinal axes in the northeastern portion of Pelham Range (Warman, et al., 1960; Osborne and Szabo, 1984) and the northern portion of the Main Post (Osborne et al. 1997). The Conasauga Formation is composed of dark-gray, finely to coarsely crystalline, medium- to thick-bedded dolomite with minor shale and chert (Osborne et al., 1989).

Overlying the Conasauga Formation is the Knox Group, which is composed of the Copper Ridge and Chepultepec dolomites of Cambro-Ordovician age. The Knox Group is undifferentiated in Calhoun County and consists of light medium gray, fine to medium crystalline, variably bedded to laminated, siliceous dolomite and dolomitic limestone that weather to a chert residuum (Osborne and Szabo, 1984). The Knox Group underlies a large portion of the Pelham Range area.

The Ordovician Newala and Little Oak Limestones overlie the Knox Group. The Newala Limestone consists of light to dark gray, micritic, thick-bedded limestone with minor dolomite. The Little Oak Limestone consists of dark gray, medium- to thick-bedded, fossiliferous, argillaceous to silty limestone with chert nodules. These limestone units are mapped together as undifferentiated at FTMC and in other parts of Calhoun County. The Athens Shale overlies the Ordovician limestone units. The Athens Shale consists of dark-gray to black shale and graptolitic shale with localized interbedded dark gray limestone (Osborne et al., 1989). These units occur within an eroded "window" in the uppermost structural thrust sheet at FTMC and underlie much of the developed area of the Main Post.

Other Ordovician-aged bedrock units mapped in Calhoun County include the Greensport Formation, Colvin Mountain Sandstone, and Sequatchie Formation. These units consist of various siltstones, sandstones, shales, dolomites and limestones and are mapped as one, undifferentiated unit in some areas of Calhoun County. The only Silurian-age sedimentary formation mapped in Calhoun County is the Red Mountain Formation. This unit consists of interbedded red sandstone, siltstone, and shale with greenish-gray to red silty and sandy limestone.

The Devonian Frog Mountain Sandstone consists of sandstone and quartzitic sandstone with shale interbeds, dolomudstone, and glauconitic limestone (Szabo et al., 1988). This unit locally occurs in the western portion of Pelham Range.

The Mississippian Fort Payne Chert and the Maury Formation overlie the Frog Mountain Sandstone and are composed of dark- to light-gray limestone with abundant chert nodules and greenish-gray to grayish-red phosphatic shale, with increasing amounts of calcareous chert toward the upper portion of the formation (Osborne and Szabo, 1984). These units occur in the northwestern portion of Pelham Range. Overlying the Fort Payne Chert is the Floyd Shale, also of Mississippian Age, which consists of thin-bedded, fissile, brown to black shale with thin intercalated limestone layers and interbedded sandstone. Osborne and Szabo (1984) reassigned the Floyd Shale, which was mapped by Warman, et al. (1960) on the Main Post of FTMC, to the Ordovician Athens Shale on the basis of fossil data.

The Jacksonville Thrust Fault is the most significant structural geologic feature in the vicinity of FTMC, both for its role in determining the stratigraphic relationships in the area and for its contribution to regional water supplies. The trace of the fault extends northeastward for approximately 39 miles between Bynum, Alabama, and Piedmont, Alabama. The fault is interpreted as a major splay of the Pell City Fault (Osborne and Szabo, 1984). The Ordovician sequence comprising the Eden thrust sheet is exposed at FTMC through an eroded "window," or "fenster," in the overlying thrust sheet. Rocks within the window display complex folding, with the folds being overturned and tight to isoclinal. The carbonates and shales locally exhibit well-developed cleavage (Osborne and Szabo, 1984). The FTMC window is framed on the northwest by the Rome Formation, north by the Conasauga Formation, northeast, east, and southwest by the Shady Dolomite, and southeast and southwest by the Chilhowee Group (Osborne et al., 1997).

2.4.2 Hydrogeology

The hydrogeology of Calhoun County has been investigated by the Geologic Survey of Alabama (GSA) (Moser and DeJarnette, 1992) and the U.S. Geological Survey (USGS) in cooperation with the GSA (Warman et al., 1960) and ADEM (Planert and Pritchette, 1989). Groundwater in the vicinity of FTMC occurs in residuum derived from bedrock decomposition, within fractured bedrock, along fault zones, and from the development of karst frameworks. Groundwater flow may be estimated to be toward major surface water features. However, because of the impacts of differential weathering and variable fracturing and the potential for conduit flow development, the use of surface topography as an indicator of groundwater flow direction must be exercised with caution in the area. Areas with well-developed residuum horizons may subtly reflect the surface topography, but the groundwater flow direction also may exhibit the influence of pre-existing structural fabrics or the presence of perched water horizons on unweathered ledges or impermeable clay lenses. Because of the various geologic factors described above, the extension of groundwater elevation contours over distances on the size and scale of FTMC is not practical without closely spaced control points (SAIC, 2000).

Precipitation and subsequent infiltration provide recharge to the groundwater flow system in the region. The main recharge areas for the aquifers in Calhoun County are located in the valleys. The ridges generally consist of sandstones, quartzite, and slate, which are resistant to weathering, relatively unaffected by faulting, and therefore relatively impermeable. The ridges have steep slopes and thin to no soil cover, which enhances runoff to the edges of the valleys (Planert and Pritchette, 1989).

The thrust fault zones typical of the county form large storage reservoirs for groundwater. Points of discharge occur as springs, effluent streams, and lakes. Coldwater Spring is the largest spring in the State of Alabama, with a discharge of approximately 32 million gallons per day. This spring is the main source of water for the Anniston Water Department, from which FTMC buys its water. The spring is located approximately 5 miles southwest of Anniston and discharges from the brecciated zone of the Jacksonville Fault (Warman et al., 1960).

Shallow groundwater on FTMC occurs principally in the residuum developed from Cambrian sedimentary and carbonate bedrock units of the Weisner Formation and the Shady Dolomite and locally in lower Ordovician carbonates. The residuum may yield adequate groundwater for domestic and livestock needs but may go dry during prolonged dry weather. Groundwater within the residuum serves as a recharge reservoir for the underlying bedrock aquifers. Bedrock permeability is locally enhanced by fracture zones associated with thrust faults and by the development of solution (karst) features.

Two major aquifers were identified by Planert and Pritchette (1989), the Knox-Shady and Tuscumbia-Fort Payne aquifers. The continuity of the aquifers has been disrupted by the complex geologic structure of the region, such that each major aquifer occurs repeatedly in different areas. The Knox-Shady aquifer group occurs over most of Calhoun County and is the main source of groundwater in the county. It consists of the Cambrian and Ordovician aged quartzite and carbonates. The Conasauga Formation is the most utilized unit of the Knox-Shady aquifer, with twice as many wells drilled as any other unit (Moser and DeJarnette, 1992).

The Tuscumbia-Fort Payne aquifer occurs in the extreme northwestern portion of the county. This aquifer consists of Mississippian age carbonates and shales. Because of its limited outcrops in the recharge area and the rugged terrain of the outcrop area, the Tuscumbia-Fort Payne aquifer is not considered a major groundwater supply in Calhoun County (Moser and DeJarnette 1992). However, it is an important source of groundwater in counties to the west (Planert and Pritchette, 1989).

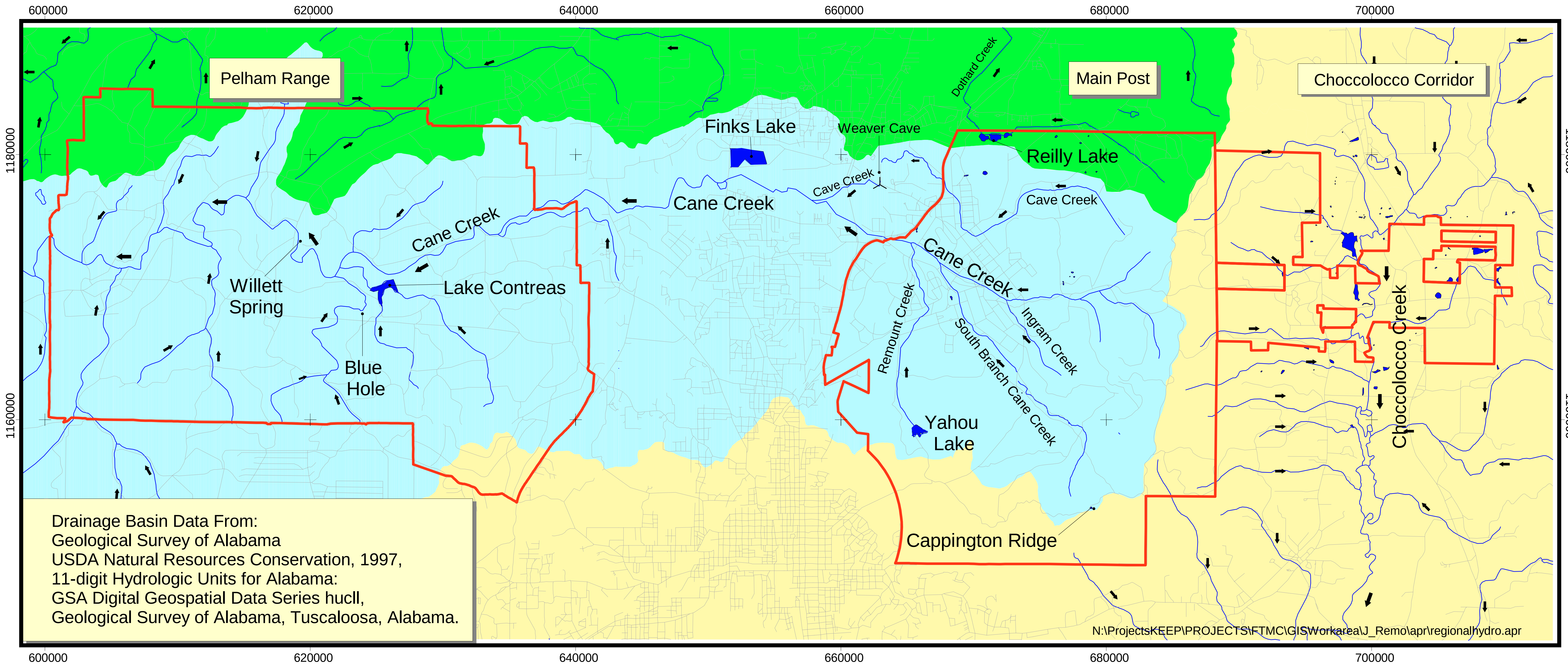
2.5 Surface Hydrology

The Choccolocco Mountains, located in the eastern portion of the Main Post, form a major surface water divide. East of this divide, the reservation consists of a relatively narrow strip called Choccolocco Corridor, which extends approximately 3.5 to 4 miles from the mountains across the floodplain of Choccolocco Creek, to the base of Rattlesnake Mountain. Choccolocco Creek and its tributaries drain this portion of FTMC and flow southward to the Coosa River.

The entire central portion of FTMC west of the drainage divide is drained by three major creeks and their tributaries. South Branch of Cane Creek receives runoff from the south-central portion, then joins Cane Creek before leaving the reservation on the western boundary. Cane Creek receives surface runoff from the central section. The north-central section of the Main Post is drained by Cave Creek, which leaves the post on the northwestern boundary. Other surface water features on the Main Post include Lake Yahou (13.5 acres), Reilly Lake (8.5 acres), Cappington Ridge (0.3 acres), Duck Pond (0.5 acre), and an aqueduct. Surface drainage is collected in small, independent networks that drain areas varying from 20 to 60 acres (SAIC, 1993). The major surface water features are shown in Figure 2-4.

The Cane/Cave Creek watershed is among the six major watersheds occurring within Calhoun County. Cane Creek, with its tributaries (Remount Creek, South Branch of Cane Creek, and Ingram Creek), originates on the FTMC Reservation. Cave Creek, which occurs as a separate body on FTMC, originates on post and discharges into Cane Creek off post. The on-post drainage area of this system covers approximately 20 square miles. Dothard Creek headwaters originate on post and flow north into the Tallasseehatchee Creek. These creek systems originate in the Choccolocco Mountains on the eastern boundary of the installation and flow west through the main cantonment. They are fed by springs originating from underlying strata.

Cane Creek, which flows westward from the Main Post across the center of Pelham Range, and its tributaries drain almost all of Pelham Range. Drainage entering the range from the south originates in the Anniston Army Depot, which joins Pelham Range to the south. Cane Creek traverses this low some 800 yards to the north, and all water collected in the low eventually drains into Cane Creek. Other surface water features on Pelham Range include Lake Contreas (27 acres), Cane Creek Lake (7.5 acres), Willet Springs (0.8 acres), and Blue Hole (0.2 acres). All drainage from FTMC and Pelham Range ultimately empties into the Coosa River. Floodplains up to 2,500 feet wide traverse this sector and slope toward the center of the range. The wide floodplains are absent in the southern portion of the range.



Legend

- Pelham Range, Main Post, and Choccolocco Corridor Boundries
- Major Streams and Rivers
- Roads
- Ponds and Lakes
- Surface Water Flow Direction
- Cave
- Cane Creek Drainage Basin
- Tallasseehatchee Creek Drainage Basin
- Choccolocco Creek Drainage Basin

N

4500 0 4500 9000 Feet

NAD 83 State Plane Feet

Figure 2 - 4

Surface Water Hydrology and Drainage Basins

Fort McClellan
Calhoun County, Alabama

U.S. Army Corps of Engineers
Mobile District
Fort McClellan
Calhoun County, Alabama
Contract No. DACA21-96-D-0018

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2.6 Sensitive Environments

2.6.1 Wetlands

Wetland habitats within FTMC are generally located in the valleys along creek floodplains, near streams, and in depressions. Wetlands identified within the Main Post are illustrated on Figure 2-5. The indicator plant species that assist in defining a wetland include water oaks, sweet gum, bulrush, needlerush, and cattail. Wetlands identified on Pelham Range are shown on Figure 2-6. The Main Post, Pelham Range, and Choccolocco Corridor have an abundance of wetlands representing important habitats for a wide variety of plants and animals.

Wetland communities found on the Main Post are the Marcheta Hill Orchard Seep, Cave Creek Seep, South Branch of Cane Creek, and 200 acres west of Reilly Airfield (Endangered Species Management Plan [ESMP]) (Garland, 1996). Additionally, wetland habitat potentially exists at or around the installation's lakes, namely Lake Reilly and Lake Yahou, and along the creeks, namely Cane Creek and Cave Creek (Roy F. Weston [Weston], 1990). A detailed discussion of wetlands is included in Section 5.3.2.

2.6.2 Sensitive Habitats

Fort McClellan operated under the guidelines of the Endangered Species Act of 1973, the regulations of the U.S. Fish and Wildlife Service (USFWS), Army Regulation 200-3, and its ESMP. The overall objectives of the ESMP are to sustain the existing habitat that supports populations of species identified in the ESMP and to promote the augmentation of these species into unoccupied land that has similar habitats.

The ESMP identifies 11 Special Interest Natural Areas (SINA) on the Main Post (Figure 2-5). SINAs are locations where the habitat fosters one or more rare, threatened, or endangered species. Because these species are sensitive to environmental degradation, SINAs require management practices that promote the continued well being of these ecosystems. According to the ESMP, the 11 SINAs located on the Main Post include:

- Mountain Longleaf Community Complex
- Cave Creek Seep
- Moorman Hill Mountain Juniper
- Frederick Hill Aster Site
- Bains Gap Seep

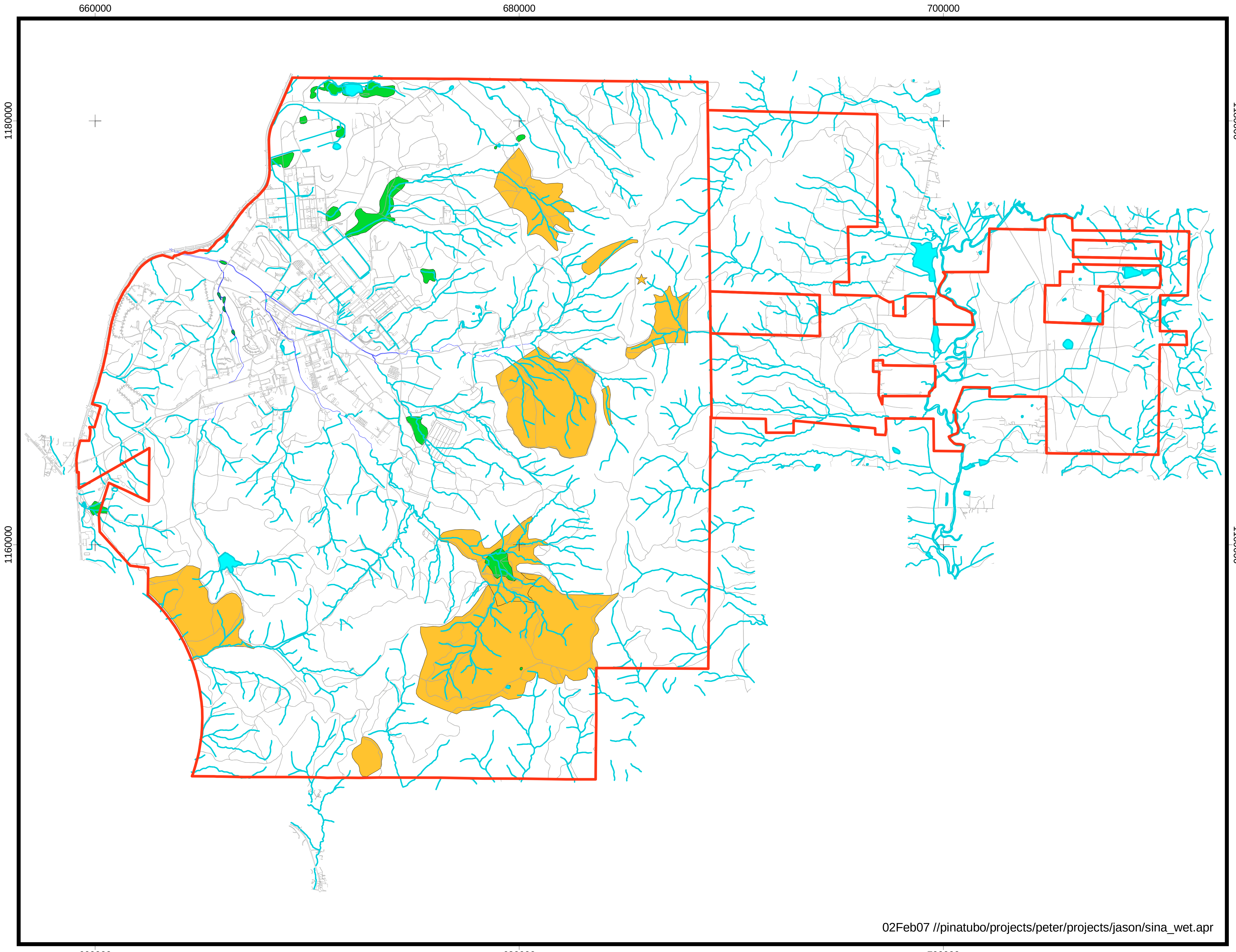

Figure 2-5

Special Interest Natural Areas and Wetlands - Main Post and Choccolocco Corridor

Legend

- Roads
- Streams - intermittent
- Streams
- FTMC Boundary
- Lakes
- Wetlands
- Special Interest Natural Areas

0 5000 10000

NAD83 State Plane coordinates

N

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Mobile District
Fort McClellan
Calhoun County, Alabama
Contract No.: DACA21-96-D-0018

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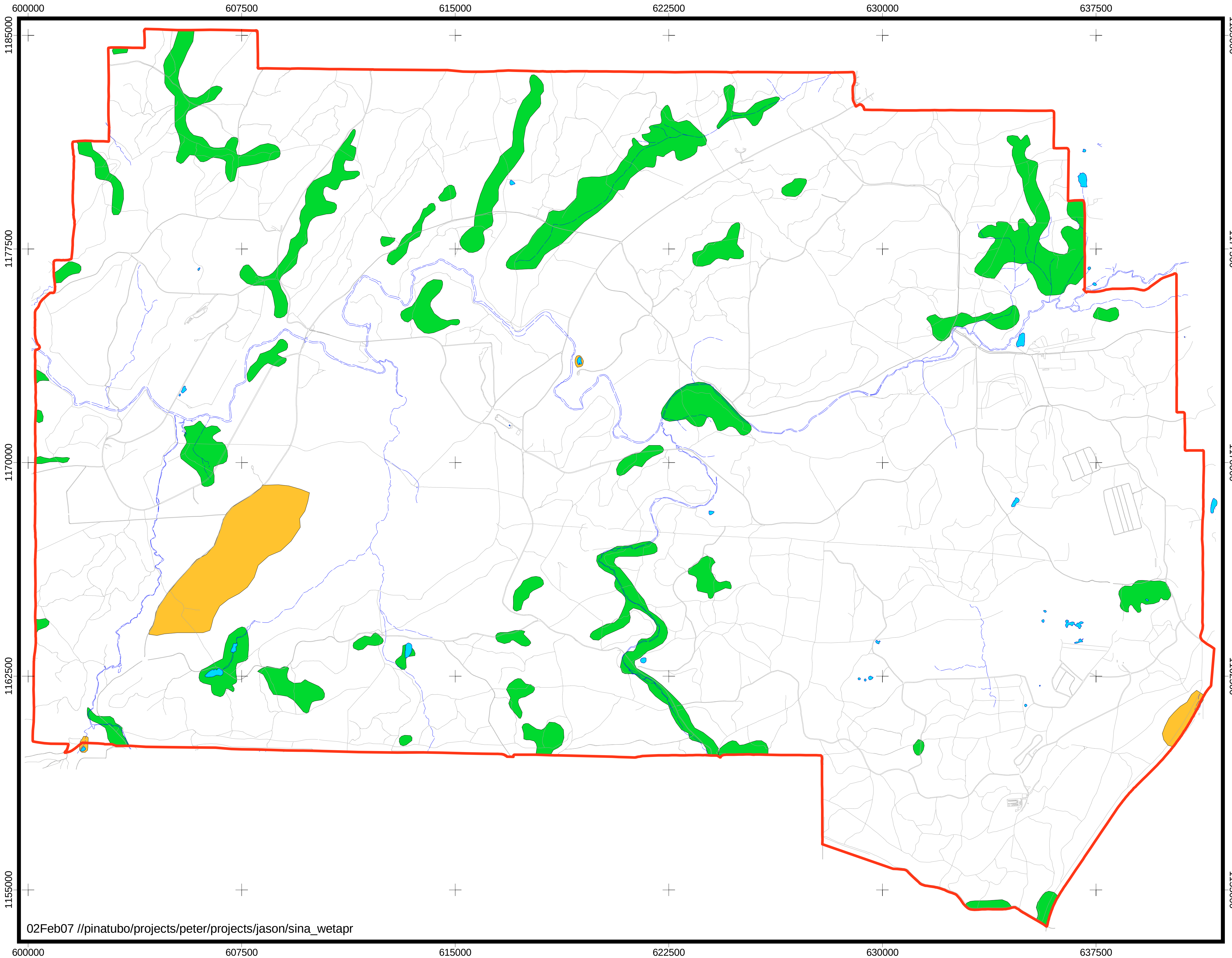
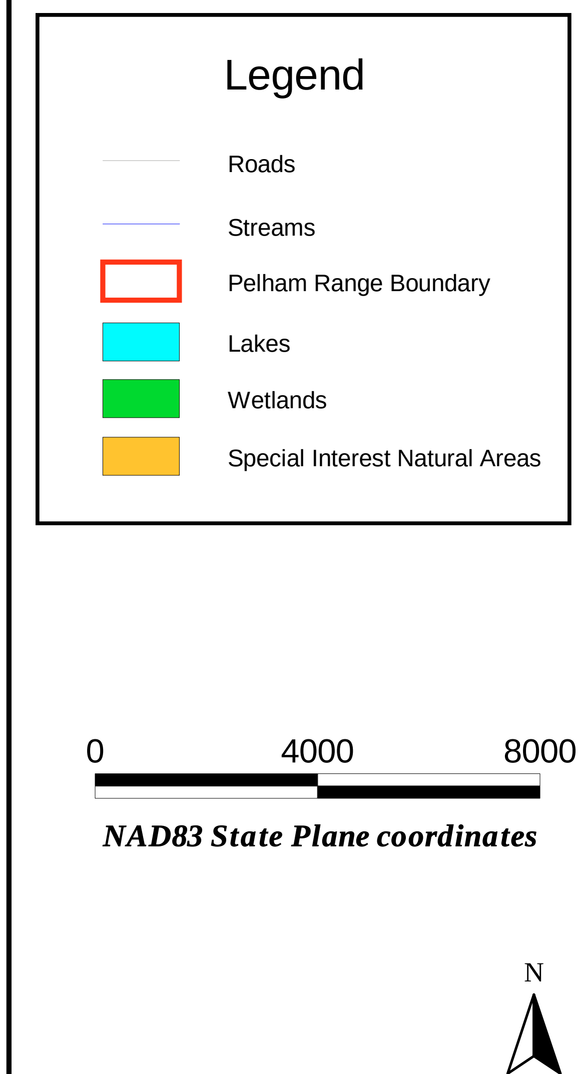


Figure 2-6

Special Interest Natural Areas and Wetlands - Pelham Range



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Fort McClellan
Calhoun County, Alabama
Contract No.: DACA21-96-D-0018

- Marcheta Hill Crow-Poison Seep
- Marcheta Hill Orchid Seep
- South Branch of Cane Creek Seep
- Stanley Hill Chestnut Oak Forest
- Reynolds Hill Turkey Oak
- Davis Hill Honeysuckle.

Five SINAs located on Pelham Range (Figure 2-6) include:

- Willett Springs
- Lloyd's Chapel Swale
- Impact Area Barren
- Cabin Club Spring
- Cane Creek Corridor.

2.6.3 Threatened and Endangered Species

Rare species deserving unofficial protection and management measures in the State of Alabama are inventoried and ranked by the Alabama Natural Heritage Program. The sensitivity of these rare species to environmental degradation is used to gauge the well-being of the habitat as a whole. A detailed discussion of threatened and endangered species is included in Section 5.2.3.

2.6.4 Cultural Resources

Cultural resources include archeological resources, and historic and architectural resources as discussed below.

Archaeological Resources. Over 70 archeological sites, both prehistoric and historic, have been identified within the boundaries of the Main Post of FTMC. Of these sites, 22 are potentially eligible or eligible for inclusion to the National Register of Historic Places (NRHP). Phase II archaeological testing is being conducted or has been conducted on these sites to determine final eligibility for the NRHP.

Historic and Architectural Resources. FTMC contains three historic districts: post headquarters, industrial, and ammunition storage districts. Within these historic districts, 89 buildings are eligible for nomination to the NRHP. New South Associates (NSA) completed a comprehensive architectural survey of FTMC in 1994 with the objective of identifying and evaluating all structures greater than 50 years in age (pre-1941); results are presented in *The Military Showplace of the South, Fort McClellan, Alabama: A Historic Building Inventory* (NSA, 1993).

2.7 Summary of Previous Investigations

A number of investigations been conducted at FTMC. This section provides a summary of the previous investigations at FTMC.

The status and historical use of chemical, biological, and radiological (CBR) training areas was investigated and documented by the U.S. Army Environmental Hygiene Agency (USAEHA) in 1975. Based on a limited records review and interview, USAEHA identified 12 areas at FTMC and Pelham Range that were possibly contaminated. Restricted access and inclusion in future land restoration and recovery programs were recommended for these areas (SAIC, 2000).

A second installation assessment consisting of records reviews, personnel interviews, and field inspections was conducted in 1977 (USATHAMA, 1977). During this assessment, burial grounds and training areas were identified within the facility in which chemical or radiological contamination existed or was suspected. In addition, records indicated that unexploded ordnance (UXO) may be present in several training areas. This study also concluded that CBR contamination had not been detected in surface water at FTMC and that a potential may exist for groundwater contamination from documented landfill operations.

Based on an extensive literature review of the fate and transport of chemical agents, decontaminants, agent decontaminant byproducts, and past on-site CBR training practices, a 1983 study identified the most probable groundwater and soil contaminants that might persist at FTMC and Pelham Range. The study investigated the persistence and potential exposure pathways for various chemical breakdown scenarios.

The 1977 installation assessment conducted by USATHAMA was re-evaluated and integrated with updated data by ESE in 1984. This study was limited to chemical agents and restricted compounds and resulted in 21 site-specific contamination assessments (SAIC, 1993).

Various U.S. Army agencies, including the FTMC Chemical School and USAEHA, conducted limited surface soil sampling and screening operations at the following sites between 1972 and 1980: Area T-5, Detection and Identification (D&I) Area, Range K, Area T-38, Range T-24A, Range J, Range L, and Landfill No. 3 (ESE, 1984). Field testing for chemical agents was negative in all known sampling and the areas were cleared for surface usage (SAIC, 2000).

USAEHA conducted an investigation at FTMC in 1986 to identify all solid waste management units (SWMU) on Base. USAEHA (1986) formally identified 41 SWMUs on FTMC and Pelham Range. Each SWMU was located, described, and evaluated to the extent possible. Five monitoring wells were installed by the agency at Landfill No. 3 as part of the investigation (SAIC, 2000).

An enhanced preliminary assessment (PA) was conducted by Roy F. Weston, Inc. in 1990 (Weston, 1990) to evaluate the status of active non-CERCLA and inactive CERCLA sites potentially impacting the U.S. Army's planned closure of FTMC. The PA identified 62 active and inactive sites on the Main Post and Pelham Range (SAIC, 2000).

The USACE-Mobile District conducted an investigation in 1991 to evaluate soil and groundwater in the vicinity of five existing or excavated underground storage tank (UST) sites in the northwestern portion of the Main Post. The investigation focused on USTs used for storing petroleum products, including gasoline, diesel, and diesel-based fuel oil. Twenty monitoring wells were installed at these sites during this investigation. Petroleum contamination of groundwater and/or soils was documented at four of the five UST sites (Ecology and Environment, Inc., 1991).

USACE initiated a site investigation (SI) in 1991 at 17 sites identified in the PA on the Main Post and Pelham Range (SAIC, 1993). Based on limited environmental sampling, including groundwater, surface water, and soil MINICAMS screening, potential environmental concerns were identified at 12 of the SI sites.

A hydrogeological evaluation of the former FTMC sanitary landfill site (Landfill No. 4) was conducted by ADEM (1993) as a component of the overall permit review process. Leachate seeps were observed at the toe of the landfill and along manmade drainage ditches near the site boundary. A program of quarterly monitoring was implemented by FTMC in 1994 for five wells located around former Landfill No. 4 (SAIC, 2000).

SAIC (2000) conducted RI/FS activities at eight areas of concern (AOC) on the Main Post, including Area T-4, Area T-5, Range T-24A, Area T-38, D&I Area, Landfill Nos. 1, 2, and 3, and four AOC at Pelham Range (Range J, Range K, and Range L, and the Old Water Hole). Investigation activities included geophysical surveys, installation of 36 groundwater monitoring wells, and collection of subsurface soil, groundwater, sediment, and surface water samples.

Through January 2002, IT has completed SIs at 68 FTMC sites. Remedial investigations are ongoing at Area T-38, Range J, Range K, Range T-24A, the Small Weapons Repair Shop, and Former Motor Pool Area 1500.

3.0 Site Investigation

Site investigations (SI) are conducted to determine the presence or absence of contamination at a site. SI activities include review of historical documents pertaining to site activities, a visual site inspection, environmental sampling and analysis. Depending on historical use of the site, monitoring well installation, field screening surveys (e.g., radiological, lead) and geophysical surveys may also be conducted. SI sampling locations are biased toward areas with the highest probability of being contaminated. Data collected during the SI are ultimately evaluated to determine whether contamination (if any) poses an unacceptable risk to human health or the environment. The evaluation process involves comparing site-specific analytical data to human health site-specific screening levels (SSSL), ecological screening values (ESV), and background screening values for FTMC.

An SI report will be prepared for each site upon completion of the field activities, laboratory and data analyses, and data validation. The SI report will describe whether contaminants are present. Furthermore, if contaminants are present, the site-specific data will be compared SSSLs and/or two-times the background screening values to determine if they pose an unacceptable risk to human health or the environment.

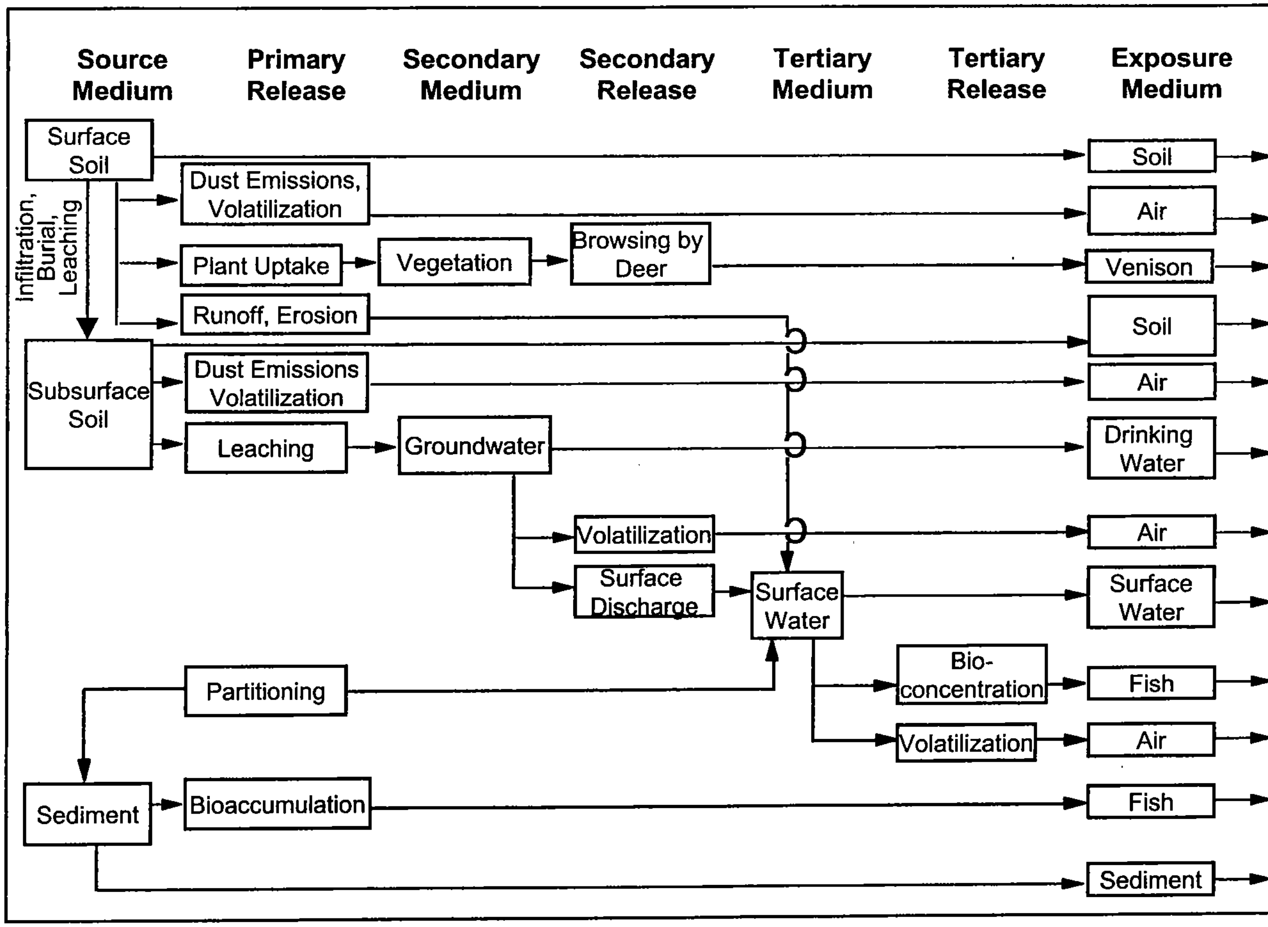
3.1 Conceptual Site Exposure Model

The CSM provides the basis for identifying and evaluating the potential risks to human health and the environment in the baseline risk assessment. The CSM (Figure 3-1 for human health, Figure 3-2 for ecology) includes the receptors appropriate for all plausible scenarios, and the potential exposure pathways. Graphical presentation of all possible pathways by which a potential receptor may be exposed, including all sources, release and transport pathways, and exposure routes, facilitates consistent and comprehensive evaluation of risk to human health and the environment, and helps to ensure that potential pathways are not overlooked. The elements necessary to construct a complete exposure pathway and develop the CSM include:

- Source (i.e., contaminated environmental) media;
- Contaminant release mechanisms;
- Contaminant transport pathways;
- Receptors; and
- Exposure pathways.

Receptor Scenarios

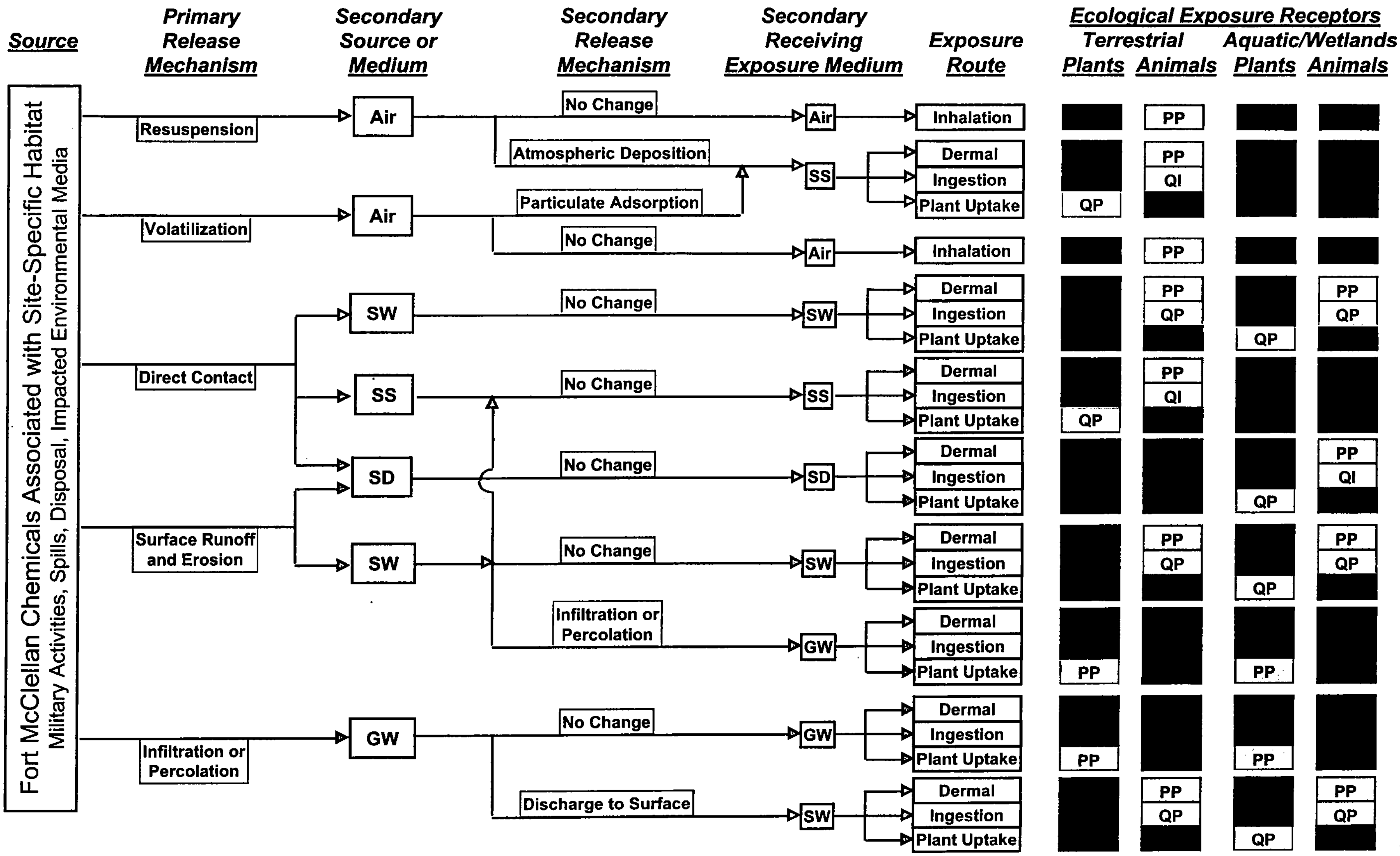
Figure 3-1
Generic Human Health Conceptual Site Exposure Model
Fort McClellan, Alabama



Exposure Medium	Exposure Route	Resident	Groundskeeper	Recreational Site User	Construction Worker	Venison and Fish Consumption	Highway Worker	National Guardsperson
Soil	Ingestion	✱	✱	✱	✱	1	✱	✱
Soil	Dermal Contact	✱	✱	✱	✱	1	✱	✱
Air	Inhalation	2	✱	2	✱	1	✱	✱
Venison	Ingestion	1	1	1	1	✱	1	1
Soil	Ingestion	1	1	1	✱	1	✱	✱
Soil	Dermal Contact	1	1	1	✱	1	✱	✱
Air	Inhalation	1	1	1	✱	1	✱	✱
Drinking Water	Ingestion	✱	✱	1	✱	1	1	✱
Drinking Water	Dermal Contact	✱	✱	1	✱	1	1	✱
Air	Inhalation	✱	3	1	3	1	1	✱
Surface Water	Ingestion	4	1	✱	1	1	1	1
Surface Water	Dermal Contact	4	1	✱	1	1	1	1
Fish	Ingestion	1	1	1	1	✱	1	1
Air	Inhalation	3	1	3	1	3	1	1
Fish	Ingestion	1	1	1	1	✱	1	1
Sediment	Ingestion	4	1	✱	1	1	1	1
Sediment	Dermal Contact	4	1	✱	1	1	1	1

✱ = Complete exposure pathway quantified in SSSL development.
1 = Incomplete exposure pathway for this receptor.
2 = Volatilization from undisturbed surface soil deemed insignificant; soil is likely to be paved or vegetated, reducing dust emissions to insignificant levels; inhalation pathway not quantified.
3 = Although theoretically complete, this pathway is judged to be insignificant.
4 = Although theoretically complete, SSSLs for these pathways are developed only for the recreational site user. SSSLs developed for the recreational site user may be used to estimate risk for this receptor.

Figure 3-2 Generic Ecological Conceptual Site Exposure Pathway Model (CSEPM)
Fort McClellan, Calhoun County, Alabama



LEGEND:
MEDIA CODES: SS = surface soil SW = surface water SD = sediment GW = groundwater SB = subsurface soil
RECEPTOR EXPOSURE CODES: QP = Quantified pathway QI = Quantified pathway for incidental exposure PP = Possible pathway not quantified ■ = Not an applicable exposure route
PATHWAY DESIGNATORS: - - - Dashed line indicates a lower contaminant migration potential

KN2/4040/I-Wide/WP/Fig 3-2.ppt/2/13/02 4:52 PM

Contaminant release mechanisms and transport pathways are not relevant for direct receptor contact with a contaminated source medium.

The receptors and pathways shown on Figures 3-1 and 3-2 reflect plausible scenarios developed from information regarding site background and history, topography, climate, ecological habitat, and demographics (ESE, 1998). The asterisks show the exposure pathways that are complete and addressed in the risk assessment. Justification for exclusion of human health pathways is provided in the footnotes and in Section 3.1.2.

At this stage in the investigation, the CSM should be considered a generic model generally applicable to FTMC as a whole. Site-specific work plans or addenda will be issued to customize the generic model to the potential contamination sources, transport mechanisms, and exposure scenarios relevant for the specific site under investigation. In addition, the CSM should be considered a living model, subject to ongoing revision and modification, as site-specific investigations are conducted, familiarity with the site increases, and lessons are learned and implemented.

3.1.1 Potential Source Areas and Release Mechanisms

Potential sources at FTMC vary from site to site depending of the nature of the activities performed there (ESE, 1998). Sources may include chemical releases or waste on the surface of the ground, or buried waste. Volatilization or dust emissions may result in distribution of contaminants from surface soil to air. Erosion and runoff during storm events may move contaminants from surface soil to surface water.

Infiltration or percolation may move wastes from surface to subsurface soil. Leaching may move contaminants from subsurface soil to groundwater. The groundwater may discharge to surface water, particularly where there are springs and seeps, at Cane Creek and other creeks and streams, at the many lakes in the area, and in low areas (ESE, 1998).

Deer and other game animals are known to inhabit large portions of FTMC. Soil contaminants may be assimilated by plants that provide browse or mast for game animals.

Contaminants introduced to surface water may dissolve in water, partition onto sediment, volatilize into the air, or bioconcentrate in fish. Similarly, contaminants in sediment may bioaccumulate in fish.

The primary and secondary release mechanisms may result in impacts to surface soil, subsurface soil, biota, surface water, sediment, and groundwater.

3.1.2 Identification of Potential Human Health Receptors

FTMC is currently under the control of the U.S. Army but is undergoing closure and transfer by the Base Realignment and Closure Commission (ESE, 1998). The Base is open to the public, except for certain restricted areas. Large portions of the Main Post are well developed, including military management facilities, housing facilities, community services facilities, and health care centers. Pelham Range was used as a training ground for many different military operations. Some of the area is open land and much of the area is wooded. Creeks and lakes are present, some of which support fish populations and sport fishing.

Current information shows several existing private and public supply wells located within the immediate vicinity of FTMC. Thus, groundwater will be evaluated as a potential source of potable water.

Because of the size and complexity of the FTMC installation, a streamlined approach to risk evaluation was employed, whereby site-specific screening levels (SSSL) are developed. The SSSLs are medium- and receptor-specific risk-based concentrations that are used to quickly and efficiently screen a site. They address all significant exposure pathways and are sufficiently site-specific that they can be used to estimate risk with as much precision as a typical baseline risk assessment. A detailed discussion of the SSSL development is included in the *Human Health and Ecological Screening Values and PAH Background Summary Report, Fort McClellan, Calhoun County, Alabama* (IT, 2000a).

The first step of SSSL development is to propose the receptor scenarios for which SSSLs should be estimated. Two approaches may be taken. The first approach is to identify all possible site-use scenarios and potential receptors and develop SSSLs for each receptor. The second approach is to combine all possible site-use scenarios under a few general types and develop SSSLs only for the most highly exposed receptor for each general site-use scenario. The latter approach is suggested here, largely because it is simpler, less expensive, and will meet the needs of the large majority of sites to be evaluated. If additional site-specificity is needed, it can usually be gained by introducing or adjusting the fraction-of-exposure-to-contaminated-medium term, as explained in Chapter 5.0 of this WP.

Based on information compiled by ESE (1998), current use of most FTMC sites can be categorized broadly as follows:

- ***Residential.*** including living areas, schools, parks, playgrounds, golf courses, retirement centers, medical facilities, stores and other commercial facilities, and all other areas that support activities associated with living in a community.

- ***Industrial.*** including employment areas, office buildings, research facilities, motor pools and garages, transportation facilities, military facilities, training fields, landfills, dumps, disposal sites, and all other areas and activities other than residential.

- ***Open Space.*** including "unused" land or buffer space, wetlands, wooded or meadow areas, and all other areas not used for residential or industrial activities (hunting, fishing or occasional visiting may occur).

Projected future uses for most sites fit the same general categories (FTMC, 1997).

Proposed Receptor Scenarios. This section proposes the receptors for which SSSLs are developed for each site-use scenario. It is expected that the receptors proposed herein are sufficient for the large majority of sites. It is possible, however, that a significantly less restrictive receptor scenario would be more appropriate for a given site with unique characteristics that influence its potential uses so that none of the site uses described above are relevant, in which case a new receptor scenario will be developed and SSSLs will be estimated specifically for the site in question.

Residential Site Use. Residential site use, as previously defined, includes all the activities and involves all the members of a population associated with living in a community. It is generally agreed that the full-time resident is the receptor most intensely exposed to surface soil and groundwater developed as a potable supply. Therefore, SSSLs will be calculated for surface soil and groundwater for the full-time resident, but not for the other users of a residential site. A resident would also be exposed to surface water and sediment, but exposure to these media is evaluated under the recreational site-user scenario rather than the residential scenario. The risk estimates for recreational exposure to surface water and sediment will be added to those for residential exposure to surface soil and groundwater to total risk for residential exposure summed across all media.

Industrial Site Use. Industrial site use includes all activities associated with employment or military activity. Media of interest include surface soil and groundwater. Some industrial receptors are exposed primarily indoors and some primarily outdoors. Outdoor workers are more intensely exposed to soil and groundwater than indoor workers; therefore, an outdoor worker scenario, herein defined as a groundskeeper, is developed to represent the most intensely exposed site worker, and SSSLs are calculated for groundskeeper exposure to both media. SSSLs will not be calculated for soil or groundwater for other potential users of an industrial site.

It is plausible that a groundskeeper may experience contact with surface water and sediment, but contact with these media would be sporadic and unpredictable. Such exposures would not reflect a chronic exposure paradigm and are not quantified. Exposure to surface water and sediment, if these media occur on a given site, will be evaluated under the recreational site-user scenario.

Open Space. Open space includes unused land, or land unsuitable for residential or industrial use. It is assumed that the site would be visited regularly by a recreational site user who would contact surface soil, surface water and sediment while playing, hiking, wading, fishing, or hunting. A recreational site-user scenario is developed to represent the receptor most intensely exposed to these media in open space.

Construction Worker. Some sites, regardless of current or future projected site use, are subject to further development, (e.g., razing or construction activities). A construction worker scenario is developed to evaluate exposure to surface and subsurface soil. Exposure to groundwater developed as a source of potable water is also evaluated. Exposure to surface water and sediment, although plausible, would be sporadic and is not quantified as explained for the groundskeeper.

Fish and Game Ingestion. Fish may be caught and consumed from those creeks and ponds sufficient to support sport fishing, and game may be harvested and consumed from woods and meadows sufficient to support sport hunting.

Highway Worker. During investigation of the FTMC facility it was learned that a portion of the property within the facility will be included in the Anniston East Bypass, which is currently under construction. Potentially exposed receptors include a highway construction worker and, eventually, a highway maintenance worker. The potential exposures of these two receptors were compared, and it was concluded that the highway construction worker would be the more highly exposed. Therefore, an exposure scenario was hypothesized for a construction worker that is sufficiently protective for all receptors associated with the highway. Media to which the highway worker would be exposed are limited to soil. It is assumed that groundwater production wells would not be installed in a highway right-of-way, precluding exposure to groundwater.

National Guardsperson. Several sites at FTMC will be released to the National Guard for use for training and exercise facilities for enlisted personnel. There are two categories of National Guardspersons (NGP) that may use the sites. The first are Range Control personnel, who act largely as maintenance workers and groundskeepers. The groundskeeper scenario mentioned above is sufficiently conservative to be protective for these workers. The second category, for which the NGP scenario is designed includes enlisted personnel who train and exercise for potential combat. NGPs would be exposed to soil, and to groundwater presumed to be developed as a potable source. Exposure to surface water or sediment would be infrequent and is not evaluated in the NGP scenario.

The receptor scenarios are summarized in Table 3-1 and developed in more detail in Section 5.2.2.3. Their use in risk and hazard estimation is explained in Section 5.2.5.

3.1.3 Identification of Ecological Receptors

Because of the size of FTMC and the diversity of the habitats present therein, a large and diverse assemblage of ecological receptors can be expected to inhabit FTMC. Ecological receptors will vary depending on the habitat present at a given site. Terrestrial habitats range from the well-developed areas of the Main Post to relatively undeveloped forests. A large variety of wetland communities are also present at FTMC. Aquatic habitats range from small ephemeral streams to large ponds.

Terrestrial Communities

- Maintained lawns
- Open fields/grasslands
- Old-field
- Typic mesophytic forests
- Piedmont monadnock forests
- Interior calcareous oak-hickory forests
- Basic oak-hickory forests

Table 3-1

Potential Receptors, Media, and Exposure Pathways
Fort McClellan, Calhoun County, Alabama

(Page 1 of 4)

Source Medium	Model	Exposure Medium	Exposure Pathway	Comment
RESIDENT				
Surface soil (future site use)	None	Soil	Incidental ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Volatilization from undisturbed surface soil deemed insignificant, large dilution factor of outdoor air: not quantified
	Dust emissions from wind erosion	Air	Inhalation	Soil covered with pavement or vegetation, dust emissions insignificant: not quantified
Groundwater (future site use)	None	Water	Drinking water Ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Quantified
Surface water (current and future site use)		Although exposure to surface water is a theoretically complete pathway for the resident, it is quantified only for the recreational site user		
Sediment (current and future site use)		Although exposure to sediment is a theoretically complete pathway for the resident, it is quantified only for the recreational site user		
GROUNDSKEEPER				
Surface soil (current and future site use)	None	Soil	Incidental ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Volatilization from undisturbed surface soil deemed insignificant, large dilution factor of outdoor air: not quantified
	Dust emissions based on activity	Air	Inhalation	Quantified

Table 3-1

Potential Receptors, Media, and Exposure Pathways
Fort McClellan, Calhoun County, Alabama

Source Medium	Model	Exposure Medium	Exposure Pathway	Comment
GROUNDSKEEPER (continued)				
Groundwater (future site use)	None	Water	Drinking water ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Insignificant, compared with other pathways, because of infrequent and short-term exposure, and large dilution factor of ambient air: not quantified
RECREATIONAL SITE USER				
Surface soil (current and future site use)	None	Soil	Incidental ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Volatilization from undisturbed surface soil deemed insignificant, large dilution factor of outdoor air: not quantified
	Dust emissions from wind erosion	Air	Inhalation	Soil covered with pavement or vegetation, dust emissions insignificant: not quantified
	None	Water	Intentional ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Insignificant risk because of large dilution factor of outdoor air: not quantified
Sediment (current and future site use)	None	Sediment	Incidental ingestion	Quantified
			Dermal contact	Quantified

Table 3-1

Potential Receptors, Media, and Exposure Pathways
Fort McClellan, Calhoun County, Alabama

Source Medium	Model	Exposure Medium	Exposure Pathway	Comment
CONSTRUCTION WORKER				
Subsurface soil (current and future site use)	None	Soil	Incidental ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Quantified as part of the dust emissions model
	Dust emissions based on activity	Air	Inhalation	Quantified
Groundwater (future site use)	None	Water	Drinking water ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Insignificant, compared with other pathways, because of infrequent and short-term exposure, and large dilution factor with outdoor air; not quantified.
VENISON CONSUMPTION				
Surface soil (current and future site use)	Bio-uptake by vegetation browsed by game animals (deer)	Venison	Consumption as part of diet	Quantified

Table 3-1

Potential Receptors, Media, and Exposure Pathways
Fort McClellan, Calhoun County, Alabama

(Page 4 of 4)

Source Medium	Model	Exposure Medium	Exposure Pathway	Comment
FISH CONSUMPTION				
Surface water (current and future site use)	Bioconcentration by aquatic organisms	Fish	Consumption as part of diet	Quantified
Sediment (current and future site use)	Bioaccumulation by aquatic organisms	Fish	Consumption as part of diet	Quantified
HIGHWAY WORKER				
Surface and subsurface soil (future site use)	None	Soil	Incidental ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Quantified as part of the dust emissions model.
	Dust emissions based on activity	Air	Inhalation	Quantified
NATIONAL GUARDSPERSON				
Surface and subsurface soil (future site use)	None	Soil	Incidental ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Quantified as part of the dust emissions model.
	Dust emissions based on activity	Air	Inhalation	Quantified
Groundwater (future site use)	None	Water	Drinking water ingestion	Quantified
			Dermal contact	Quantified
	Volatilization of VOCs	Air	Inhalation	Quantified

SSSL = Site-specific screening level.
VOC = Volatile organic compound.

- Loblolly and short-leaf pine forests
- Xeric Virginia pine ridge forests
- Dry Virginia pine-oak forests
- Mountain long-leaf pine forests.

Wetland Communities

- Mixed bottomland hardwoods
- Stream terrace hardwoods
- Creekbank hardwoods
- Water oak flat
- Sweet gum-bulrush community
- Sweet gum depression
- Mixed shrub community
- Mixed shrub-bulrush-needlerush community
- Buttonbush-bulrush community
- Bulrush-needlerush-cattail community
- Non-forested creekbank community
- Mud flat community.

Aquatic Communities

- Ephemeral stream
- Ephemeral pond
- Perennial stream
- Perennial pond.

Within these aquatic communities, physical characteristics of the stream/pond will also influence the ecological communities present. The three major substrate regimes that influence the aquatic ecological communities present in a given stream or pond are as follows:

- Cobble and boulder-bed channel
- Gravel-bed stream
- Sand-bed channel.

Potential ecological receptors will be identified for each habitat type found at a specific site. In general, ecological receptors will be identified by feeding guild and will fall into one or more of the following categories:

- Primary producers (aquatic and terrestrial)
- Herbivores (aquatic and terrestrial)
- Omnivores (aquatic and terrestrial)

- Carnivores (aquatic and terrestrial)
- Invertivores (aquatic and terrestrial)
- Piscivores (aquatic and terrestrial).

The potential ecological receptor scenarios will be developed for each site based on ecological habitat present at the site and the nature and extent of contamination at the site. Ecological exposures are discussed in more detail in Section 5.3.4 of this report.

4.0 Remedial Investigation

In general, the objectives of an RI are to characterize the nature and extent of contamination in environmental media at a site and to evaluate the level of risk to human health and the environment posed by releases of the chemicals of potential concern (COPC). If unacceptable risk to human health or the environment exists, remedial alternatives will be evaluated. Development of an RI involves a stepwise planning process that is applied to the collection and use of environmental data. The process begins by stating the environmental problem to be addressed or the decision to be made. Next, the information required to select an appropriate course of action is identified. Specifications regarding the type of data needed, the way data will be used, and the desired degree of uncertainty in conclusions to be derived from the data are then developed through a process that involves the decision-makers and data generators. If necessary, field investigation and laboratory analysis are repeated to adequately characterize a site for the purpose of developing and evaluating remedial alternatives. A decision diagram for an RI is shown on Figure 4-1. The specific objectives for RIs to be conducted at FTMC will be presented in the SFSPs.

4.1 Conceptual Site Model

Details regarding the development of the CSM, including potential source areas, release mechanisms, and receptors are presented in Section 3.1. The generic RI decision process is depicted on Figure 4-1.

4.2 Preliminary Identification of ARARs

The following sections provide general discussions of potential chemical-specific ARARs or to-be-considered (TBC) criteria, which, at least preliminarily, must be identified initially in order to establish DQOs. Complete ARAR analyses will be conducted, if necessary, on a site-specific basis following characterization and during the FS.

Potential sources for ARARs for FTMC are described in the following subsections. TBC criteria include state or federal screening criteria that may be used to evaluate contaminants when ARARs are not available.

Objective: The objectives of a remedial investigation are to characterize the nature and extent contamination in environmental media and to evaluate the level of risk to human health and the environment posed by releases of the chemicals of concern.

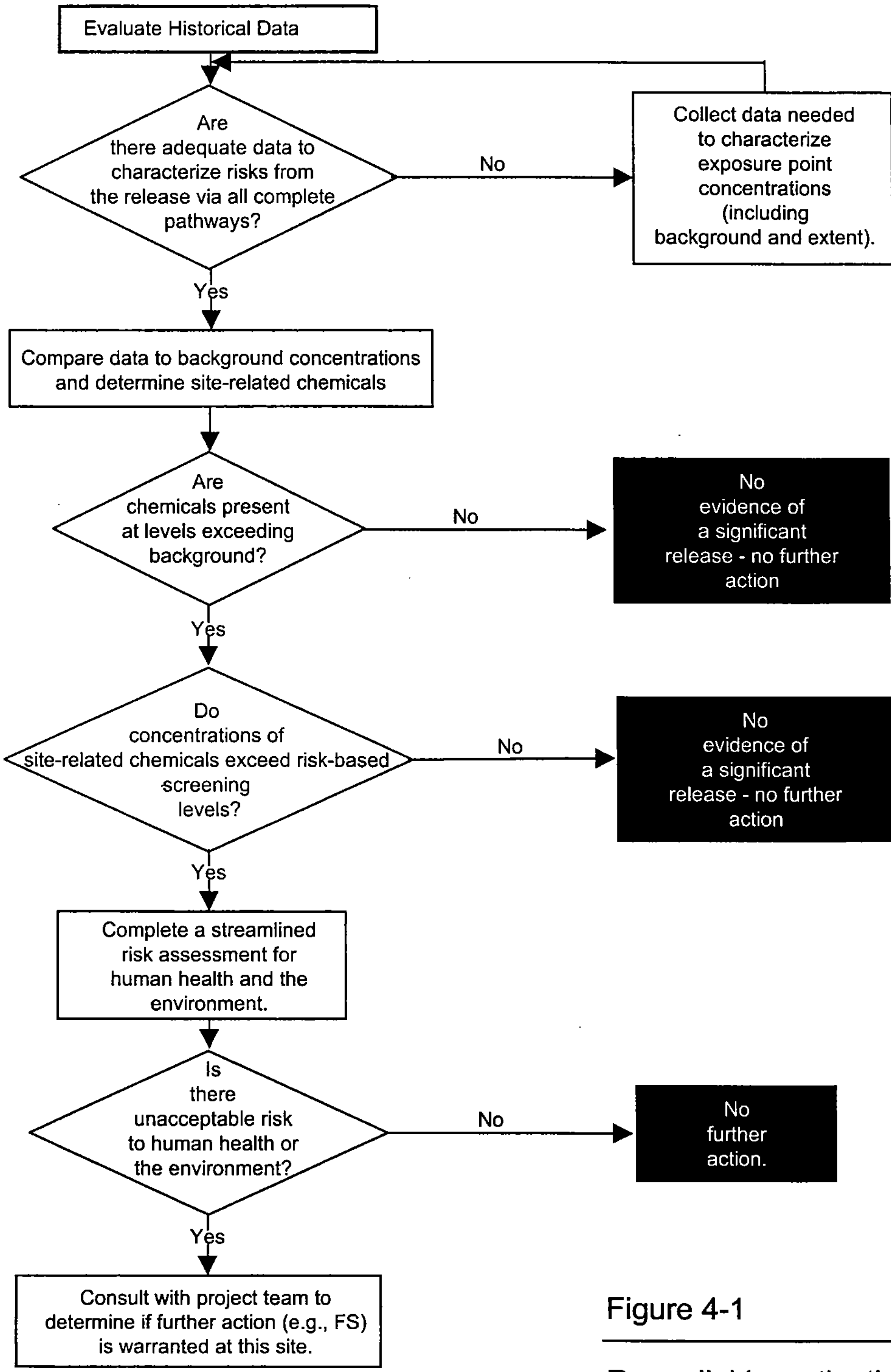


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Figure 4-1

Remedial Investigation Decision Diagram
Fort McClellan

4.2.1 Groundwater ARARs

Potential ARARs for groundwater include Resource Conservation and Recovery Act (RCRA) (Subpart F) maximum contaminant levels (MCL), Safe Drinking Water Act MCLs, and State of Alabama MCLs and Secondary Drinking Water Standards. TBC criteria include EPA Region IX Preliminary Remediation Goals (PRG) for tap water.

4.2.2 Surface Water ARARs

Potential ARARs for surface water include federal water quality criteria for freshwater organisms and for human health with respect to ingestion of water and aquatic organisms. Additional TBC ARARs include the Alabama Surface Water Quality Criteria and standards, as well as EPA Region IV freshwater screening values.

4.2.3 Soil and Sediment ARARs

ARARs are not available for soil or sediment. TBC criteria for soil and sediment include EPA Region IV soil and sediment screening values for ecological receptors and EPA soil screening levels. EPA Region IX PRGs may be used as TBC criteria for soil and sediment to evaluate potential impacts to human health from these media.

4.3 Data Quality Objectives

DQOs are qualitative statements that define the acceptability of data generated by an investigation. The data generated by site-specific investigations at the FTMC must be of sufficient quality to be used to complete the RI/FS.

4.4 Data Gaps and Data Needs

The last step in the RI/FS scoping process is assessment of the data gaps and data needs. This summary consists of identifying site-specific gaps in available data and the location, matrix, analyses, and data categories necessary to fill the data gaps.

4.5 Supplemental Comparison of Site and Background Data

This section describes supplemental methodology for comparisons of concentrations of inorganic constituents in samples from background areas versus samples from FTMC investigation sites. This methodology may be used to supplement the screening process established during the SIs, and provides an additional rigorous and scientific method to assist in identification of inorganic site-related chemicals.

The site-to-background comparisons discussed herein consist of the hot measurement test, nonparametric Wilcoxon rank sum (WRS) test, and box plots, all of which are performed in tandem as an initial screening step. Each analyte that fails one or both statistical tests will undergo geochemical evaluation. The purpose of the geochemical evaluation is to examine the site data within the context of natural elemental associations, geochemical indicators (pH, redox, etc.), and organic contaminants, as appropriate. Naturally high background levels of constituents can thus be differentiated from potentially contaminated samples.

This integrated statistical and geochemical approach is a highly effective means of distinguishing site-related contamination from background levels of constituents, and is consistent with strategies recommended in the literature (Hardin and Gilbert, 1993; EPA, 1995a; U.S. Navy, 1998 and 1999). It has been successfully demonstrated at other facilities that this approach is sufficiently rigorous for identifying and explaining suspect inorganic concentrations in soil and groundwater (IT, 1998, 2000b, 2000c, 2001a, 2001b, 2001c). The comparisons will be performed for soil, groundwater, surface water, and sediment analytical data.

The statistical techniques are described in Section 4.5.1 and the geochemical evaluation techniques are provided in Section 4.5.2. The methodology is summarized in Section 4.5.3 and examples using FTMC site data are provided in Appendix A.

4.5.1 Statistical Procedures

The statistical phase of FTMC site-to-background comparisons will consist of the hot measurement test, WRS test, and box plots. For each medium of interest, each inorganic analyte in the site data set will undergo the three statistical procedures in parallel.

Contamination can be caused by a variety of processes that yield different spatial distributions of elevated contaminant concentrations. Slight but pervasive contamination can occur from non-point-source releases, and can result in slight increases in contaminant concentrations in a large percentage of samples. Localized contamination can result in elevated concentrations in a small percentage of the total number of site samples. No single two-sample statistical comparison test is sensitive to both of these modes of contamination. For this reason, the use of multiple simultaneous tests is recommended for comparison of site and background distributions (EPA, 1989a, 1992a, and 1994a; U.S. Navy, 1998 and 1999).

The WRS test is sensitive to slight but pervasive contamination, but is not sensitive to localized releases. The hot measurement test is effective in identifying localized contamination, but is not sensitive to slight but pervasive contamination. The WRS test and hot measurement test are thus complementary. In addition to these tests, box plots are useful for visually comparing the site and background distributions and for properly interpreting the results of the WRS test.

4.5.1.1 Hot Measurement Test

The hot measurement test consists of comparing each site measurement with a concentration value that is representative of the upper limit of the background distribution (EPA, 1994a). Ideally, a site sample with a concentration above the background screening value would have a low probability of being a member of the background distribution, and may be an indicator of contamination. It is important to select such a background screening value carefully so that the probability of falsely identifying site samples as contaminated or uncontaminated is minimized.

The 95^{th} upper tolerance limit (UTL_{95}) is recommended as a screening value for normally or lognormally distributed analytes and the 95^{th} percentile is recommended as a screening value for nonparametrically distributed analytes (EPA, 1989a, 1992a, and 1994a). Site samples with concentrations above these values are not necessarily contaminated, but should be considered suspect. The UTL_{95} (for normal or lognormal distributions) and the 95^{th} percentile (for nonparametric distributions) are thus proposed as the background screening values for FTMC site-to-background comparisons. These values have been calculated for the FTMC background soil, groundwater, surface water, and sediment data sets, and are provided in Appendix A.

To perform the test, each analyte's site maximum detected concentration (MDC) will be compared to the background UTL_{95} or 95^{th} percentile, in accordance with the type of background distribution. If the site MDC exceeds the background screening value, then that analyte will undergo a geochemical evaluation. If the MDC does not exceed the background screening value, then localized contamination is not indicated. The remaining statistical procedures will be carried out in parallel with this comparison, to determine if slight but pervasive contamination is present at the site.

4.5.1.2 Wilcoxon Rank Sum Test

The WRS test has been recommended for use in site-to-background comparisons (U.S. Navy, 1998 and 1999; EPA, 2000a). The WRS test will be performed when the site and background data sets each contain less than 50 percent nondetects (i.e., measurements reported as not detected above the method detection limit). The WRS test will not performed on data sets containing 50 percent or more nondetects. The medians of such data sets are unknown, and hence the test results would lack sufficient power to yield reliable results.

The WRS test compares two data sets of size *n* and *m* ($n > m$), and tests the null hypothesis that the samples were drawn from populations with distributions having the same medians. To perform the test, the two sets of observations are pooled and arranged in order from smallest to largest. Each observation is assigned a rank; that is, the smallest is ranked 1, the next largest is ranked 2, and so on up to the largest observation, which is ranked ($n + m$). If ties occur between or within samples, each one is assigned the midrank. Next, the sum of the ranks of smaller data set *m* is calculated. Then the test statistic *Z* is determined,

$$Z = \frac{W - m(m+n+1)/2}{\sqrt{mn(m+n+1)/12}}$$

where:

W = Sum of the ranks of the smaller data set
m = Number of data points in the smaller group
n = Number of data points in the larger group.

This test statistic *Z* is used to find the two-sided significance. For instance, if the test statistic yields a probability of a Type I error (p-level) less than 0.05, then there is a statistically significant difference between the medians at the 95 percent confidence level. A Type I error involves rejecting the null hypothesis when it is true. If the p-level is greater than 0.05, then there is no reasonable justification to reject the null hypothesis at the 95 percent confidence level. It can therefore be concluded that the medians of the two data sets are similar, and can be assumed to be drawn from the same population.

If the p-level is less than 0.05, then the medians of the two distributions are significantly different at the 95 percent confidence level. This can occur if the site data are shifted higher or lower than the background data. If the site data are shifted higher relative to background, then contamination may be indicated, and the analyte in question will be carried on for geochemical evaluation. If the p-level is greater than 0.05, then pervasive site contamination is not suspected. As previously discussed, the hot measurement test will be performed in parallel with the WRS test, to detect potential localized contamination.

4.5.1.3 Box-and-Whisker Plots

A quick, robust graphical method recommended by EPA to visualize and compare two or more groups of data is the box plot (EPA, 1989a and 1992a). An example box plot is provided on Figure 4-2. These plots provide a summary view of the entire data set, including the overall location and degree of symmetry. The box encloses the central 50 percent of the data points so that the top of the box represents the 75th percentile and the bottom of the box represents the 25th percentile. The small box within the larger box represents the median of the data set. The upper whisker extends outward from the box to either 1.5 times the interquartile distance (i.e., range between 25th and 75th percentiles) or to the maximum point, whichever is larger. The lower whisker extends either 1.5 times the interquartile distance or to the minimum point, whichever is smaller. Values outside the whiskers are shown as circles representing distinct points. Nondetect results are set to one-half of the reporting limit for plotting purposes.

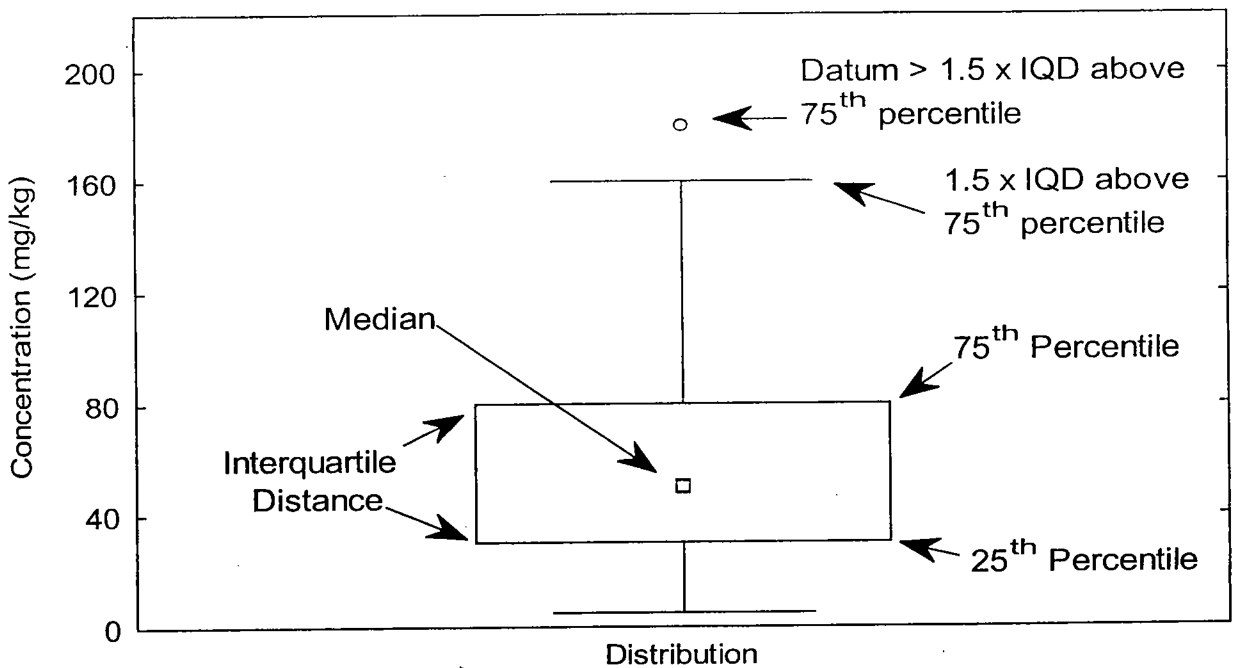
For each analyte, box plots of site and background data will be placed side by side to visually compare the distributions and qualitatively determine whether the data sets are similar or distinct. As described previously, the WRS test may indicate that the medians of the site and background data sets are significantly different. Examination of the box plots will confirm whether that difference is caused by site data that are shifted higher or lower relative to background.

The use of a lognormal vertical concentration axis may be useful for elements that have large ranges and lognormal distributions. It should be noted that comparison of the box plots will be hindered if there is a high percentage of nondetects, particularly when there are differences in reporting limits between the two data sets. Interpretation of the plots should consider the relative differences in the sizes of the two data sets being compared. The larger of the two sets will tend to have higher maximum concentrations if both sets are drawn from the same population.

4.5.2 Geochemical Evaluations

If an analyte fails one or both of the statistical tests described in Section 4.5.1, then a geochemical evaluation will be performed to determine if the elevated concentrations are caused by natural processes. The importance of geochemical evaluations in distinguishing between site and background data sets has been recognized in the industry (EPA, 1995a; U.S. Navy, 1998 and 1999; Barclift, *et al.*, 2000). When properly evaluated, geochemistry can provide mechanistic explanations for apparently high, yet naturally occurring, constituents. Anomalous samples that may represent contamination can also be readily distinguished from uncontaminated samples.

Figure 4-2. Example Box Plot
Installation-Wide Work Plan
Fort McClellan, Calhoun County, Alabama



This section discusses the major processes that should be considered when evaluating analytical data for various environmental media in site-to-background comparisons.

4.5.2.1 Soil and Sediment

Site-to-background comparisons of trace metals in soil and sediment based solely on statistical techniques are prone to high false-positive indications (conclusion that the sample is contaminated when it is really not) for a number of reasons. Trace element distributions in soil tend to have very large ranges (two or three orders of magnitude are not uncommon), and are highly right-skewed, resembling lognormal distributions. Accurate characterization of the upper tails of broadly skewed distributions requires a large number of background samples, which are usually not available. The situation is compounded if the site data set is larger than the background data set, which further increases the probability of apparent background exceedances.

The statistical tests described previously treat each analyte as an independently behaving entity, and do not consider the geochemical context in which each element resides. However, mineralogy and soil chemistry reveal that naturally occurring elements in soil and sediment exist in predictable proportion to other elements. Trace element concentrations are expected to co-vary with major element concentrations, and these relationships can be visualized with correlation plots. Sediment studies in particular have made effective use of these relationships to distinguish between naturally occurring and anthropogenic concentrations.

Aluminum is typically used in sediment studies as a normalizer of trace element concentrations because it is naturally abundant; anthropogenic contribution is uncommon; and it is a primary component of clay minerals, which concentrate many trace elements (Windom, *et al.*, 1989; Hanson, *et al.*, 1993; Daskalakis and O'Connor, 1995). Iron is also an important reference element because of the relative abundance of iron oxide minerals, with which many trace elements associate, and thus it has also been used as a normalizer in sediment studies (Daskalakis and O'Connor, 1995; Schiff and Weisberg, 1997). Trace elements have also been correlated with total organic carbon (TOC); however, associations with TOC are often much less significant than those with reference elements and TOC is often increased through anthropogenic inputs (Windom, *et al.*, 1989; Daskalakis and O'Connor, 1995).

Correlation of Major Elements and Trace Elements. The geochemical evaluation for soil and sediment is based on the natural associations of trace elements with specific minerals in the soil or sediment matrix. As an example, arsenic in most uncontaminated oxic soil is almost exclusively associated with iron oxide minerals (Bowell, 1994; Schiff and Weisberg, 1997). (The term "iron oxide" is used here to include oxides, hydroxides, oxyhydroxides, and hydrous oxides of iron.) This association of arsenic with iron oxide is a result of the adsorptive behavior of this particular trace metal in an oxic soil environment. Arsenic is present in oxic soil pore fluid as negatively charged oxyanions ($HAsO_4^{-2}$, $H_2AsO_4^{-}$) (Brookins, 1988). These anions have strong affinities to adsorb on the surfaces of iron oxides, which maintain a strong positive surface charge (Electric Power Research Institute [EPRI], 1986). Soil samples with high percentages of iron oxide frequently have proportionally higher concentrations of arsenic.

The absolute concentrations of arsenic and iron can vary by several orders of magnitude at a site, but the arsenic/iron ratios in each sample are usually quite constant at a given site as long as no contamination is present (Daskalakis and O'Connor, 1995). If a sample has some naturally occurring arsenic plus additional arsenic from an herbicide or some other source, then it will have a high arsenic/iron ratio relative to the other uncontaminated samples. These ratios thus serve as a powerful technique for identifying contaminated samples.

The evaluation includes the generation of plots in which arsenic concentrations in a set of samples are plotted on the y-axis, and the corresponding iron concentrations are plotted on the x-axis. The slope of a best-fit line through the samples is equal to the average arsenic-to-iron background ratio. If the samples with the highest arsenic concentrations plot on the same linear trend as the other samples, then it is most probable that the elevated concentrations are natural, and are caused by the natural occurrence of high levels of iron oxides in those samples. If the site samples with elevated arsenic concentrations plot above the trend displayed by the uncontaminated samples, then there is evidence that those samples have an excess contribution of arsenic, and contamination may be indicated.

Each trace element is associated with one or more minerals in the soil or sediment matrix. Vanadium and selenium, along with arsenic, form anionic species in solution, and are associated with iron oxides. Divalent metals such as barium, cadmium, lead, and zinc tend to form cationic species in solution and are attracted to clay mineral surfaces. These trace elements would be evaluated against aluminum, which is a major component of clay minerals.

Soil boring logs, geologic maps, and other available field observations will be examined to determine the soil lithology, which will indicate the probable mineralogical controls on natural trace element distributions. For example, a soil sample comprised primarily of clay would be enriched in aluminum and the associated metals such as barium, cadmium, lead, and zinc. Plots of aluminum concentrations versus barium, cadmium, lead, or zinc concentrations would be constructed in those instances. If a soil sample has a high proportion of iron oxide minerals, that sample would be enriched in iron and associated metals such as arsenic, selenium, and vanadium. Plots of iron versus arsenic, selenium, or vanadium would be constructed in those cases. Soils formed from the weathering of limestone would be expected to contain a high proportion of calcium carbonate. Trace elements such as lead and zinc may substitute for calcium in carbonate minerals, and plots of calcium versus lead or zinc may also be constructed in those instances.

All available background data are incorporated in the correlation plots, and provide a baseline against which the site data are compared. If there is no contamination present, the plot is expected to exhibit a generally linear trend. Potential contamination is readily identified by anomalous site samples that plot above the trend. Nondetect samples are not included in the correlation plots, as their replacement values (such as one-half of the reporting limit) are assumed quantities that have no meaning in the geochemical context. Censored data serve only to obscure the relationships that the correlation plots attempt to depict. The geochemical correlation plots will be prepared only for those data sets containing reference element concentrations (e.g., aluminum, iron, calcium, etc).

4.5.2.2 Groundwater and Surface Water

Groundwater and surface water samples often contain elevated concentrations of inorganic constituents. These elevated concentrations may be due to naturally high dissolved concentrations, the presence of suspended particulates in the samples, reductive dissolution effects, or contamination resulting from FTMC activities. This section discusses the major geochemical processes that should be considered in the evaluation of groundwater and surface water analytical data.

Effects of Suspended Particulates. The presence of trace elements adsorbed on suspended particulates can greatly increase trace element concentrations as reported by an analytical laboratory. These adsorbed trace elements are not in true solution, and can be removed by settling or filtration. The same concepts involved in the evaluation of soil and sediment data also apply to groundwater and surface water data: samples containing trace elements adsorbed on suspended clay particulates should show a positive correlation with aluminum concentrations, and samples containing trace elements adsorbed on suspended iron oxides should show a positive correlation with iron concentrations. These correlations are evaluated by generating x-y plots of the concentrations of an elevated trace metal versus aluminum or iron (depending on the trace element).

The most common suspended particulates in groundwater samples are clay minerals, hydrous aluminum oxides ($Al_2O_3 \bullet nH_2O$), and hydroxides [$Al(OH)_3$]; and iron oxide (Fe_2O_3), iron hydroxide [$Fe(OH)_3$], and iron oxyhydroxide ($FeO \bullet OH$) minerals, collectively referred to as "iron oxides." All clay minerals contain aluminum and have low solubilities over a neutral pH range of 6 to 8. Measured concentrations of aluminum in excess of ~1 milligram per liter (mg/L) indicate the presence of suspended clay minerals (Hem, 1985), with higher aluminum concentrations being a qualitative indicator of the mass of suspended clay minerals. Iron also has a very low solubility under neutral pH and moderate to oxidizing redox conditions (Hem, 1985), so that measured iron concentrations in excess of ~1 mg/L under these conditions indicate the presence of suspended iron oxides.

The presence of suspended clay or iron oxides in groundwater samples has particular importance in the interpretation of trace element concentrations. Most clay particles maintain a negative surface charge under neutral pH conditions, and have a strong tendency to adsorb positively charged (cationic) aqueous species. Iron oxides display the opposite behavior, maintaining a positive surface charge under neutral pH conditions, and have a strong tendency to adsorb negatively charged (anionic) aqueous species.

Barium, lead, and zinc are usually present in groundwater as divalent cations (Ba^{+2}, Pb^{+2}, Zn^{+2}) and thus tend to concentrate on clay surfaces (EPRI, 1984; Brookins, 1988). Arsenic, selenium, and vanadium are usually present under oxidizing conditions as oxyanions ($HAsO_4^{-2}$, $HSeO_3^-$, $H_2VO_4^-$), and thus tend to concentrate on iron oxide surfaces (Bowell, 1994; Hem, 1985; Pourbaix, 1974; Brookins, 1988).

Chromium can be present in groundwater as a mixture of aqueous species with different charges such as $Cr(OH)_2^+$, $Cr(OH)_3^\circ$, and $Cr(OH)_4^-$ (EPRI, 1984). The positive, neutral, and negative charges on these species result in the distribution of chromium on several different types of sorptive surfaces, including clay and iron oxide minerals.

As an example, the concentrations of zinc (y-axis) will be plotted against aluminum (x-axis) for site and background samples. If the site and background samples display a common linear trend, then it is most likely that the elevated zinc concentrations are due to the presence of suspended clay minerals in the samples. The slope of a best-fit line through the points representing uncontaminated samples is equal to the average zinc/aluminum ratio. If some site samples plot above the trend established by the background samples, then those site samples have an anomalously high zinc/aluminum ratio, and most likely contain excess zinc that cannot be explained by these natural processes.

Alternative techniques for assessing the effects of suspended particulates on trace element concentrations are the evaluation of correlations of trace element concentrations versus turbidity, and comparison of analyses of filtered versus unfiltered splits of samples. Turbidity measurements are qualitative, and do not distinguish between suspended clay minerals, iron oxides, and natural organic material, so this approach lacks the resolution provided by trace element versus aluminum or trace element versus iron correlations.

The intent of filtration is to remove suspended particulates; however, there is no specific filter size that effectively separates elements that are present as suspended particulates from solutes that are in true solution. The diameters of suspended particulates range from an upper limit of 5 microns to a lower limit of 0.005 microns (Hem, 1985). The use of a standard 0.45 micron filter could thus allow a significant fraction of the finer range of particulates to pass if they are present in the sample. Despite these limitations, correlations of trace elements versus turbidity and comparisons of the analyses of filtered versus unfiltered splits of samples are still useful for providing independent confirmation of the conclusions reached by evaluation of the aluminum and iron ratios.

To evaluate the effects of suspended particulates, correlation plots of major elements, such as aluminum and iron, versus trace elements will be constructed as described above. For uncontaminated water under neutral pH, oxidizing conditions, a positive correlation is expected if the trace elements are adsorbed on suspended particulates (such as clay or iron oxide minerals). If there is no positive correlation between major and trace elements, then the elevated concentrations are probably not due to suspended particulates. Comparisons of the analyses of filtered versus unfiltered samples may also be performed to provide independent confirmation of the conclusions reached by evaluation of the aluminum and iron ratios.

Effects of Reductive Dissolution. Iron and manganese oxides concentrate several trace elements such as arsenic, selenium, and vanadium on mineral surfaces, as discussed above. In soils and sedimentary aquifers, these elements are almost exclusively associated with iron and manganese oxide minerals and grain coatings, as long as the redox conditions are moderate to oxidizing (EPRI, 1984).

The release of organic contaminants such as jet fuel, gasoline, or chlorinated solvents can establish local reducing environments caused by anaerobic microbial degradation of the organic compounds. The establishment of local reducing conditions can drive the dissolution of iron and manganese oxides, which become soluble as the redox potential drops below a threshold value. Dissolution of these oxide minerals can mobilize the trace elements that were adsorbed on the oxide surfaces, which is a process termed "reductive dissolution." Several investigations have documented the mobilization of arsenic, selenium, and other trace elements under locally reducing redox conditions (Sullivan and Aller, 1996; Nickson, *et al.*, 2000; Belzile, *et al.*, 2000).

Evidence for reductive dissolution would be a correlation between elevated trace elements (arsenic, selenium, and vanadium in particular) versus lower redox conditions. Low redox conditions can be identified by local depressions in oxidation-reduction potential or dissolved oxygen measurements, or the presence of reducing gases such as hydrogen, methane, ethane, or ethene. Anaerobic microbes can also reduce sulfate to sulfide and nitrate to ammonia, resulting in local depressions in sulfate and nitrate concentrations, and local detections of sulfide and ammonia. In areas impacted by chlorinated solvents, additional evidence for the establishment of anaerobic reducing conditions is the presence of dichloroethene and/or vinyl chloride, which are reductive dechlorination products resulting from the microbial degradation of trichloroethene or tetrachloroethene under anaerobic conditions.

If the elevated inorganic constituents are due to reductive dissolution effects, then this process needs to be taken into account if remedial actions are considered. For instance, if in situ oxidation techniques are used under these circumstances for the remediation of organic contaminants, then the inorganic constituents that have elevated concentrations will most likely precipitate or adsorb, so that the dissolved-phase concentrations will decrease. However, if techniques such as the in situ application of hydrogen release compounds are used to accelerate reductive dechlorination of solvents, then the concentrations of inorganic constituents in groundwater may actually increase.

To evaluate the effects of reductive dissolution, correlations between elevated trace elements (particularly arsenic, selenium, and vanadium) and lower redox conditions will be tested. All available laboratory and field data will be examined to determine if there is a local reducing environment that is driving the dissolution of iron and manganese oxides. Low redox conditions can be identified by local depressions in oxidation-reduction potential or dissolved oxygen measurements; the presence of reducing gases such as hydrogen, methane, ethane, or ethene; local depressions in sulfate and nitrate concentrations and local detections of sulfide and ammonia; and the presence of dichloroethene and/or vinyl chloride. If the available data do not indicate low redox conditions, then the elevated trace element concentrations are probably not due to reductive dissolution.

4.5.3 Summary of the Methodology

To detect potential localized contamination, site data will be compared to a background screening value consisting of the UTL_{95} for normally or lognormally distributed analytes and the 95^{th} percentile for nonparametrically distributed analytes. Potential contamination that is slight but pervasive will be identified with the WRS test. Box plots will be used to visually compare the site and background distributions and to properly interpret the results of the WRS test. Any analyte that fails one or both statistical tests will be retained for geochemical evaluation.

For soil and sediment, correlation plots will be constructed to compare the relationships of trace elements versus major elements. Naturally occurring trace elements typically maintain a constant ratio with the major elements with which they associate, thereby defining a linear trend with a positive slope; contaminated samples would contain an excess contribution of trace element(s) and would plot off the linear trend. For groundwater and surface water samples, the geochemical evaluations will consider the effects of suspended particulates (explored through correlation plots) and reductive dissolution (identified by low redox conditions). All available geochemical parameters, soil boring logs, and field observations will be examined as part of the geochemical evaluations.

Data Adequacy and Quality. The FTMC background study report provides a background data set of high quality, fully validated chemical analyses of target analyte list elements in soil, groundwater, surface water, and sediment (SAIC, 1998). It is assumed in this methodology that site data sets of adequate size and quality are available for evaluation. The minimum number of samples required to adequately characterize site conditions should be determined based on a number of site-specific and project-specific factors.

Statistical tests such as the WRS test may have insufficient power to correctly identify differences between two data sets if one or both of the sample sizes are too small. Part of the Data Quality Objectives process is an identification of the possible decision errors and their consequences. Tolerable error rates for false positive and false negative decision errors are usually determined on a site-by-site basis, based on the consequences of decision errors, should they occur. The valid number of samples can then be defined based on the tolerable error rates. For soils, adequate spatial coverage is required, so that larger sites should have more samples than smaller sites. The shape, range, and variance of the distributions should also be considered, because a greater number of samples is required to characterize broad distributions relative to narrow ones, and a greater number of samples is required to characterize skewed (lognormal) distributions relative to normal ones. If distinctly different soil types are present, then they may need to be treated as separate distributions. Likewise, if compositionally distinct soil profiles exist at the site, then samples from different depths may need to be treated as separate distributions.

For groundwater, seasonal trends may exist so that multiple rounds from each well are required to capture the temporal variance. Procedures for seasonal trend identification and adjustment are provided in EPA, 1989a. Samples obtained from different screened intervals below the water table may need to be grouped into distinct data sets if vertical compositional gradients exist.

Uncertainties. It is important to note that there are several sources of uncertainty inherent in the procedures described in this methodology. Statistical tests are predicated on assumptions about the data sets. Decision errors can be reduced, but cannot be eliminated. The analytical data sets themselves are a source of uncertainty, particularly when they are characterized by a large proportion of nondetects or estimated values below the reporting limit.

It is worth remembering that the geochemical evaluations rely in part on professional judgment, and qualitative assessment is a necessary part of the process. Samples that plot off the linear trend on a correlation plot are certainly suspect, but because all uncertainty cannot be eliminated from the evaluation, such plots cannot be construed as definitive proof of contamination. However, anomalous samples should be flagged as suspect and their results used as a basis for further investigation, risk assessment, or remediation, as appropriate.

4.6 Remedial Investigation Report

An RI report will be prepared for each site upon completion of all field activities, laboratory and data analyses, and data validation activities in accordance with *Guidance for Conducting*

Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988). The typical RI report will include the following topics:

- Site description and history
- Study area investigation
- Comparison of site and background data
- Nature and extent of contamination
- Contaminant fate and transport
- Human health risk assessment
- Ecological risk assessment
- Summary and conclusions.

5.0 Streamlined Human Health and Ecological Risk Assessment

The human health risk assessment work plan describes the protocol for a streamlined risk assessment (SRA). The SRA concept was developed for FTMC to capture the economy of scale associated with a large facility consisting of hundreds of individual sites, many of which are expected to be uncontaminated or only lightly contaminated and to qualify for no further action (NFA). "Streamlined" refers only to the manner in which the risk assessment is performed, not to the level of precision achieved or documentation provided. The basis of the SRA is the development of SSSLs, which should be considered as site-specific preliminary remediation goals. They incorporate all the exposure and toxicity assumptions and the same level of documentation that is generally associated with a regular CERCLA baseline human health risk assessment (BHHRA) (EPA, 1989b). Therefore, an SRA provides the same precision and level of documentation of a CERCLA BHHRA.

To date, the SRA has been used in several SIs and EE/CAs, but no RIs. Several parcels have been approved for NFA. At least one site was discovered to be sufficiently contaminated to require further sampling and evaluation, and an RI will be performed. It is important to note that the SRA approach will be used in the RI for this site as it was in the SI, because the SRA incorporates the same level of precision and documentation as a CERCLA BHHRA. The only difference is that additional sampling performed since the SI will have improved site characterization so that the SRA will provide more definitive information for risk management.

The SRA is preceded by a data evaluation steps to identify a list of site-related chemicals. The data evaluation process is described in Section 5.1 and the methodology for performing the SRA is described in Section 5.2. Briefly, the SRA consists of the following:

- Comparing site-related chemicals with receptor- and medium-specific SSSLs. Sites with no site-related chemical concentrations exceeding SSSLs are recommended for no further action (NFA) provided the data are adequate.

- If only one or a few site-related chemical concentrations exceed their respective SSSLs, a qualitative or simple quantitative discussion may be sufficient to defend NFA or to identify the "risk drivers" and propose remedial goal options (RGO).

- If the situation is more complex than can be handled as described in the previous bullet, risk and hazard estimates are quantified for at least one, and in most cases, multiple site-use scenarios, and RGOs are developed.

5.1 Identification of Site-Related Chemicals and Development of Source-Term Concentrations

Prior to initiation of a SRA, a list of chemicals present in site samples (CPSS) and a list of site-related chemicals will be compiled. All chemicals detected in site media are considered CPSS. Chemicals undetected in all samples from a given medium are considered to be not present. From the list of CPSS, site-related chemicals are selected as follows:

- The data for each chemical will be sorted by medium. Surface soil (usually 0 to 1 foot below land surface) and subsurface soil (usually 1 to 12 feet) will be considered separate media.

- The analytical data may have qualifiers from the analytical laboratory quality control (QC) or from the data validation process that reflect the level of confidence in the data. Some of the more common qualifiers and their meanings are (EPA 1989b):

  - U Chemical was analyzed for but not detected; the associated value is the sample-specific reporting limit.

  - J Value is estimated, probably below the reporting limit.

  - R QC indicates that the data are unusable (chemical may or may not be present).

  - B Concentration of chemical in sample is not sufficiently higher than concentration in the blank (using five-times, ten-times rule, as follows).

  Organic chemicals are omitted from consideration if they are common laboratory contaminants (acetone, 2-butanone, methylene chloride, toluene, phthalate esters) and if all sample concentrations are less than ten times the highest blank concentration. Other organic chemicals are omitted if all analytical results are less than five times the highest concentration detected in any blank.

  "J" qualified data are used in the risk assessment; "R" and "B" qualified data are not. The handling of "U" qualified data (nondetects) in the SRA is described below.

- Chemicals that are detected infrequently may be artifacts in the data that do not reflect site-related activity or disposal practices. These chemicals should not be included in the risk evaluation. Generally, chemicals that are detected only at low concentrations in less than 5 percent of the samples from a given medium are dropped from further consideration, provided there are at least 21 samples in the data set, unless their presence is expected based on historical information about the site. Chemicals detected infrequently at high concentrations are retained in the evaluation, unless other information exists to suggest that their presence is unlikely to be related to site activities.

- Chemical concentrations will be compared to background concentrations as an indication of whether a chemical is present from site-related activity or as background. This comparison is generally valid for inorganic chemicals, but not usually for organic chemicals, because inorganic chemicals are naturally occurring and most organic chemicals are not. There are exceptions, however, such as background levels of pesticides and herbicides in an agricultural area in which such chemicals have been routinely used in crop production according to manufacturer's directions. Polynuclear aromatic hydrocarbons (PAH), a class of organic compounds that form from natural or anthropogenic combustion of organic matter, including fossil fuels, are another exception. PAHs generally are ubiquitous in the environment, and background levels at FTMC have been estimated (IT, 2000a).

  The comparison of site concentrations with background may be performed in two steps. The first step consists of comparing site maximum detected concentrations (MDC) with two times the mean concentration of background, as specified by EPA (2001a) Region IV and as established during the SI process. If the MDC does not exceed two times the mean of the background, the chemical is considered to be present at concentrations comparable to background and is not selected as a site-related chemical and is not carried forward to the COPC selection process described in Section 5.2.1. If the site MDC exceeds two times the mean of the background, a supplemental comparison step may be performed. The supplemental step consists of the more rigorous statistical and geochemical analysis described in Section 4.5. Chemicals determined to be present at concentrations greater than background by the supplemental comparison step are considered to be site related and are carried forward to the COPC selection process.

- Essential nutrients such as calcium, chloride, iodine, magnesium, phosphorus, potassium, and sodium may be eliminated as site-related chemicals, provided their presence in a particular medium is judged to be unlikely to cause adverse effects on human health.

- Chemicals not eliminated using the screening processes will be considered to be site-related and will be quantitatively evaluated in the SRA (Section 5.2) and in the habitat-specific screening ecological risk assessment (Section 5.3).

- A table will be prepared for each medium with the following information:

  -Chemical name
  -Frequency of detection
  -Range of detected concentrations
  -Range of reporting limits
  -Arithmetic mean of site concentrations
  -Background screening criterion
  -95% upper tolerance limit on the background data set
  -Selection as site-related chemical.

Although most of the steps in the data evaluation are similar for both ecological and human health risk, the methods diverge with regards to the screening benchmark levels used, or the methods by which site-specific screening levels are calculated. Thus, it is possible for a chemical to be selected as a COPC for the SRA, but not the ecological risk assessment; or alternatively, for chemicals to be selected as a chemical of potential ecological concern (COPEC) for ecological risk, but not for the SRA.

5.2 Streamlined Human Health Risk Assessment

Environmental source media to be considered in the SRA include surface soil (0 to 1 foot), subsurface soil (1 to 12 feet), surface water, groundwater, and sediment. Validated data from the most recent sampling efforts will be used, along with appropriate historical data, to quantify potential human health risks.

5.2.1 Chemicals of Potential Concern

The first step of the SRA is selecting COPC and developing source-term concentrations for each of the COPC. COPC are selected by comparing the MDC of the site-related chemical to its cancer-based and noncancer-based SSSLs. The SSSLs chosen reflect relevant exposure scenarios under current or projected future site uses. Provided the toxicological data are adequate, SSSLs are developed for an incremental lifetime cancer risk (ILCR) of one-in-a-million (1E-6) and a noncancer hazard index (HI) of 0.1. A site-related chemical is selected as a COPC if its MDC exceeds either of its SSSLs. Therefore, a site-related chemical may be selected as a cancer-based COPC, a noncancer-based COPC or both. Site-related chemicals whose MDCs do not exceed either of their SSSLs are considered to contribute insignificantly to risk and are not evaluated further in the SRA.

The source-term concentration (STC) is interpreted as a representative concentration of COPC in an environmental medium. It is mathematically equivalent to the exposure-point concentration for exposure routes involving direct contact (e.g., ingestion, dermal contact), and it is the starting point for estimating the exposure-point concentration for indirect pathways (e.g., inhalation, food-chain pathways). The method by which it is estimated depends on the medium.

5.2.1.1 Soil, Sediment, Surface Water

Soil, sediment and surface water have in common the fact that exposure may occur over a random area. For example, a youthful trespasser may roam over several acres as he walks, hikes or plays games (exposure to soil). He may wade or play from any point on the shore of a pond, or along the entire length of a stream as it passes through an area (exposure to sediment and surface water). A construction project, on the other hand, may involve a much smaller area. This gives rise to the concept of exposure unit (EU), which is the area over which a receptor is assumed to be uniformly and randomly exposed. Often, the entire pond, or number of ponds, or the entire length of a stream within a site may comprise an EU for surface water and sediment, unless access is restricted. A large site of several acres may be a single EU for a groundskeeper or sportsman, but an EU for an on-site resident or construction worker may be much smaller, perhaps less than one acre. The STC is the representative concentration of COPC within the EU. STCs, therefore, may vary from one receptor scenario to another, depending on the size of the EU.

- Because of the uncertainty associated with characterizing contamination in environmental media, both the mean and the upper confidence level (UCL) of the mean are usually estimated for each COPC in each medium of interest. The upper 95 percent confidence limit of the mean is generally referred to as the UCL. In general, "outliers" are included in the calculation of the UCL because high values are plausible in environmental contamination scenarios. Inclusion of outliers increases the overall conservatism of the SRA.

- Analytical results are presented as nondetects ("U" qualifier) whenever chemical concentrations in samples do not exceed the detection or quantitation limits for the analytical procedures for those samples. Generally, the detection limit is the lowest concentration of a chemical that can be "seen" above the normal, random noise of an analytical instrument or method. To apply statistical procedures to a data set with nondetects, a concentration value must be assigned to the nondetects. Nondetects are assumed to be present at one-half the detection limit (EPA, 1989b).

- Data sets are tested for normality and lognormality using probability plots and the Shapiro-Wilks test (EPA, 1992b) in the software package STATISTICA™. Statistical analysis is performed only on those chemicals whose MDCs exceed their background screening criteria. If statistical testing shows that the data set is normally distributed, the UCL for a normal distribution is calculated. If statistical testing shows that the data set is lognormally distributed, the UCL for a lognormal distribution is calculated. If the data set fits both normal and lognormal distributions, the UCL is calculated for the distribution that provides the better fit.

The UCL for a normal distribution is calculated as follows (EPA, 1992c):

$$UCL = \bar{x} + t_{1\ \alpha,n\ 1}\, x\, (s / \sqrt{n}) \qquad \textbf{Eq. 5-1}$$

where:

$\bar{x}$	=	sample arithmetic mean
t_1	=	critical value for Student's t-distribution
α	=	0.05 (95 percent confidence limit for a one-tailed test)
n	=	number of samples in data set
s	=	sample standard deviation.

The UCL is calculated for a lognormal distribution as follows (Gilbert, 1987):

$$UCL = e^{\left(\bar{y} + (0.5\ \_\ s_y^2) + \left[H_{0.95} - \frac{s_y}{(n1)^{0.5}}\right]\right)} \qquad \textbf{Eq. 5-2}$$

where:

$\bar{y}$	=	Σy/n (sample arithmetic mean of the log-transformed data, y = ln x)
s_y	=	sample standard deviation of the log-transformed data
n	=	number of samples in the data set
$H_{0.95}$	=	value for computing the one-sided upper 95 percent confidence limit on a lognormal mean from standard statistical tables (Land, 1975).

Nonparametric data sets provide considerably greater uncertainty, and developing a UCL requires judgement. The first step is to develop a nonparametric UCL. The nonparametric UCL is the (one-sided) UCL on the median, rather than the mean, because the median is a better estimate of central tendency for a nonparametric distribution. It is estimated by ranking the data observations from the smallest to the largest. The rank order of the observation selected as the UCL is estimated from the following equation (Gilbert, 1987):

$$u = p(n + 1) + Z_{1-\alpha} \sqrt{n\, p\, (1 - p)}$$ **Eq. 5-3**

where:

u	=	rank order of observation selected as UCL
p	=	quantile on which UCL is calculated (p = 0.5)
n	=	number of samples in the data set
α	=	confidence limit (95 percent)
$Z_{1-\alpha}$	=	normal deviate variable for a one-sided UCL.

Recently, the methodology for estimating UCLs for lognormal and nonparametric distributions has come under question by the EPA(1997a, 2001b), particularly for data sets for which the method yields values below the arithmetic mean or above the MDC. Several newer procedures are currently being evaluated. IT evaluated the alternatives and decided that a method known as the Chebychev approach provides a reasonable blend of improved accuracy and practicality. Therefore, UCLs will be calculated in the manner described above and by the Chebychev approach for lognormal and nonparametric COPC data sets.

The Chebychev equation for calculating UCLs is as follows (EPA, 1997a):

$$UCL = \bar{x} + ks / n$$ **Eq. 5-4**

where:

$\bar{x}$	=	sample arithmetic mean
k	=	4.47 (EPA, 1997a)
s	=	sample standard deviation
n	=	number of samples in data set.

Other alternative approaches may be used if they become better developed and more generally accepted. The rationale for selecting one over the other will be presented in the SRA.

Non-detects in the data set will be assumed to be present at a concentration equivalent to one-half the method detection limit, if available, or one-half the reporting limit if the method detection limit is not available.

In some cases (particularly with small data sets), the MDC may be selected as the UCL. The UCL or the MDC, whichever is smaller, is selected as the STC, and is understood to represent a conservative estimate of average for use in the SRA.

5.2.1.2 Groundwater

EPA (2001a) recommends that the arithmetic average of data from the most contaminated part of the plume be adopted as the STC for COPC identified in groundwater. In many cases no plume is distinguishable, or plumes from different sources co-mingle. The MDC for each COPC will be adopted as the STC for these cases.

5.2.2 Exposure Assessment

Exposure is the contact of a receptor with a chemical or physical agent. An exposure assessment estimates the type and magnitude of potential exposure of a receptor to chemicals found at or migrating from a site (EPA, 1989b). An exposure assessment includes the following steps:

- Characterize the physical setting
- Identify the contaminant sources, release mechanisms, and migration pathways
- Identify the potentially exposed receptors
- Identify the potential exposure pathways
- Estimate exposure concentrations
- Estimate chemical intakes or contact rates.

5.2.2.1 Physical Setting

The physical setting of FTMC, including its historical and current use, proposed future use, topography, climate, and demographics of the area, is described in detail in Chapter 2.0. Proposed or projected site-use is subject to change as some sites are released and others are found to be more highly contaminated than originally thought. An SRA will always be based on the most plausible and applicable site-use projections as indicated in the most current re-use plan. Also, most SRAs will evaluate a future residential site-use scenario, even if such a scenario is highly unlikely. Should residential site-use "pass" in the SRA, the site in question can be released without restriction.

5.2.2.2 Contaminant Sources, Release Mechanisms, and Migration Pathways

Contaminant sources, release mechanisms, and migration pathways are presented in Figure 3-1 and discussed in Section 3.1.1. Briefly, waste on the surface or buried in the ground may contaminate surface and subsurface soil. Runoff and erosion may move contaminants to surface water and sediment. Contaminants in subsurface soil may leach to groundwater. In low areas, contaminated groundwater may discharge to the surface, contaminating surface water and sediment. Potentially contaminated source media include surface soil, subsurface soil, groundwater, surface water, and sediment.

5.2.2.3 Receptors and Exposure Pathways

Receptors, selected to represent all potentially exposed groups of people at any of the sites at FTMC, and the pathways by which they may be exposed to contaminants, were introduced in Section 3.1.2 and Figure 3-1, and summarized in Table 3-1. The receptor and exposure scenarios are developed in more detail here. The exposure variable values used in the SSSL models are compiled in Table 5-1.

Most risk assessments are based on a reasonable maximum exposure (RME) assumption. The intent of the RME assumption is to estimate the highest exposure level that could reasonably be expected to occur, but not necessarily the worst possible case; i.e., approximately the 90th percentile (EPA, 1989b, 1991a, 1993). In keeping with EPA (1989b, 1991a) guidance, variables chosen for the RME scenario for contact or intake rate, exposure frequency (EF), and exposure duration (ED) are generally upperbounds. Other variables, e.g., body weight (BW) and exposed skin surface area (SA), are generally central or average values. In the case of contact rates consisting of multiple components, e.g., dermal contact with soil or water, which consists of a dermal absorption factor (ABS) and soil-to-skin adherence factor (AF) for soil, and permeability coefficient (PC) and exposure time (ET) for water, only one variable, ABS or PC, needs to be an upperbound. The conservatism built into the individual variables ensures that the entire estimate for contact rate is more than sufficiently conservative. Recently, EPA (1998) reviewed an analysis of several studies that evaluated dermal exposure to soil (EPA, 1997b) to estimate reasonable central values for SA and AF.

The scenarios described in the following subsections assume that 100 percent of a receptor's time of exposure to a given medium is spent in contact with contaminated medium at the site. For example, it is assumed that the groundskeeper spends 8 hours per day, 250 days per year exposed to contaminated surface soil on a given site. This assumption may be overly conservative for some sites, for example, small sites for which a full-time groundskeeper would not be required. For these situations, a fraction of exposure (FI) term is provided in the SSSL equations to allow adjusting for the fraction of time a receptor plausibly could be expected to spend in contact with the contaminated medium on the site. The default value for FI is 1, unless site-specific data

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
INCIDENTAL INGESTION OF SOIL					
Age-adjusted soil incidental ingestion factor (IFadj), mg-years/kg-day	114[a]	NA	NA	NA	NA
Soil incidental ingestion rate (IRso), mg/day	Child: 200[b]	100[b]	100[b]	200[c]	200[c]
Fraction exposed to contaminated medium (FIso), unitless	1[c]	1 or site-specific[c]	0.25 or site-specific[c]	1 or site-specific[c]	1[c]
Exposure frequency (EF), days/year	350[b]	250[b]	104[c]	250[b]	48[c]
Exposure duration (ED), years	Child: 6[d]	25[b]	10[d]	1[c]	27[c]
Body weight (BW), kg	Child: 15[d]	70[b]	45[d]	70[b]	70[b]
Averaging time, cancer (ATc), days[e]	25,550	25,550	25,550	25,550	25,550
Averaging time, noncancer (ATn), days[f]	Child: 2190	9125	3650	365	9855
INCIDENTAL INGESTION OF SEDIMENT					
Sediment incidental ingestion rate (IRsd), mg/day	NA	NA	100[b]	NA	NA
Fraction exposed to contaminated medium (FIsd), unitless	NA	NA	0.13 or site-specific[c]	NA	NA
Exposure frequency (EF), days/year	NA	NA	104[c]	NA	NA
Exposure duration (ED), years	NA	NA	10[d]	NA	NA

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
INCIDENTAL INGESTION OF SEDIMENT (continued)					
Body weight (BW), kg	NA	NA	45[d]	NA	NA
Averaging time, cancer (AT), days[e]	NA	NA	25550	NA	NA
Averaging time, noncancer (AT), days[f]	NA	NA	3650	NA	NA
INHALATION OF VOCs AND RESUSPENDED DUST FROM SOIL					
Fraction exposed to contaminated medium (FIso), unitless	NA	1 or site-specific[c]	NA	1 or site-specific[c]	1[c]
Inhalation rate (IRa), m^3/day	NA	20[b]	NA	20[b]	24
Exposure frequency (EF), days/year	NA	250[b]	NA	250[b]	48[i]
Exposure duration (ED), years	NA	25[b]	NA	1[c]	27[c]
Body weight (BW), kg	NA	70[b]	NA	70[b]	70[b]
Averaging time, cancer (AT), days[f]	NA	25,550	NA	25,550	25,550
Averaging time, noncancer (AT), days[e]	NA	9125	NA	365	9855
DERMAL CONTACT WITH SOIL					
Fraction exposed to contaminated medium (FIso), unitless	1[c]	1 or site-specific[c]	0.25 or site-specific[c]	1 or site-specific[c]	1[c]
Age-adjusted body surface area-soil factor (SASadj), cm^2-years/kg-day	2520[g]	NA	NA	NA	NA

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
DERMAL CONTACT WITH SOIL (continued)					
Body surface area exposed to soil (SAso), cm^2	Child: 1800[g]	5250[g]	5250[g]	5250[g]	5250[g]
Soil-to-skin adherence factor (AFso), mg/cm^2	7E-2[g]	1E-2[g]	4E-2[g]	1.0E-1[g]	0.1[g]
Exposure frequency (EF), days/year	350[b]	250[b]	104[c]	250[b]	48[c]
Exposure duration (ED), years	Child: 6[d]	25[b]	10[d]	1[c]	27[c]
Body weight (BW), kg	Child: 15[d]	70[b]	45[d]	70[b]	70[b]
Averaging time, cancer (ATc), days[e]	25,550	25,550	25,550	25,550	25,550
Averaging time, noncancer (ATn), days[f]	Child: 2190	9125	3650	365	9855
Dermal absorption factor (ABS), unitless	CSV	CSV	CSV	CSV	CSV
DERMAL CONTACT WITH SEDIMENT					
Fraction exposed to contaminated medium (FIsd), unitless	NA	NA	0.13 or site-specific[c]	NA	NA
Body surface area exposed to sediment (SAsd), cm^2	NA	NA	5250[g]	NA	NA
Sediment-to-skin adherence factor (AFsd), mg/cm^2	NA	NA	2.9E-1[g]	NA	NA
Exposure frequency (EF), days/year	NA	NA	104[c]	NA	NA
Exposure duration (ED), years	NA	NA	10[d]	NA	NA

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
DERMAL CONTACT WITH SEDIMENT (continued)					
Body weight (BW), kg	NA	NA	45[d]	NA	NA
Averaging time, cancer (AT), days[e]	NA	NA	25550	NA	NA
Averaging time, noncancer (AT), days[f]	NA	NA	3650	NA	NA
Dermal absorption factor (ABS), unitless	NA	NA	CSV	NA	NA
INGESTION OF SURFACE WATER					
Intentional surface water ingestion rate, (IRsw), L/day	NA	NA	1[c]	NA	NA
Fraction exposed to contaminated medium (FIsw), unitless	NA	NA	1 or site-specific[c]	NA	NA
Exposure frequency (EF), days/year	NA	NA	104[c]	NA	NA
Exposure duration (ED), years	NA	NA	10[d]	NA	NA
Body weight (BW), kg	NA	NA	45[d]	NA	NA
Averaging time, cancer (AT), days[e]	NA	NA	25550	NA	NA
Averaging time, noncancer (AT), days[f]	NA	NA	3650	NA	NA
DERMAL CONTACT WITH SURFACE WATER					
Fraction exposed to contaminated medium (FIsw), unitless	NA	NA	1[c]	NA	NA

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
DERMAL CONTACT WITH SURFACE WATER (continued)					
Body surface area exposed to surface water (SAsw), cm^2	NA	NA	4000[i]	NA	NA
Permeability coefficient (PC), cm/hour	NA	NA	CSV	NA	NA
Exposure time (ETsw), hour/day	NA	NA	2[c]	NA	NA
Exposure frequency (EF), days/year	NA	NA	104[c]	NA	NA
Exposure duration (ED), years	NA	NA	10[d]	NA	NA
Body weight (BW), kg	NA	NA	45[d]	NA	NA
Averaging time, cancer (AT), days[e]	NA	NA	25550	NA	NA
Averaging time, noncancer (AT), days[f]	NA	NA	3650	NA	NA
DRINKING WATER INGESTION OF GROUNDWATER					
Fraction exposed to contaminated medium (FIgw), unitless	1[c]	1[c]	NA	1[c]	1[c]
Age-adjusted drinking water ingestion factor (DWFadj), L-years/kg-day	1.09[c]	NA	NA	NA	NA
Drinking water ingestion rate (DWgw), L/day	Child: 1[d] Adult: 2[d]	1[b]	NA	1[b]	2.8[d]
Exposure frequency (EF), days/year	350[b]	250[b]	NA	250[b]	48[c]

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
DRINKING WATER INGESTION OF GROUNDWATER (continued)					
Exposure duration (ED), years	Child: 6[d] Adult: 24[d]	25[b]	NA	1[c]	27[c]
Body weight (BW), kg	Child: 15[d] Adult: 70[d]	70[b]	NA	70[b]	70[b]
Averaging time, cancer (ATc), days[e]	25,550	25,550	NA	25,550	25,550
Averaging time, noncancer (ATn), days[f]	Child: 2190 Adult: 8760	9125	NA	365	9855
DERMAL CONTACT WITH GROUNDWATER					
Fraction exposed to contaminated medium (FIgw), unitless	1[c]	1[c]	NA	1[c]	1[c]
Age-adjusted body surface area-groundwater factor (SAWadj), cm^2-years/kg-day	9140	NA	NA	NA	NA
Body surface area exposed to groundwater (SAgw), cm^2	Child: 7300[h] Adult: 18,150[h]	4100[h]	NA	4100[h]	18,150[h]
Permeability coefficient (PC), cm/hour	CSV	CSV	NA	CSV	CSV
Exposure time (ETgw), hour/day	0.2[h]	1[c]	NA	1[c]	0.2[h]
Exposure frequency (EF), days/year	350[b]	250[b]	NA	250[b]	48[c]

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
DERMAL CONTACT WITH GROUNDWATER (continued)					
Exposure duration (ED), years	Child: 6[d] Adult: 24[d]	25[b]	NA	1[c]	27[c]
Body weight (BW), kg	Child: 15[d] Adult: 70[d]	70[b]	NA	70[b]	70[b]
Averaging time, cancer (ATc), days[e]	25,550	25,550	NA	25,550	25,550
Averaging time, noncancer (ATn), days[f]	Child: 2190 Adult: 8760	9125	NA	365	9855
INHALATION OF VOCS FROM GROUNDWATER					
Fraction exposed to contaminated medium (FIgw), unitless	1[c]	NA	NA	NA	1[c]
Age-adjusted groundwater inhalation factor (GWIFadj); L-years/kg-day	0.7[c]	NA	NA	NA	NA
Exposure frequency (EF), days/year	350[b]	NA	NA	NA	48[c]
Exposure duration (ED), years	Child: 6[d]	NA	NA	NA	27[b]
FISH CONSUMPTION					
Fraction exposed to contaminated medium (FIsw), unitless	1[c]	NA	NA	NA	NA

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels
Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
FISH CONSUMPTION (continued)					
Age-adjusted fish consumption rate (FCadj), g-years/kg-day	17.8[c]	NA	NA	NA	NA
Fish consumption rate (FC), g/day	Child: 12[c]	NA	NA	NA	NA
Exposure frequency (EF), days/year	350[b]	NA	NA	NA	NA
Exposure duration (ED), years	Child: 6[d]	NA	NA	NA	NA
Body weight (BW), kg	Child: 15[d]	NA	NA	NA	Child: 15[d]
Averaging time, cancer (ATc), days[e]	25,550	NA	NA	NA	NA
Averaging time, noncancer (ATn), days[f]	Child: 2190	NA	NA	NA	NA
VENISON INGESTION					
Fraction exposed to contaminated medium (FIso), unitless	1[c]	NA	1[c]	NA	NA
Venison consumption rate (VC), g/day	30[c]	NA	30[c]	NA	NA
Exposure frequency (EF), days/year	350[b]	NA	350[b]	NA	NA
Exposure duration (ED), years	10[d]	NA	10[d]	NA	NA
Body weight (BW), kg	45[d]	NA	45[d]	NA	NA
Averaging time, cancer (ATc), days[e]	25,550	NA	25,550	NA	NA

Table 5-1

Exposure Assumptions Used to Estimate Site-Specific Screening Levels Fort McClellan, Calhoun County, Alabama

Pathway Variable	On-Site Resident	Groundskeeper	Recreational Site User	Construction Worker	National Guardsperson
VENISON INGESTION (continued)					
Averaging time, noncancer (ATn), days[f]	3650	NA	3650	NA	NA

NA = Not applicable.
CSV = Chemical-specific value

[a] U.S. Environmental Protection Agency (EPA), 1991, *Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals)*, Including Revisions to Chapter 4 (November 1992), and Appendix D: "Corrections to RAGS-Part B Sections 3.3.1 and 3.3.2 (April 1993)," Office of Emergency and Remedial Response, Washington, DC. Publication 9285.7-01B.
[b] U.S. Environmental Protection Agency (EPA), 1991, *Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors*, Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.6-03.
[c] Assumed; see text.
[d] U.S. Environmental Protection Agency (EPA), 2001, *Region 4 Human Health Risk Assessment Bulletin - Supplement to RAGS: Interim Human Health Risk Assessment Bulletin*, EPA Region IV, Atlanta, Georgia, on line.
[e] Calculated as the product of 70 years (assumed human lifetime) x 365 days/year.
[f] Calculated as the product of ED (years) x 365 days/year.
[g] U.S. Environmental Protection Agency (EPA), 1998, "Risk Review Comments, Human Health Aspects, Fort McClellan, Anniston, AL," Memorandum from Ted Simon, OTS, to Bart Reedy, FFB/BRAC, EPA Region 4, Atlanta, GA, 5 August.
[h] EPA, 1992, *Dermal Exposure Assessment: Principles and Applications*, Interim Report, Office of Research and Development, Washington, DC, EPA/600/8-91/011B, including Supplemental Guidance dated August 18, 1992.
[i] U.S. Environmental Protection Agency (EPA), 1997, *Exposure Factors Handbook*, Office of Research and Development, National Center for Environmental Assessment, Washington, DC, EPA/600/P-95/002F, August.

permit justification of a smaller value. In this manner, the generic SSSLs can be adjusted to more site-specific considerations.

The averaging time (AT) for noncancer evaluation is computed as the product of ED (years) times 365 days per year, to estimate an average daily dose over the entire exposure period (EPA, 1989b). For cancer evaluation, AT is computed as the product of 70 years, the assumed human lifetime, times 365 days per year, to estimate an average daily dose prorated over a lifetime, regardless of the frequency or duration of exposure. This methodology assumes that the risk from short-term exposure to a high dose of a given carcinogen is equivalent to long-term exposure to a correspondingly lower dose, provided that the total lifetime doses are equivalent. This approach is consistent with current EPA (1986a) policy of carcinogen evaluation, although it introduces considerable uncertainty into the cancer evaluation.

Resident. EPA Region IV generally evaluates residential cancer risk by adding the cancer risk for a child with the cancer risk for an adult. This approach combines the conservatism provided by the larger soil and drinking water ingestion rates for the child (when expressed as a rate per unit body weight) with the greater exposure duration of the adult. The Region IV approach cannot be duplicated exactly in SSSL development; i.e., it is not appropriate to derive separate SSSLs for adult and child residential receptors, because the smaller (more restrictive) of the two (the child for soil ingestion, the adult for drinking water ingestion) may not provide sufficient conservatism for a full residential (child + adult = 30 years) exposure duration. These conservatisms, however, are captured in the age-adjusted resident introduced by EPA (1991b).

The child provides the more restrictive noncancer assessment of exposure to soil because of the greater soil ingestion rate and body surface area exposed when expressed on a body weight basis. The child provides the more restrictive noncancer assessment of exposure to metals and SVOCs in groundwater because of the greater drinking water ingestion rate and body surface area exposed when expressed on a body weight basis. The situation with VOCs in groundwater, however, is not clear, because inhalation of VOCs is evaluated for adults, but not children, in a showering scenario (young children are assumed to bathe rather than shower where exposure to airborne VOCs is less). Evaluation of inhalation of VOCs is restricted to the showering scenario because both the receptor and the source (hot water) are confined together in a small space (shower stall or bathtub with shower curtain drawn) so that inhalation of VOCs is maximized. Other opportunities exist for exposure to VOCs; however, such exposure probably would not occur in a confined space and the large dilution factor of freely circulating ambient air would likely reduce airborne concentrations in the breathing zone to levels much lower than those experienced while showering. Inhalation of VOCs during showering, therefore, is considered the upperbound for exposure by this route.

The EF of 350 days per year (EPA, 1991a) is used for both cancer and noncancer SSSL development. The age-adjusted resident is assumed to be exposed 6 years as a child and 24 years as an adult for a total 30-year exposure duration (EPA, 1991a, 2001a). The child resident is a 0- to 6-year-old with an average BW of 15 kilograms (kg), a soil incidental ingestion rate of 200 milligrams per day (mg/day), a drinking water ingestion rate of 1 liter per day (L/day), and an average body SA of 7,300 square centimeters (cm^2) (based on data for 2- to 6-year-old male and female children [EPA, 1997b]). The adult resident has a BW of 70 kg, a soil incidental ingestion rate of 100 mg/day, a drinking water ingestion rate of 2 L/day, and an average body SA of 18,150 cm^2 (average for males and females [EPA, 1997b]). A soil incidental ingestion factor of 114 mg-years/kg-day, developed by EPA (1991b) from the child and adult soil incidental ingestion, BW, and ED data previously provided is used in the cancer evaluation. An age-adjusted drinking water ingestion factor of 1.09 L-years/kg-day is estimated in the same manner using the data provided.

EPA (2001a) considers that inhalation of VOCs during showering is equivalent to ingesting 2 L of water per day. Cancer evaluation of VOCs in groundwater requires that an inhalation factor be developed to reflect the time that the age-adjusted receptor spends as an adult. An age-adjusted inhalation factor of 0.7 L-years/kg-day is developed by analogy to the age-adjusted drinking water ingestion factor as follows:

$$GWIFadj = \frac{(EDtot - EDc) \bullet DWgw}{BWa} \qquad \textbf{Eq. 5-5}$$

where:

GWIFadj	=	age-adjusted groundwater inhalation factor (L-years/kg-day)
EDtot	=	total residential exposure duration (30 years [EPA, 1991a])
EDc	=	exposure duration child (6 years [EPA, 2001a])
DWgw	=	drinking water ingestion rate (2 L/day [EPA, 2001a])
BWa	=	body weight adult (70 kg [EPA, 2001a]).

It is assumed that adults shower for 12 minutes per day and that children take baths for 20 minutes per day (EPA, 1992d). An age-adjusted body surface area factor for contact with groundwater of 9,140 cm^2-years/kg-day is developed by analogy to the soil incidental ingestion and drinking water ingestion factors as follows:

$$SAWadj = \frac{(EDc) \bullet (SAWc)}{BWc} + \frac{(EDtot - EDc) \bullet (SAWa)}{BWa} \qquad \textbf{Eq. 5-6}$$

where:

SAWadj	=	age-adjusted body surface area-groundwater factor (cm^2-years/kg-day)
ED_c	=	exposure duration child (6 years [EPA, 2001a])
SAWc	=	body surface area of a child exposed to groundwater during bathing (7300 cm^2 [EPA, 1992d])
BWc	=	body weight child (15 kg [EPA, 2001a])
EDtot	=	total residential exposure duration (30 years [EPA, 1991a])
SAWa	=	body surface area of an adult exposed to groundwater during showering (18,150 cm^2 [EPA, 1992d])
BWa	=	body weight adult (70 kg [EPA, 1991a]).

EPA (1998) recommends body SAs of 1,800 cm^2 for the child and 5,250 cm^2 for the adult for estimating dermal exposure to soil in a residential setting. An age-adjusted body SA-soil factor of 2,520 cm^2-years/kg-day is developed from these assumptions by analogy to the age-adjusted body SA-groundwater factor. EPA (1998) recommends an AF of 0.07 milligrams per square centimeter (mg/cm^2) for the adult resident, and 0.06 mg/cm^2 for the child. To simplify, the AF of 0.07 mg/cm^2 will be used as a conservative estimate for both the adult and child resident.

Groundskeeper. The groundskeeper is assumed to be a 70-kg adult who works 8 hours per day, approximately 5 days per week year-round on site, for a total of 250 days per year for 25 years (EPA, 1991a). The respiratory rate for the groundskeeper is assumed to be 20 cubic meters (m^3) per 8-hour workday (2.5 m^3 per hour), and the soil incidental ingestion rate is assumed to be 100 mg/day, which is comparable to that for an agricultural worker.

EPA (1998) recommends a body SA of 5,250 cm^2 and an AF of 0.01 mg/cm^2 for the groundskeeper for estimating dermal exposure to soil.

In the future site-use scenario, the groundskeeper may be exposed to groundwater, which could be developed as a source of drinking water. His drinking water ingestion rate is assumed to be 1 L/day (EPA, 1991a). He may also experience dermal contact with groundwater used for irrigation, to clean equipment, and to rinse dust or perspiration from his body. For this evaluation, it is assumed that the head, arms, and hands, approximately 4,100 cm^2 (EPA, 1992d), are exposed intermittently throughout the day for up to an hour per day.

FI for the soil pathways is ordinarily assumed to be 1, implying that the groundskeeper spends his entire work day in contact with site soil. An FI less than 1 may be appropriate for small sites or if other site-specific factors justify assuming that the groundskeeper would not spend his entire work day in contact with site soil.

Recreational Site User. The recreational site user is assumed to be a nearby resident who makes regular visits to the site for playing, hiking, hunting, fishing, or other recreational purposes. It is assumed that the recreational site user visits the site 2 days per week for a total of 104 visits per year, and is exposed to surface soil for 4 hours/day. In addition, the recreational site user is assumed to spend 2 hours per day in contact with surface water and sediment while wading if surface water exists on the site. Contact with surface water is assumed to be intermittent rather than continuous, and it is assumed that uptake of organic chemicals across the dermis does not reach steady state.

EPA (2001a) defines a trespasser as a 7- to 16-year-old youth with an average BW of 45 kg exposed for 10 years. These assumptions are adopted for the recreational site user. A soil incidental ingestion rate of 100 mg/day is assumed for persons over 6 years old to account for incidental soil and dust ingestion by a resident (EPA, 1991a). It is assumed that the activities resulting in incidental sediment ingestion are similar to those resulting in incidental soil ingestion; therefore, the 100 mg/day soil incidental ingestion rate is adopted also for sediment. Assuming residents are awake and exposed to soil 16 hours per day, a fraction of 4/16 (0.25) is introduced to evaluate recreational site user exposure to soil, and a fraction of 2/16 (0.13) is introduced to evaluate exposure to sediment.

EPA (1997b) identifies a 45-kg youth as being approximately 13 years old with a total body SA of approximately 14,700 cm^2. EPA (1998) recommends a body SA of 5,250 cm^2 and an AF of 0.04 mg/cm^2 for the recreational site user for estimating dermal exposure to soil. A body SA of 5,250 cm^2 and an AF of 0.29 are recommended for evaluation of dermal contact with sediment.

During wading, the recreational site user is assumed to expose his feet, lower legs, hands, and forearms to surface water. Assuming that these body regions constitute 27 percent of the body SA of a 45-kg youth, as they do for an adult (EPA, 1997b), the skin SA exposed to surface water is estimated at 4,000 cm^2.

These described exposure assumptions are sufficiently conservative to address sites where the recreational site user is a nearby resident and exposure would be frequent. However, it is reasonable to adjust the fraction term downward for remote sites or those that are difficult to reach where the EF would be considerably less than that previously described.

It is likely that a recreational site user spending 4 to 6 hours on a site some distance from a source of potable water may become thirsty and intentionally drink available surface water. Data regarding the intentional consumption of surface water in a recreational use setting are not available; however, it is not unlikely that water consumption might approach that of a site worker. Therefore, the default assumption for water consumption of 1 L/day for workers is adopted for surface water ingestion for the recreational site user.

Construction Worker. The construction worker is assumed to be a 70-kg adult who works 8 hours per day, approximately 5 days per week year-round on site for a total of 250 days per year (EPA, 1991a). Construction projects, which may be performed on any site where further development or the installation or repair of below-ground utilities may occur, are assumed to last 1 year. The respiratory rate for the construction worker is assumed to be 20 m^3/8-hour workday (2.5 m^3/hour). Excavation and soil grading activities, which result in intensive soil contact, are assumed to last for 3 months; thereafter, construction activities are assumed to result in less intensive soil contact. Soil ingestion rates of 480 and 100 mg/day are assumed for the intensive and less intensive soil contact periods, respectively (EPA, 1991a), resulting in a time-weighted average rounded to 200 mg/day.

EPA (1998) recommends a body SA of 5,250 cm^2 and an AF of 0.1 mg/cm^2 for the construction worker for estimating dermal exposure to soil.

In the future scenario, the construction worker may be exposed to groundwater, which could be developed as a source of drinking water. His drinking water ingestion rate is assumed to be 1 L/day, the same as the groundskeeper (EPA, 1991a). He may also experience dermal contact with groundwater used to clean equipment and to rinse dust or perspiration from his body. It is assumed that the head, arms, and hands, approximately 4,100 cm^2 (EPA, 1992d), are exposed intermittently throughout the day for up to an hour per day.

Fish and Game Ingestion. A nearby resident is assumed to harvest and consume fish from those bodies of water able to support sport fishing. Telephone conversations with individuals familiar with fishing on FTMC reveal the following (Garland, 1998; Owen, 1998):

- Sport fishing occurs on both the Main Post and the Pelham Range; there is no evidence that subsistence fishing occurs.

- Reilly Lake and Yahou Lake are the only bodies of surface water on the Main Post that support sport fishing. The lakes are stocked with bass, brim, and catfish. Therefore, surface water and sediment only from Reilly and Yahou Lakes and the streams that flow directly into them are evaluated for fish consumption. Most fish harvested from the lakes range from ½ to 2 pounds. Most sport fishing on the Main Post occurs from late February through May; less fishing occurs in July through September, and very little occurs from October to late February.

- Fishing on Pelham Range is largely limited to Cane Creek, where crappies are pursued during their spawning run (late February through April). Therefore, surface water and sediment only from Cane Creek, Cave Creek, and the perennial tributaries that flow into them are evaluated for fish consumption.

Data are not available regarding the harvest or consumption of sport-caught fish at FTMC. Although much of the sport fishing is catch-and-release, some anglers retain and presumably consume their catch. Fishing frequency on FTMC is somewhat seasonal; however, fish freeze easily and well and potentially may contribute to the diet throughout the year. Since site-specific data are not available to refine fish consumption estimates, default data evaluated by ADEM (1994) and EPA (1997b) are used to develop the necessary exposure variable values.

ADEM (1994) interviewed 1,586 anglers at fishing sites throughout Alabama to estimate daily per capita consumption of freshwater fish caught from the study site. Two survey methods were used:

- The Harvest Method, in which anglers identified the fish from their catch to be consumed at the next meal and the weight of edible fish was estimated.

- The 4-Ounce Serving Method, in which the angler reported from recall the number of 4-ounce servings of fish (represented by the size of the palmar surface of the open hand) from the study site typically consumed at a meal.

There were no statistically significant differences in the results from the two survey methods. The means and 95 percent UCL were 32.6 and 39.3 grams per day (g/day) for the Harvest Method, and 30.3 and 37.1 g/day for the 4-Ounce Serving Method. The average of the means and 95 percent UCLs for the two methods (rounded to two significant figures) is 31 and 38 g/day, respectively.

The ADEM (1994) mean fish consumption estimate for anglers (31 g/day) is somewhat higher than the means reported by EPA (1997b) for the general United States population (6.1 to 24.4 g/day), which suggests that Alabama anglers may consume more fish than the general population. An EPA (1997b) survey estimated a mean total fish consumption rate for Michigan anglers of 29.4 g/day, very similar to the ADEM (1994) mean. Anglers and their families are the subpopulation for which fish consumption SSSLs should be designed because of their potential for greater fish consumption than the general population.

The ADEM (1994) UCL for fish consumption of 38 g/day for fish caught from the study site is the starting point for derivation of fish consumption SSSLs for FTMC. The only shortcoming of the ADEM (1994) study is that it did not estimate fish consumption by children, considered by the EPA to be a potentially sensitive subpopulation requiring separate evaluation. The EPA (1997b) evaluation of Michigan anglers, however, reported total fish consumption rates of 29.4 g/day for anglers and 11.4 g/day for children 1 through 5 years old. From these data, assuming fish consumption is negligible during the first year of life, a time-weighted mean average fish consumption rate of 9.5 g/day is estimated for 0 to 6-year-old children. The childhood fish ingestion rate of 9.5 g/day from the EPA (1997b) data is used only to establish the relationship between childhood and adult fish ingestion, which is then used to estimate an equivalent childhood fish ingestion rate from the ADEM (1994) data. The EPA (1997b) data suggest that childhood fish consumption is 0.32 times the adult fish consumption rate (9.5 g/day for child/29, 4 g/day for angler, presumed to be adult). Applying this ratio to the ADEM (1994) angler UCL fish ingestion rate of 38 g/day yields an equivalent childhood fish ingestion rate of 12 g/day.

An age-adjusted fish consumption factor of 17.8 g-years/kg-day is estimated as follows:

$$FCadj = \frac{EDc \bullet FCc}{BWc} + \frac{(EDtot - EDc) \bullet FCa}{BWa} \quad \textbf{Eq. 5-7}$$

where:

FCadj	=	age-adjusted fish consumption factor
EDc	=	exposure duration child 6 years [EPA, 2001a])
FCc	=	fish consumption rate 0- through 6-year-old child (12 g/day)
BWc	=	body weight child (15 kg [EPA, 2001a])
EDtot	=	total residential exposure duration (30 years [EPA, 1991a])
FCa	=	fish consumption rate adult (38 g/day [ADEM, 1994]).
BWa	=	body weight adult (70 kg [EPA, 1991a]).

The child provides the more restrictive noncancer assessment fish consumption because of the greater fish consumption rate when expressed on a BW basis.

A nearby resident is assumed to hunt, harvest, and consume game. The game is assumed to be venison, because deer is the species hunted most widely and most likely to be able to provide a regular contribution to the diet. Since much of FTMC is wooded interspersed with meadows, it is favorable habitat for deer, and the sportsman is assumed to harvest a deer each year. Reliable data regarding ingestion of venison were not located. However, it is unlikely that the sportsman would consume more than the equivalent of one 8-ounce serving per week, or approximately 30 g/day. Data are not available from which to estimate a separate venison consumption rate for children. Therefore, the 30 g/day ingestion rate combined with the recreational site user BW of 45 kg is considered to be sufficiently conservative for all receptors.

The EF is assumed to be 350 days/year and the ED is assumed to be 10 years for fish and game consumption.

It is assumed that 100 percent of fish and venison consumed is harvested from the site under investigation.

National Guardsperson. The NGP scenario is developed largely from information obtained during a telephone conversation with Maj. Bernie Case, currently with the NG stationed at FTMC (Case, 2001). Persons may enlist for NG duty as early as age 17, and may continue until age 60. Six years is a requirement of all who enlist. Twenty years of service is required to receive benefits. Major Case estimates that the average duration of enlistment is 15 years, and that 27 years represents a reasonable upper bound. The estimate of 27 years is adopted as an RME estimate of exposure duration for the NGP.

There are two categories of NGPs that may use sites on Pelham Range. The first are Range Control personnel, who act largely as maintenance workers and groundskeepers. The groundskeeper scenario described above is sufficiently conservative to be protective for these workers. The second category includes enlisted personnel who generally train and exercise for two weeks during the summer (14 days) and one weekend each month (2 days per weekend times 12 weekends = 24 days) for a total of 38 days per year. A few enlisted personnel may volunteer during peacetime to train an additional 2 to 3 weekends or perhaps more during any given year. During times of war or national emergency (e.g., subsequent to the 11 September 2001 attack), enlisted personnel may undergo approximately 10 days of additional training before deployment. The exposure frequency of 38 days per year is considered typical. An exposure frequency of 38 days + 10 days = 48 days is developed as an RME estimate and is adopted for this evaluation. The NGP is assumed to be an adult with a body weight of 70 kg (EPA, 1991a).

Combat personnel participate in weapons firing, marching, digging "fox holes," bivouacing, and other military exercises and activities to train for combat. Engineering personnel participate in many of the above, and also use heavy equipment to build waterway fording sites, bridges, and excavations for protecting troops or large pieces of equipment. Collectively, these activities are expected to result in intense exposure to surface and subsurface soil, including incidental ingestion, dermal contact, and inhalation of dust and volatiles.

Empirical data regarding incidental soil ingestion by NGPs is not available. However, a soil incidental ingestion rate of 200 milligrams per day (mg/day) was developed for construction worker exposure (see above). Since at least some of the activities performed by NGPs and construction workers may be similar, and both receptors are expected to be intensely exposed to soil, the incidental ingestion rate of 200 mg/day is adopted for the NGP. Also, the body surface area exposed to soil (5250 cm^2) and the soil-to-skin adherence factor (0.1 mg/cm^2) estimated for the construction worker are adopted for the NGP.

The NGP would be exposed to airborne dust and volatiles from soil as a result of excavation and other activities, similar to the situation for the construction worker. It is assumed that the model that predicts airborne concentrations of dust would be sufficiently conservative to account for airborne concentrations of volatiles. Therefore, the dust-loading factor of 0.2 milligrams per cubic meter of air (mg/m^3) developed for the construction worker is adopted for the NGP. The reciprocal of the dust-loading factor of 0.2 mg/m^3 is equivalent to a particulate emission factor of 5 m^3/mg, which is used to evaluated NGP inhalation exposure to airborne dust and volatiles.

Empirical data are not available from which to estimate an inhalation rate for NGPs. Traditionally, an inhalation rate of 20 m^3 per 8-hour workday has been used for occupational exposure including construction work. NG activities, however, frequently exceed the typical 8-hour workday. In addition, the NGPs may be on site for 24 hours per day, especially during bivouacking, although levels of airborne dust and volatiles from soil are expected to decrease markedly during rest periods. EPA (1997b) recommends inhalation rates of 1.5 m^3/hour for moderate outdoor activity for adults, and 0.4 m^3/hour during rest. It is assumed for this evaluation that NGPs are involved in moderate outdoor activity for 16 hours/day, and that quantification of exposure during the period of activity is sufficiently conservative to "cover" for the far less intense exposure expected during rest. An inhalation rate of 24 m^3/day is estimated as the product of 1.5 m^3/hour and 16 hours/day.

NGPs cross streams at fording sites and may build bridges over streams. Generally, fording streams is infrequent, and equipment is used to build bridges. Consequently, the opportunity for direct contact with surface water is infrequent, and exposures are likely to be very short-term. Therefore, exposure to surface water and sediment is assumed to be insignificant, and SSSLs are not developed for NGP exposure to these media.

Potable water for all NG activities is currently provided by the City of Anniston. However, it may be appropriate to assume that groundwater could be developed as a source of potable water that could be used in the future by the NGPs. Typical uses of water include drinking water, cooking, showering and cleaning equipment. Relevant exposure routes include ingestion, dermal contact, and inhalation of volatiles released into the breathing zone during water use. Quantification of the ingestion pathway will be limited to drinking water consumption because other ingestion events would be insignificant by comparison. Drinking water is defined as water consumed as a beverage, as well as water used in cooking and to make other beverages. EPA (1991a) recommends a drinking water ingestion rate of 2 liters (L) per day as a reasonable upper bound estimate for residential adults. NGPs undergoing rigorous training and exercise, particularly in a hot and humid area, may be expected to consume somewhat more than 2 L/day. Data reviewed by EPA (1997b) suggest that the 90 to 95th percentile on drinking water ingestion rates may reach approximately 40 milliliters per kg body weight per day, or approximately 2.8

L/day for a 70-kg adult. A U.S. Army study (reviewed by EPA, 1997b) reported a value as high as 11.4 L/day as a "planning factor," but it is not clear the extent to which this is based on measurements and the extent to which the estimates have been inflated to provide a cushion for planning purposes. The 90 to 95th percentile drinking water consumption rate of 2.8 L/day suggested by EPA (1997b) is adopted for the purposes of this evaluation.

Dermal exposure may occur occasionally throughout the day during the use of potable water. The most intense exposure, however, would be expected to occur during showering, which is assumed to occur once daily. The entire body surface area (18,150 cm^2) is assumed to contact water for a 12-minute (0.2 hour) period of time (EPA, 1992d). Inhalation of airborne volatiles may occur during any use of potable water; however, natural air currents and the large volume of ambient air are expected to dilute airborne concentrations to toxicologically insignificant concentrations. Showering is considered an exception because the receptor and vapors from heated water are confined in a relatively small space and air exchange is minimized. Therefore, inhalation of volatiles is addressed for the showering scenario.

It was learned during preparation of the Fill Area SI report that a portion of Parcel 233 (fill area west of Iron Mountain Road and Range 19) lies within the right-of-way of the Anniston East Bypass, a proposed four-lane highway intended to remove traffic congestion from the city. Part of the fill area will be removed during the construction phase to make way for the highway. Highway construction differs greatly from "fixed location" construction projects in several ways, so that the standard construction worker exposure scenario described above does not apply. Therefore, a highway construction scenario was hypothesized and SSSLs were developed. Documentation was provided in an appendix to the Fill Area SI report. The highway construction scenario is not included herein because it is not expected that other parcels will be included in the proposed highway right-of-way.

5.2.3 Site-Specific Screening Level Equations

SSSLs are developed for each medium for each relevant receptor scenario described above. Initially, SSSLs were developed and compiled in an appendix for most metals that may be present in various media at concentrations exceeding background, and for several organic chemicals representative of the important chemical classes, i.e., VOCs, SVOCs, polychlorinated biphenyls (PCB)/pesticides, and the polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/PCDF).

Subsequently it was requested that SSSLs be developed for all chemicals that may appear as site-related chemicals in any of the parcels; i.e., nearly all chemicals included in the standard analytical methods. The SSSL tables were expanded as requested, but no attempt was made to distribute the expanded SSSL tables to all users. The SSSLs were re-calculated subsequent to the expansion to ensure that the most current toxicity and other chemical-specific values were used. These SSSLs were presented in IT (2000a). Toxicity profiles were included that provided documentation for the chemical-specific values. The SSSLs are taken from IT (2000a) when needed for an SRA. Toxicity values are routinely checked to ensure that the SSSLs use only the most current.

5.2.3.1 Soil

Resident. There are two exposure routes by which the resident may contact contaminants in soil that are quantified: incidental ingestion and dermal contact. These exposure routes are combined to estimate SSSLs for residential exposure to soil as follows:

For cancer risk (based on age-adjusted resident exposure):

$$SSSL_{SLRESc} = \frac{TR \bullet ATc \bullet (1/FIso) \bullet (1/EF) \bullet CF1}{(IFadj \bullet SFo) + (SASadj \bullet AFso \bullet ABS \bullet SFd)} \qquad \textbf{Eq. 5-8}$$

where:

$SSSL_{SLRESc}$	=	cancer-based site-specific screening level for soil, resident, (mg/kg, calculated)
TR	=	target cancer risk (unitless, 1E-6)
ATc	=	averaging time, cancer (days)
FIso	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
CF1	=	conversion factor (1E+6 mg/kg)
IFadj	=	age-adjusted soil incidental ingestion factor (mg-years/kg-day)
SFo	=	oral cancer slope factor (per mg/kg-day)
SASadj	=	age-adjusted body surface area-soil factor (cm^2-years/kg-day)
AFso	=	soil-to-skin adherence factor (mg/cm^2)

ABS	=	dermal absorption factor (unitless)
SFd	=	dermal cancer slope factor (per mg/kg-day).

For noncancer effects (based on child resident exposure):

$$SSSL_{SLRESn} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIso) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{\left(\frac{IRso}{RfDo}\right) + \left(\frac{SAso \bullet AFso \bullet ABS}{RfDd}\right)} \quad \textbf{Eq. 5-9}$$

where the variables are the same as previously defined, except:

$SSSL_{SLRESn}$	=	noncancer-based site-specific screening level for soil, resident, (mg/kg, calculated)
THI	=	target hazard index (unitless, 1E-1)
BW	=	body weight (kg)
ATn	=	averaging time, noncancer (days)
ED	=	exposure duration (years)
IRso	=	soil incidental ingestion rate (mg/day)
RfDo	=	oral reference dose (mg/kg-day)
SAso	=	body surface area exposed to soil (cm^2/day)
RfDd	=	dermal reference dose (mg/kg-day).

Groundskeeper. There are three exposure routes by which the groundskeeper may contact contaminants in soil that are quantified: incidental ingestion, inhalation of airborne dust and dermal contact. The National Council on Radiation Protection and Measurements (NCRP), (1984) suggests a dust-loading or particulate emission factor (PEF) of 100 micrograms per cubic meter ($\mu g/m^3$) for activities that include maintenance work or groundskeeping. The reciprocal is equivalent to a dust emissions factor of 1E-2 $m^3/\mu g$. Multiplying this value by 1E+3 $\mu g/mg$ yields a dust PEF of 1E+1 m^3/mg, which is used to evaluate groundskeeper inhalation exposure to airborne dust. These exposure routes are combined to estimate SSSLs for groundskeeper exposure to soil as follows:

For cancer risk:

$$SSSL_{SLGKc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIso) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{[IRso \bullet SFo] + [SAso \bullet AFso \bullet ABS \bullet SFd] + \left[\frac{IRa \bullet SFi}{PEF}\right]} \quad \textbf{Eq. 5-10}$$

where:

$SSSL_{SLGKc}$	=	cancer-based site-specific screening level for soil, groundskeeper, (mg/kg, calculated)
TR	=	target cancer risk (unitless, 1E-6)
BW	=	body weight (kg)
ATc	=	averaging time, cancer (days)
FIso	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF1	=	conversion factor (1E+6 mg/kg)
IRso	=	soil incidental ingestion rate (mg/day)
SFo	=	oral cancer slope factor (per mg/kg-day)
SAso	=	body surface area exposed to soil (cm^2)
AFso	=	soil-to-skin adherence factor (mg/cm^2)
ABS	=	dermal absorption factor (unitless)
SFd	=	dermal cancer slope factor (per mg/kg-day)
IRa	=	inhalation rate, m^3/day
SFi	=	inhalation cancer slope factor (per mg/kg-day)
PEF	=	dust particulate emission factor (m^3/mg).

For noncancer effects:

$$SSSL_{SLGKn} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIso) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{\left[\frac{IRso}{RfDo}\right] + \left[\frac{SAso \bullet AFso \bullet ABS}{RfDd}\right] + \left[\frac{IRa}{RfDi \bullet PEF}\right]} \qquad \textbf{Eq. 5-11}$$

where the variables are the same as previously defined, except:

$SSSL_{SLGKn}$	=	noncancer-based site-specific screening level for soil, groundskeeper (mg/kg, calculated)
THI	=	target hazard index (unitless, 1E-1)
ATn	=	averaging time, noncancer (days)
RfDo	=	oral reference dose (mg/kg-day)
RfDd	=	dermal reference dose (mg/kg-day)
RfDi	=	inhalation reference dose (mg/kg-day).

Recreational Site User. There are two exposure routes by which the residential site user may contact contaminants in soil that are quantified: incidental ingestion and dermal contact. These exposure routes are combined to estimate SSSLs for recreational site user exposure to soil as follows:

For cancer risk:

$$SSSL_{SLRECc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIso) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{[IRso \bullet SFo] + [SAso \bullet AFso \bullet ABS \bullet SFd]} \qquad \textbf{Eq. 5-12}$$

where:

$SSSL_{SLRECc}$	=	cancer-based site-specific screening level for soil, recreational site user (mg/kg, calculated)
TR	=	target cancer risk (unitless, 1E-6)
BW	=	body weight (kg)
ATc	=	averaging time, cancer (days)
FIso	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF1	=	conversion factor (1E+6 mg/kg)
IRso	=	soil incidental ingestion rate (mg/day)
SFo	=	oral cancer slope factor (per mg/kg-day)
SAso	=	body surface area exposed to soil (cm^2)
AFso	=	soil-to-skin adherence factor (mg/cm^2)
ABS	=	dermal absorption factor (unitless)
SFd	=	dermal cancer slope factor (per mg/kg-day).

For noncancer effects, use Equation 5-9, substituting $SSSL_{SLRECn}$ for $SSSL_{SLRESn}$, where:

$SSSL_{SLRECn}$	=	noncancer-based site-specific screening level for soil, recreational site user (mg/kg, calculated).

Construction Worker. There are three exposure routes by which the construction worker may contact contaminants in soil that are quantified: incidental ingestion, inhalation of airborne dust and VOCs, and dermal contact. It is assumed that a conservative model that predicts airborne concentrations of dust raised by activity on the site would be sufficiently conservative to include airborne concentrations of VOCs from volatilization. Plausible values for a dust-loading factor include 6E-4 g/m^3 for construction work (DOE, 1983), and 1E-4 g/m^3 for other activity (NCRP, 1984). It is assumed that construction activities requiring intimate contact with soil, for which a dust-loading factor of 6E-4 g/m^3 is appropriate, may last for one-fourth of a construction period. The remaining three-fourths of the time is more realistically characterized by a dust-loading factor of 1E-4 g/m^3. Therefore, a time-weighted average dust-loading factor for construction work of 2E-4 g/m^3 (2E-1 mg/m^3) is estimated for the construction worker. The reciprocal is equivalent to a PEF of 5E+0 m^3/mg, which is used to evaluate construction worker inhalation exposure to airborne dust and VOCs. These exposure routes are combined to estimate SSSLs for construction worker exposure to soil as follows:

For cancer risk, use Equation 5-10, substituting $SSSL_{SLCSTc}$ for $SSSL_{SLGKc}$, where:

$SSSL_{SLCSTc}$	=	cancer-based site-specific screening level for soil, construction worker (mg/kg, calculated).

For noncancer effects, use Equation 5-11, substituting $SSSL_{SLCSTn}$ for $SSSL_{SLGKn}$, where:

$SSSL_{SLCSTn}$	=	noncancer-based site-specific screening level for soil, construction worker (mg/kg, calculated).

Venison Consumption. In this scenario, deer are potentially exposed by browsing the plants growing on contaminated soil. Deer may also ingest soil, but soil ingestion is of greater significance for animals that graze, such as cattle and sheep, and is not evaluated herein. Consuming venison represents an indirect pathway for exposure of humans to soil. This pathway is evaluated only for those open or recreational use sites able to support browsing deer. Chemicals evaluated are limited to the metals for which there are oral toxicity values, and the persistent, lipophilic organic chemicals expected to bioaccumulate in biological tissue, i.e., the organochlorine pesticides (e.g., dichlorodiphenyltrichloroethane, dieldrin, chlordane), PCBs, and PCDD/PCDF.

The following simplifying assumptions permit estimating an overall soil-to-venison transfer factor for SSSL development:

- Soil-to-plant transfer factors are available for metals (Baes, et al., 1984) and may be estimated for organic compounds (Travis and Arms, 1988), and are expressed as the ratio of the concentration of chemical in the aerial part of plants (mg of chemical/kg of plant dry matter [DM]) to the concentration in soil (mg of chemical/kg of soil). Deer browse roughage, such as buds, twigs, leaves and grasses, for longer periods during the year than they consume nuts or mast, such as acorns. Therefore soil-to-plant transfer factors for metals for the vegetative parts of plants, rather than the reproductive parts, will be used.

- Deer are small ruminants and as such are not unlike cattle; thus, it is reasonable to assume they may have similar physiological processes that could yield browse-to-venison biotransfer factors similar to forage-to-beef biotransfer factors. Unlike beef, however, deer meat does not marble with fat, and deer fat is quite unpalatable and is likely to be trimmed rather than consumed. Therefore, biotransfer factors for edible venison are derived by adjusting biotransfer factors for beef to account for differences in the fat content of table-ready beef (cooked choice retail cuts trimmed to 0 inches of fat, average 14.4 percent fat) and venison (cooked boneless muscle meats, average 2.9 percent fat) (Nutrient Database, on-line). Therefore, browse-to-venison biotransfer factors are derived by multiplying forage-to-beef biotransfer factors by 2.9/14.4 or 0.2.

- Deer are expected to consume 1.74 kg of browse per day (Sample, et al., 1996), which is approximately 50 percent DM (0.87 kg browse DM per day) (Mautz, et al., 1976).

- Deer are expected to browse a much larger area than the potentially contaminated areas encompassed in any of the sites at FTMC. Therefore the fraction of total browse consumed from the contaminated site is expected to be small. It is assumed that one-tenth of a deer's daily browse (0.087 kg browse DM per day) is obtained from the site under investigation.

Soil-to-plant biotransfer factors (Bp) for organic compounds are calculated from the following equation (Travis and Arms, 1988):

$$\log Bp = 1.588\ (0.578 \bullet \log Kow) \qquad \textbf{Eq. 5-13}$$

where:

Bp	=	soil-to-plant biotransfer factor (kg soil/kg of plant DM)
Kow	=	octanol-water partition coefficient.

Plant-to-beef biotransfer factors (Bb) for organic compounds are calculated from the following equation (Travis and Arms, 1988):

$$\log Bb = 7.6 + \log Kow \qquad \textbf{Eq. 5-14}$$

where:

Bb	=	plant to beef biotransfer factor (days/kg)
Kow	=	octanol-water partition coefficient.

An overall soil-to-venison factor that reflects these assumptions can be expressed as:

$$Bv = (0.087)\ (Bp)\ (0.2)\ (Bb)\ (CF2) \qquad \textbf{Eq. 5-15}$$

where:

Bv	=	overall soil-to-venison biotransfer factor (mg soil/g venison, calculated)
0.087	=	browse DM ingested by deer from potentially contaminated site (kg/day)
Bp	=	soil-to-plant biotransfer factor (kg soil/kg of plant DM)
0.2	=	factor to adjust for differences in fat content of table-ready beef and venison (unitless)
Bb	=	plant-to-beef biotransfer factor (days/kg)
CF2	=	conversion factor (1E+3 mg/g).

The overall soil-to-venison biotransfer factor is used to estimate soil SSSLs for venison consumption as follows:

For cancer risk:

$$SSSL_{SLVc} = \frac{TR \bullet BW \bullet ATc \bullet (1/EF) \bullet (1/ED) \bullet CF1}{VC \bullet Bv \bullet SFo} \qquad \textbf{Eq. 5-16}$$

where:

$SSSL_{SLVc}$	=	cancer-based site-specific screening level for soil, venison consumption (mg/kg, calculated)
TR	=	target cancer risk (unitless, 1E-6)
BW	=	body weight (kg)
ATc	=	averaging time, cancer (days)
FIso	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF1	=	conversion factor (1E+6 mg/kg)
VC	=	venison consumption rate (g/day)
Bv	=	overall soil-to-venison biotransfer factor (mg soil/g venison)
SFo	=	oral cancer slope factor (per mg/kg-day).

For noncancer effects:

$$SSSL_{SLVn} = \frac{THI \bullet BW \bullet ATn \bullet (1/EF) \bullet (1/ED) \bullet CF1}{\left(\frac{VC \bullet Bv}{RfDo}\right)} \qquad \textbf{Eq. 5-17}$$

where the variables are the same as previously defined, except:

$SSSL_{SLVn}$	=	noncancer-based site-specific screening level for soil, venison consumption (mg/kg, calculated)
THI	=	target hazard index (unitless, 1E-1)
ATn	=	averaging time, noncancer (days)
RfDo	=	oral reference dose (mg/kg-day).

National Guardsperson. There are three exposure routes by which the NGP may contact contaminants in soil that are quantified: incidental ingestion, inhalation of airborne dust and VOCs, and dermal contact. The PEF of 5E+0 m^3/mg developed for the construction worker is used to evaluate NGP inhalation exposure to airborne dust and VOCs. These exposure routes are combined to estimate SSSLs for NGP exposure to soil as follows:

For cancer risk, use Equation 5-10, substituting $SSSL_{SLNGPc}$ for $SSSL_{SLGKc}$, where:

$SSSL_{SLNGPc}$	=	cancer-based site-specific screening level for soil, National Guardsperson (mg/kg, calculated).

For noncancer effects, use Equation 5-11, substituting $SSSL_{SLNGPn}$ for $SSSL_{SLGKn}$, where:

$SSSL_{SLNGPn}$	=	noncancer-based site-specific screening level for soil, National Guardsperson (mg/kg, calculated).

5.2.3.2 Groundwater

An important exposure route for contact with groundwater is dermal contact, the evaluation of which requires a PC and the lag time for chemicals to cross the stratum corneum (τ). When possible, values for PC are taken from EPA (1992d). If PC values are not available, they will be calculated from the formula (EPA, 1992d):

$$Log(PC) = 2.72 + 0.71(\log K_{ow})0.0061(MW) \quad \textbf{Eq. 5-18}$$

where:

PC = permeability coefficient (cm/hour, calculated)
log K_{ow} = log of the octanol/water partition coefficient (unitless)
MW = molecular weight.

Resident. Chemicals in groundwater are assigned to three classes for SSSL development: inorganic chemicals (largely metals), VOCs and SVOCs. For evaluating residential exposure to groundwater, VOCs include those chemicals with a molecular weight less than 200 grams per mole, and a Henry's law constant greater than 1E-5 atmosphere-m^3/mole. All other organic chemical classes, including pesticides/PCBs, dioxins, etc., are considered to be SVOCs. There are three exposure routes by which the on-site resident may contact contaminants in groundwater that are quantified: ingestion of drinking water, dermal contact, and inhalation of volatiles released during household use. Drinking water ingestion pertains to all classes of potential contaminants. Inhalation pertains only to VOCs and is evaluated only for adults in a showering scenario. Dermal uptake pertains only to organic chemicals; dermal uptake of inorganic chemicals associated with residential use of water is considered insignificant relative to drinking water ingestion (EPA, 2001a). Separate equations are used to develop SSSLs for the different chemical classes in groundwater:

For cancer risk, inorganic chemicals in groundwater (age-adjusted resident exposure):

$$SSSL_{GWRESc} = \frac{TR \bullet ATc \bullet (1/FIgw) \bullet (1/EF)}{DWFadj \bullet SFo} \quad \textbf{Eq. 5-19}$$

where:

$SSSL_{GWRESc}$ = cancer-based site-specific screening level for groundwater, resident (mg/L, calculated)
TR = target cancer risk (unitless, 1E-6)
ATc = averaging time, cancer (days)
FIgw = fraction exposed to contaminated medium (unitless)
EF = exposure frequency (days/year)
DWFadj = age-adjusted drinking water ingestion factor (L-years/kg-day)
SFo = oral cancer slope factor (per mg/kg-day).

For cancer risk, VOCs in groundwater (age-adjusted resident exposure):

$$SSSL_{GWRESc} = \frac{TR \bullet ATc \bullet (1/FIgw) \bullet (1/EF)}{(DWFadj \bullet SFo) + (GWIFadj \bullet SFi)} \qquad \textbf{Eq. 5-20}$$

where the variables are the same as previously defined, except:

GWIFadj	=	age-adjusted groundwater inhalation factor (L-years/kg-day)
SFi	=	inhalation cancer slope factor (per mg/kg-day).

The previous equation assumes that the age-adjusted groundwater inhalation factor, based on adult ingestion of 2 L/day of drinking water, is sufficiently conservative to account for dermal uptake of VOCs, as well as inhalation exposure.

For cancer risk, SVOCs in groundwater (age-adjusted resident exposure):

$$SSSL_{GWRESc} = \frac{TR \bullet ATc \bullet (1/FIgw) \bullet (1/EF)}{(DWFadj \bullet SFo) + (SAWadj \bullet PC \bullet ETgw \bullet CF3 \bullet SFd)} \qquad \textbf{Eq. 5-21}$$

where the variables are the same as previously defined, except:

SAWadj	=	age-adjusted body SA-groundwater factor (cm^2-years/kg-day)
PC	=	permeability coefficient (cm/hour)
CF3	=	conversion factor (1E-3 L/cm^3)
ETgw	=	exposure time (hours)
SFd	=	dermal cancer slope factor (per mg/kg-day).

For noncancer effects, inorganic chemicals in groundwater (based on child resident exposure):

$$SSSL_{GWRESn} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIgw) \bullet (1/EF) \bullet (1/ED)}{\frac{DW}{RfDo}} \qquad \textbf{Eq. 5-22}$$

where:

$SSSL_{GWRESn}$	=	noncancer-based site-specific screening level for groundwater, resident (mg/L, calculated)
THI	=	target hazard index (unitless, 1E-1)
BW	=	body weight (kg)
ATn	=	averaging time, noncancer (days)
FIgw	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
DW	=	drinking water ingestion rate (L/day)
RfDo	=	oral reference dose (mg/kg-day).

For noncancer effects, SVOCs in groundwater (based on child resident exposure):

$$SSSL_{GW\text{-}RES\text{-}n} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIgw) \bullet (1/EF) \bullet (1/ED)}{\left(\frac{DW}{RfDo}\right) + \left(\frac{SAgw \bullet PC \bullet ETgw \bullet CF3}{RfDd}\right)} \qquad \textbf{Eq. 5-23}$$

where the variables are the same as previously defined, except:

SAgw	=	body surface area exposed to groundwater (cm^2)
PC	=	permeability coefficient (cm/hour)
CF3	=	conversion factor (1E-3 L/cm^3)
ETgw	=	exposure time (hours).

Developing residential SSSLs for noncancer effects for VOCs in groundwater is not as straight-forward as the other chemical classes, because neither the adult nor the child consistently provides the more restrictive evaluation. Therefore, it is necessary to develop noncancer SSSLs for VOCs in groundwater for both the adult and the child resident and chose the more restrictive (smaller) of the two. Equation 5-23 is used to estimate SSSLs for noncancer effects for VOCs for the child resident. The following equation is used to estimate SSSLs for noncancer effects for VOCs for the adult resident:

$$SSSL_{GWRESn} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIgw) \bullet (1/EF) \bullet (1/ED)}{(DW_{gw}/RfDo) + (DW_{gw}/RfDi)} \qquad \textbf{Eq. 5-24}$$

where:

$SSSL_{GWRESn}$	=	noncancer-based site-specific screening level for groundwater, resident (mg/L, calculated)
THI	=	target hazard index (unitless, 1E-1)
BW	=	body weight (kg)
ATn	=	averaging time, noncancer (days)
FIgw	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
DW_{gw}	=	drinking water ingestion rate (L/day)
RfDo	=	oral reference dose (mg/kg-day)
RfDi	=	inhalation reference dose (mg/kg-day).

Groundskeeper. There are two exposure routes by which the groundskeeper may contact contaminants in groundwater that are quantified: drinking water ingestion and dermal contact. These exposure routes are combined to estimate SSSLs for groundskeeper exposure to groundwater as follows:

For cancer risk:

$$SSSL_{GWGKc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIgw) \bullet (1/EF) \bullet (1/ED)}{(DWgw \bullet SFo) + (SAgw \bullet PC \bullet CF3 \bullet SFd \bullet ETgw)} \qquad \textbf{Eq. 5-25}$$

where:

$SSSL_{GWGKc}$	=	cancer-based site-specific screening level for groundwater, groundskeeper(mg/L, calculated)
TR	=	target cancer risk (unitless, 1E-6)
BW	=	body weight (kg)
ATc	=	averaging time, cancer (days)
FIgw	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
DWgw	=	drinking water ingestion rate (L/day)
SFo	=	oral cancer slope factor (per mg/kg-day)
SAgw	=	body surface area exposed to groundwater (cm^2)
PC	=	permeability coefficient (cm/hour)
CF3	=	conversion factor (1E-3 L/cm^3)

SFd	=	dermal cancer slope factor (per mg/kg-day)
ETgw	=	exposure time (hours).

For noncancer effects, use Equation 5-23, substituting $SSSL_{GWGKn}$ for $SSSL_{GWRESn}$, where:

$SSSL_{GWGKn}$	=	noncancer-based site-specific screening level for groundwater, groundskeeper (mg/L, calculated).

Construction Worker. There are two exposure routes by which the construction worker may contact contaminants in groundwater that are quantified: drinking water ingestion and dermal contact. Equation 5-25 is used to develop cancer-based SSSLs for construction worker exposure to groundwater by substituting $SSSL_{GWCSTc}$ for $SSSL_{GWGKc}$, where:

$SSSL_{GWGKc}$ = cancer-based site-specific screening level for groundwater, construction worker (mg/L, calculated).

Equation 5-23 is used to develop noncancer-based SSSLs for construction worker exposure to groundwater by substituting $SSSL_{GWCSTn}$ for $SSSL_{GWRESn}$, where:

$SSSL_{GWGKn}$ = noncancer-based site-specific screening level for groundwater, construction worker (mg/L, calculated).

National Guardsperson. The NGP may be exposed to groundwater by three exposure routes that are quantified: drinking water consumption, dermal contact, and inhalation of volatiles released during showering. Drinking water consumption is relevant for all three chemical classes. Inhalation of volatiles is relevant only for VOCs. Dermal uptake is quantified only for organic chemicals (VOCs and SVOCs) because EPA Region IV considers dermal uptake of inorganic chemicals to be much less significant than drinking water consumption. Separate equations are used to develop SSSLs for the different chemical classes.

SSSLs for inorganic chemicals in groundwater are derived as follows – based on cancer risk:

Eq. 5-26

$$SSSL_{GWNGPc} = \frac{TR \bullet BW \bullet ATc \bullet (1/EF) \bullet (1/ED)}{DW \bullet SFo}$$

– and based on noncancer effects:

$$SSSL_{GWNGPn} = \frac{THI \bullet BW \bullet ATn \bullet (1/EF) \bullet (1/ED)}{DW / RfDo}$$ **Eq. 5-27**

where the variables are the same as previously defined, except (for Equation 5-26):

$SSSL_{GWNGPc}$	=	cancer-based site-specific screening level for groundwater, National Guardsperson, (mg/L, calculated),

and (for Equation 5-27):

$SSSL_{GWNGPn}$	=	noncancer-based site-specific screening level for groundwater, National Guardsperson (mg/L, calculated).

SSSLs for VOCs in groundwater are derived as follows – based on cancer risk:

$$SSSL_{GWNGPc} = \frac{TR \bullet BW \bullet ATc \bullet (1/EF) \bullet (1/ED)}{(IRdw \bullet SFo) + (2 \bullet SFi)}$$ **Eq. 5-28**

– and based on noncancer effects:

$$SSSL_{GWNGPn} = \frac{THI \bullet BW \bullet ATn \bullet (1/EF) \bullet (1/ED)}{\left(\frac{IRdw}{RfDo}\right) + \left(\frac{2}{RfDi}\right)}$$ **Eq. 5-29**

where the variables are the same as previously defined, except:

2	=	constant (L/day, see below).

The constant of 2 L/day in Equations 5-28 and 5-29 reflects the EPA Region IV assumption that the dermal uptake and inhalation of VOCs during a shower is equivalent to that obtained from ingestion of 2 L of water per day. Inhalation uptake is expected to exceed dermal uptake; therefore, inhalation toxicity values rather than dermal toxicity values are used in the evaluation.

SSSLs for SVOCs in groundwater are derived as follows – based on cancer risk:

$$SSSL_{GWNGPc} = \frac{TR \bullet BW \bullet ATc \bullet (1/EF) \bullet (1/ED)}{(IRdw \bullet SFo) + (SAgw \bullet PC \bullet ETgw \bullet CF3 \bullet SFd)}$$ **Eq. 5-30**

– and based on noncancer effects:

$$SSSL_{GWNGPn} = \frac{THI \bullet BW \bullet ATn \bullet (1/EF) \bullet (1/ED)}{\left(\frac{IRdw}{RfDo}\right) + \left(\frac{SAgw \bullet PC \bullet ETgw \bullet CF3}{RfDd}\right)}$$ **Eq. 5-31**

where the variables are the same as previously defined.

5.2.3.3 Surface Water

Recreational Site User. There are two exposure routes by which the recreational site user may contact contaminants in surface water that are quantified: intentional ingestion and dermal contact. These exposure routes are combined to estimate SSSLs for recreational site user exposure to surface water as follows:

For cancer risk:

$$SSSL_{SWRECc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIsw) \bullet (1/EF) \bullet (1/ED)}{(IRsw \bullet SFo) + (SAsw \bullet PC \bullet ETsw \bullet CF3 \bullet SFd)}$$ **Eq. 5-32**

where:

$SSSL_{SWRECc}$	=	cancer-based site-specific screening level for surface water, recreational site user, (mg/L, calculated)
TR	=	target cancer risk (unitless, 1E-6)
BW	=	body weight (kg)
ATc	=	averaging time, cancer (days)
FIsw	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
IRsw	=	surface water ingestion rate (L/day)
SFo	=	oral cancer slope factor (per mg/kg-day)
SAsw	=	body surface area exposed to surface water (cm^2)
PC	=	permeability coefficient (cm/hour)

CF3	=	conversion factor (1E-3 L/cm^3)
ETsw	=	exposure time (hours)
SFd	=	dermal cancer slope factor (per mg/kg-day).

For noncancer effects:

$$SSSL_{SWRECn} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIsw) \bullet (1/EF) \bullet (1/ED)}{\left(\frac{IRsw}{RfDo}\right) + \left(\frac{SAsw \bullet PC \bullet ETsw \bullet CF3}{RfDd}\right)} \quad \textbf{Eq. 5-33}$$

where:

$SSSL_{SWRECn}$	=	noncancer-based site-specific screening level for surface water, recreational site user (mg/L, calculated)
THI	=	target hazard index (unitless, 1E-1)
BW	=	body weight (kg)
ATn	=	averaging time, noncancer (days)
FIsw	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
IRsw	=	surface water ingestion rate (L/day)
RfDo	=	oral reference dose (mg/kg-day)
SAsw	=	body surface area exposed to surface water (cm^2)
PC	=	permeability coefficient (cm/hour)
CF3	=	conversion factor (1E-3 L/cm^3)
RfDd	=	dermal reference dose (mg/kg-day)
ETsw	=	exposure time (hours).

Fish Consumption. In this scenario, fish are potentially exposed by living in contaminated surface water. Consuming fish represents an indirect pathway for exposure of humans to surface water. This pathway is evaluated only for those bodies of surface water able to support sport fishing, which include Reilly Lake and Yahou Lake and streams that flow directly into these lakes on the Main Post, and Cave Creek, Cane Creek, and perennial streams that flow directly into them on Pelham Range. Chemicals evaluated are limited to the metals for which oral toxicity values exist, and the persistent, lipophilic organic chemicals expected to bioconcentrate in fish tissue, i.e., the organochlorine pesticides, PCBs, and PCDD/PCDF. A surface water-to-fish bioconcentration factor (BCF) is used to estimate surface water SSSLs for fish consumption. BCF values are taken from various EPA and other sources. Empirical data are chosen when available. The BCF values are documented in the Toxicity Profiles appended to IT (2000a).

They are subject to change as updated information becomes available.

SSSLs for fish consumption are calculated as follows:

For cancer risk (based on age-adjusted receptor):

$$SSSL_{SWF_n} = \frac{THI \bullet BW \bullet ATn \bullet (1/EF) \bullet (1/ED) \bullet CF4}{\left(\frac{FC \bullet BCF}{RfDo}\right)} \quad \textbf{Eq. 5-34}$$

where:

$SSSL_{SWFc}$	=	cancer-based site-specific screening level, fish consumption (mg/L, calculated)
TR	=	target cancer risk (unitless, 1E-6)
ATc	=	averaging time, cancer (days)
EF	=	exposure frequency (days/year)
CF4	=	conversion factor (1E+3 g/kg)
FCadj	=	age-adjusted fish consumption rate (g-years/kg-day)
BCF	=	surface water-to-fish bioconcentration factor (L water/kg fish)
SFo	=	oral cancer slope factor (per mg/kg-day).

For noncancer effects (based on child receptor):

$$SSSL_{SWFn} = \frac{THI \bullet BW \bullet ATn \bullet (1/EF) \bullet (1/ED) \bullet CF4}{\left(\frac{FC \bullet BCF}{RfDo}\right)} \quad \textbf{Eq. 5-35}$$

where:

$SSSL_{SWFn}$	=	noncancer-based site-specific screening level, fish consumption (mg/L, calculated)
THI	=	target hazard index (unitless, 1E-1)
ATn	=	averaging time, noncancer (days)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF4	=	conversion factor (1E+3 g/kg)
FC	=	fish consumption rate (g/day)

BCF	=	surface water-to-fish bioconcentration factor (L water/kg fish)
RfDo	=	oral reference dose (mg/kg-day).

Sport fishing on Pelham Range is largely limited to crappies during their spawning run, from late February through April, which constitutes approximately 11 weeks, or 0.2 years. During the remainder of the year, the fish reside in the Coosa River and are not subjected to potential contamination on the site. Therefore, the surface water SSSLs for fish consumption derived as described are multiplied by five for use on Pelham range. No adjustment is applied for use on the Main Post, because Reilly and Yahou Lakes are stocked with fish that are assumed to remain in the lakes year round.

All surface water SSSLs developed for the recreational site user are also applied to the on-site residential scenario.

5.2.3.4 Sediment

Recreational Site User. There are two exposure routes by which the recreational site user may contact contaminants in sediment that are quantified: incidental ingestion and dermal contact. These exposure routes are combined to estimate SSSLs for recreational site user exposure to sediment as follows:

For cancer risk:

$$SSSL_{SDRECc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIsd) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{(IRsd \bullet SFo) + (SAsd \bullet AFsd \bullet ABS \bullet SFd)} \qquad \textbf{Eq. 5-36}$$

where:

$SSSL_{SDRECc}$	=	cancer-based site-specific screening level, recreational site user, (mg/L, calculated)
TR	=	target cancer risk (unitless, 1E-6)
BW	=	body weight (kg)
ATc	=	averaging time, cancer (days)
FIsd	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)

CF1	=	conversion factor (1E+6 mg/kg)
IRsd	=	sediment incidental ingestion rate (mg/day)
SFo	=	oral cancer slope factor (per mg/kg-day)
SAsd	=	body surface area exposed to sediment (cm^2)
AFsd	=	sediment-to-skin adherence factor (mg/cm^2)
ABS	=	dermal absorption factor (unitless)
SFd	=	dermal cancer slope factor (per mg/kg-day).

For noncancer effects:

$$SSSL_{SDRECn} = \frac{THI \bullet BW \bullet ATn \bullet (1/FIsd) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{\left(\frac{IRsd}{RfDo}\right) + \left(\frac{SAsd \bullet AFsd \bullet ABS}{RfDd}\right)} \qquad \textbf{Eq. 5-37}$$

where the variables are the same as previously defined, except:

$SSSL_{SDRECn}$	=	noncancer-based site-specific screening level, recreational site user (mg/L, calculated)
THI	=	target hazard index (unitless, 1E-1)
ATn	=	averaging time, noncancer (days)
RfDo	=	oral reference dose (mg/kg-day)
RfDd	=	dermal reference dose (mg/kg-day).

Fish Consumption. In this scenario, fish are potentially exposed by feeding in contaminated sediment in surface water bodies. Consuming fish represents an indirect pathway for exposure of humans to sediment. This pathway is evaluated only for sediment in those bodies of surface water able to support sport fishing. Metals evaluated are limited to the mercury, the only metal for which data regarding the ratio of the concentration in fish to the concentration in sediment are available. Organic chemicals evaluated are limited to the persistent, lipophilic chemicals expected to bioaccumulate in fish tissue, i.e., the organochlorine pesticides, PCBs, and PCDD/PCDF.

Values for the ratio of the concentration of contaminant in fish to the concentration in sediment (Df), are available for neither mercury nor organic compounds. A Df value for mercury, however, can be estimated from the concentration of mercury in sediment and the edible fish associated with that sediment. Several data compilations are available; however, probably the most appropriate is a study of several lakes in northeastern Minnesota (Nichols, 1995). In this study, the average concentration in sediment was 0.160 mg of mercury/kg of sediment (Sorensen, et al., 1990). The average concentration in edible fish (Northern Pike) was 0.450 mg of mercury/kg of fresh fish.

$$Df = \frac{0.450\ mg/kg}{0.160\ mg/kg} \qquad \textbf{Eq. 5-38}$$

The resulting Df is 2.8 (mg mercury/kg fish)/(mg mercury/kg sediment).

Biota-to-sediment-accumulation factors (BSAF), defined as the ratio of the concentration of contaminant in fish lipid to the concentration in sediment organic carbon, are available for PCBs, PCDD/PCDF, and a limited number of pesticides (EPA, 1995b). The BSAF values can be converted to Df values as follows:

$$Df = \frac{BSAF \bullet F_{lipid}}{F_{oc}} \qquad \textbf{Eq. 5-39}$$

where:

Df	=	ratio of the concentration in fish to the concentration in sediment ([mg contaminant/kg fish]/[mg contaminant/kg sediment])
BSAF	=	ratio of the concentration in fish lipid to the concentration in sediment organic carbon ([mg contaminant/kg fish]/[mg contaminant/kg sediment])
F_{lipid}	=	default fish lipid content (unitless fraction, 0.07 [EPA, 1994b])
F_{oc}	=	default sediment organic carbon content (unitless fraction, 0.04 [EPA, 1994b]).

The Df is used to estimate sediment SSSLs for fish consumption as follows:

For cancer risk (based on age-adjusted receptor):

$$SSSL_{SDFc} = \frac{TR \bullet ATc \bullet (1/EF) \bullet CF4}{FCadj \bullet Df \bullet SFo} \qquad \textbf{Eq. 5-40}$$

where:

$SSSL_{SDFc}$	=	cancer-based site-specific screening level, fish consumption (mg/kg, calculated)
TR	=	target cancer risk (unitless, 1E-6)
ATc	=	averaging time, cancer (days)
EF	=	exposure frequency (days/year)
CF4	=	conversion factor (1E+3 g/kg)
FCadj	=	age-adjusted fish consumption rate (g-years/kg-day)
Df	=	ratio of the concentration in fish to the concentration in sediment ([mg contaminant/kg fish]/[mg contaminant/kg sediment])
SFo	=	oral cancer slope factor (per mg/kg-day).

For noncancer effects (based on child receptor):

$$SSSL_{SDFn} = \frac{THI \bullet BW \bullet ATn \bullet (I/EF) \bullet (I/ED) \bullet CF4}{\left(\frac{FC \bullet Df}{RfDo}\right)} \qquad \textbf{Eq. 5-41}$$

where:

$SSSL_{SDFn}$	=	noncancer-based site-specific screening level, fish consumption (mg/kg, calculated)
THI	=	target hazard index (unitless, 1E-1)
BW	=	body weight (kg)
ATn	=	averaging time, noncancer (days)
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
CF4	=	conversion factor (1E+3 g/kg)
FC	=	fish consumption rate (g/day)
Df	=	ratio of the concentration in fish to the concentration in sediment ([mg contaminant/kg fish]/[mg contaminant/kg sediment])
RfDo	=	oral reference dose (mg/kg-day).

Sport fishing on Pelham Range is largely limited to crappies during their spawning run, from late February through April, which constitutes approximately 11 weeks, or 0.2 years. During the remainder of the year, the fish reside in the Coosa River and are not subjected to potential contamination on the site. Therefore, the sediment SSSLs for fish consumption derived as previously described are multiplied by five for use on Pelham range. No adjustment is applied for use on the Main Post, because Reilly and Yahou Lakes are stocked with fish that are assumed to remain in the lakes year-round.

All sediment SSSLs developed for the recreational site user are also applied to the on-site residential scenario.

5.2.4 Toxicity Evaluation

Toxicity is defined as the ability of a chemical to induce adverse effects in biological systems. The purpose of the toxicity assessment is two-fold:

- Identify the cancer and noncancer effects that may arise from exposure of humans to chemicals (hazard assessment).

- Provide an estimate of the quantitative relationship between the magnitude and duration of exposure and the probability or severity of adverse effects (dose-response assessment).

The latter is accomplished by the derivation of cancer and noncancer toxicity values, as described in the following text. The toxicity values are used in the SSSL equations (5.8 through 5.41).

5.2.4.1 Evaluation of Cancer Risk

A few chemicals are known to be human carcinogens and many more are suspect. The evaluation of the potential carcinogenicity of a chemical includes both a qualitative and a quantitative aspect (EPA, 1986a). The qualitative aspect is a weight-of-evidence evaluation of the likelihood that a chemical might induce cancer in humans. EPA (1986a) recognizes six weight-of-evidence group classifications for carcinogenicity:

- ***Group A - Human Carcinogen.*** Human data are sufficient to identify the chemical as a human carcinogen.

- ***Group B1 - Probable Human Carcinogen.*** Human data indicate that a causal association is credible, but alternative explanations cannot be dismissed.

- ***Group B2 - Probable Human Carcinogen.*** Human data are insufficient to support a causal association, but testing data in animals support a causal association.

- ***Group C - Possible Human Carcinogen.*** Human data are inadequate or lacking, but animal data suggest a causal association, although the studies have deficiencies that limit interpretation.

- ***Group D - Not Classifiable as to Human Carcinogenicity.*** Human and animal data are lacking or inadequate.

- ***Group E - Evidence of Noncarcinogenicity to Humans.*** Human data are negative or lacking, and adequate animal data indicate no association with cancer.

The toxicity value for carcinogenicity, called a cancer slope factor (SF), is an estimate of potency. Potency estimates are developed only for chemicals in Groups A, B1, B2 and C, and only if the data are sufficient. The potency estimates are statistically derived from the dose-response curve from the best human or animal study or studies of the chemical.

The SF is usually expressed as "extra risk" per unit dose, that is, the additional risk above background in a population corrected for background incidence. It is calculated by the expression:

$$(p_{(d)} - p_{(0)}) / (1 - p_{(0)}) \qquad \textbf{Eq. 5-42}$$

where:

$p_{(d)}$ = the probability of cancer associated with dose = 1 mg/kg-day
$p_{(0)}$ = the background probability of developing cancer at dose = 0 mg/kg-day.

The SF is expressed as risk per milligram per kilogram per day (mg/kg-day). To be appropriately conservative, the SF is usually the 95 percent upperbound on the slope of the dose-response curve extrapolated from high (experimental) doses to the low-dose range expected in environmental exposure scenarios. EPA (1986a) assumes that there are no thresholds for carcinogenic expression; therefore, any exposure represents some quantifiable risk.

The oral SF is usually derived directly from the experimental dose data, because oral dose is usually expressed as mg/kg-day. When the test chemical was administered in the diet or drinking water, oral dose first must be estimated from data for the concentration of the test chemical in the food or water, food or water intake data, and BW data.

The EPA (2001c) Integrated Risk Information System (IRIS) expresses inhalation cancer potency as a unit risk based on concentration, or risk per μg of chemical per m^3 of ambient air. Because cancer risk characterization requires a potency expressed as risk per mg/kg-day, the unit risk must be converted to the mathematical equivalent of an inhalation cancer SF, or risk per unit dose. Since the inhalation unit risk is based on continuous lifetime exposure of an adult human (assumed to inhale 20 m^3 of air/day and to weigh 70 kg), the mathematical conversion consists of multiplying the unit risk (per μg/m^3) by 70 kg and by 1,000 μg/mg, and dividing the result by 20 m^3/day.

5.2.4.2 Evaluation of Noncancer Effects

Many chemicals, whether or not associated with carcinogenicity, are associated with noncancer effects. The evaluation of noncancer effects (EPA, 1989c) involves:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration (acute or chronic) or route (oral or inhalation) of exposure

- Identification of the critical effect for each duration of exposure (i.e., the first adverse effect that occurs as dose is increased)

- Estimation of the threshold dose for the critical effect for each duration of exposure

- Development of an uncertainty factor (UF), i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect, slope of the dose-response curve, and deficiencies in the database, in regard to developing a reference dose (RfD) for human exposure

- Identification of the target organ for the critical effect for each route of exposure.

These information points are used to derive an exposure route- and duration-specific toxicity value called an RfD, expressed as mg/kg-day, which is considered to be the dose for humans, with uncertainty of an order of magnitude or greater, at which adverse effects are not expected to occur. Mathematically, it is estimated as the ratio of the threshold dose to the UF. For purposes of risk assessment, chronic exposure is defined as equal to or greater than 7 years, i.e., at least 10 percent of expected life span; subchronic exposure is defined as 2 weeks to 7 years.

IRIS (EPA, 2001c) and the Health Effects Assessment Summary Tables (HEAST) (EPA, 1997c) express the inhalation noncancer reference value as a reference concentration (RfC) in units of mg/m^3. Because noncancer risk characterization requires a reference value expressed as mg/kg-day, the RfC must be converted to an inhalation RfD. Since the inhalation RfC is based on continuous exposure of an adult human (assumed to inhale 20 m^3 of air/day and to weigh 70 kg) the mathematical conversion consists of multiplying the RfC (mg/m^3) by 20 m^3/day and dividing the result by 70 kg.

5.2.4.3 Target Organ Toxicity

As a matter of science policy, the EPA assumes dose- and effect-additivity for noncarcinogenic effects (EPA, 1989b). This assumption provides the justification for adding the hazard quotients (HQ) or hazard indices (HI) in the risk characterization for noncancer effects resulting from exposure to multiple chemicals, pathways, or media. EPA, however, acknowledges that adding all HQ or HI values may overestimate hazard, because the assumption of additivity is probably appropriate only for those chemicals that exert their toxicity by the same mechanism.

Mechanism of toxicity data sufficient for predicting additivity with a high level of confidence are available for very few chemicals. In the absence of such data, EPA (1989b) assumes that chemicals that act on the same target organ may do so by the same mechanism of toxicity. That is, target organ serves as a surrogate for mechanism of toxicity. When total HI for all media for a receptor exceeds 1.0 due to the contributions of several chemicals, it may be appropriate to segregate the chemicals by route of exposure and mechanism of toxicity (i.e., target organ) and estimate separate HI values for each.

As a practical matter, since human environmental exposures are likely to involve near- or sub-threshold doses, the target organ chosen for a given chemical is the one associated with the critical effect. If more than one organ is affected at the threshold, all are chosen. Target organ is also selected on the basis of duration of exposure (i.e., target organs for chronic or subchronic exposure to low or moderate doses are selected rather than the target organs for acute exposure to high doses) and route of exposure. Because dermal RfD values are derived from oral RfD values, the oral target organ is adopted as the dermal target organ. For some chemicals, no target organ is identified. This occurs when no adverse effects are observed or when adverse effects such as reduced longevity or growth rate are not accompanied by recognized organ- or system-specific functional or morphologic alteration.

5.2.4.4 Dermal Toxicity Values

Dermal RfDs and SFs are derived from the corresponding oral values, provided there is no evidence to suggest that dermal exposure induces exposure route-specific effects that are not appropriately modeled by oral exposure data. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal absorption factor (GAF), expressed as a decimal fraction. The resulting dermal RfD, therefore, is based on absorbed dose. The RfD based on absorbed dose is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses. The dermal SF is derived by dividing the oral SF by the GAF. The oral SF is divided, rather than multiplied, by the GAF because SFs are expressed as reciprocal dose.

5.2.4.5 Sources of Toxicity Information Used in SSSL Development

Toxicity values are chosen using the following hierarchy:

- The EPA's on-line IRIS data base (EPA, 2001c) containing toxicity values that have undergone the most rigorous Agency review

- The latest version of the annual HEAST, including all supplements (EPA, 1997c)

- Other EPA documents, memoranda, former Environmental Criteria and Assessment Office, or National Center for Environmental Assessment (NCEA) derivations for the Superfund Technical Support Center.

All toxicity values, regardless of their source, are evaluated for appropriateness for use in risk assessment.

When toxicity values are not located, the primary literature may be surveyed to determine whether sufficient data exist that would permit derivation of a toxicity value. The use of surrogate chemicals is also considered, if the chemical structure, adverse effects, and toxic potency of the surrogate and chemical of interest are judged to be sufficiently similar. EPA Region IV toxicologists are consulted in all such cases.

GAFs, used to derive dermal RfD values and SFs from the corresponding oral toxicity values, are obtained from the following sources:

- Oral absorption efficiency data compiled by the NCEA for the Superfund Health Risk Technical Support Center of the EPA

- Federal agency reviews of the empirical data, such as Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles and various EPA criteria documents

- Other published reviews of the empirical data

- An EPA Region IV compilation of GAF values

- The primary literature.

GAFs obtained from reviews are compared to empirical (especially more recent) data, when possible, and are evaluated for suitability for use for deriving dermal toxicity values from oral toxicity values. The suitability of the GAF increases when the following similarities are present in the oral pharmacokinetic study from which the GAF is derived and in the key toxicity study from which the oral toxicity value is derived:

- The same strain, sex, age and species of test animal was used.

- The same chemical form (e.g., the same salt or complex of an inorganic element or organic compound) was used.

- The same mode of administration (e.g., diet, drinking water or gavage vehicle) was used.

- Similar dose rates were used.

The most defensible GAF for each chemical is used in the risk assessment.

When quantitative data are insufficient, a default GAF is used. EPA (2001a) recommends a GAF of 0.8 for VOCs, 0.5 for SVOCs, and 0.2 for inorganic chemicals.

Toxicity profiles, which document the toxicity values, GAFs and other chemical-specific values useful for risk assessment, are compiled in IT (2000a). The toxicity values and other chemical-specific values are subject to change as updated information becomes available. Therefore, the chemical-specific values are checked and the SSSLs re-computed as necessary each time an SRA is initiated.

5.2.5 Site Evaluation

5.2.5.1 Chemical of Potential Concern Selection

Site evaluation is performed in a step-wise fashion. The first step compares site-related chemical MDCs in all environmental media of interest with all applicable SSSLs. The environmental media of interest are those that are suspected of being contaminated and were sampled for chemical analysis. Applicable SSSLs are those that reflect all exposure scenarios that are possible for the site (Table 5-2). For example, a site currently under industrial use is evaluated for industrial use (groundskeeper) and also for residential use (resident), if it is possible (even though highly unlikely) that the site could support residential use in the future. A site currently considered open space would be evaluated as open space (recreational site user, fish consumption, venison consumption) and also for industrial use (groundskeeper) and residential use (resident), if these uses are possible. A site currently used as residential would be evaluated for residential use (resident) and also for industrial use (groundskeeper) to provide risk managers with additional information should they desire to downgrade site use from residential to industrial (if, for example, the site failed the risk evaluation for residential use).

Generally, a construction worker evaluation is included at every site that is evaluated for industrial or residential use. A construction worker usually is not included in open space evaluations unless construction or excavation is plausible.

Surface water bodies (surface water and sediment) are evaluated for fish consumption only if they can support sport fishing; wooded areas and meadows are evaluated for game consumption only if they can support sport hunting.

Site-related chemicals whose MDCs exceed SSSLs are selected as COPC for that receptor scenario. For example, it is possible that a chemical could be selected as a COPC in surface soil for residential and industrial site use, but not for use as open space or for venison ingestion. If no COPC are selected for any receptors, the site is recommended for NFA. If few COPC are selected, or the extent to which site concentrations exceed SSSLs is small, a qualitative or simple quantitative discussion may be sufficient to defend NFA or to identify the risk drivers and

Table 5-2

Site Evaluation Step One: Comparing MDCs with SSSLs for COPC Selection Fort McClellan, Calhoun County, Alabama

Environmental Medium	Site Use and/or Receptor Scenario	Comment
Surface soil	Residential (resident)	Comparison made unless site is physically unsuitable for residential use.
	Industrial (groundskeeper)	Comparison made unless site is physically unsuitable for industrial use.
	Open space (recreational site user)	Comparison made unless site is or will be developed for other use and site has no attractive features.
	Venison consumption	Comparison made only if site is or could become suitable habitat for deer.
Subsurface soil	Construction worker	Comparison made for all sites except those designated only as open space for which construction is not plausible.
Surface water	Recreational site user	Comparison made for all bodies of surface water in which a person might play or fish.
	Fish consumption	Comparison made only if body of surface water could support sport fishing.
Sediment	Recreational site user	Comparison made for all bodies of surface water in which a person might play or fish
	Fish consumption	Comparison made only if body of surface water could support sport fishing.

MDC = maximum detected concentration; SSSL = site-specific screening level.

propose RGOs. If the situation is more complicated it may be necessary to develop an SRA to quantify cancer risk and noncancer hazard and to estimate RGOs.

5.2.5.2 Estimating Cancer Risk and Noncancer Hazard

ILCRs and HIs are estimated for each receptor and each medium for which COPC are selected. For example, if COPC were selected in surface soil for the resident but not the groundskeeper, ILCRs and HIs would be estimated only for the resident exposed to surface soil. If COPC are selected in groundwater for both the resident and the groundskeeper, ILCRs and HIs would be estimated for both the resident and the groundskeeper. ILCRs and HIs are summed across COPC to obtain total ILCR and total HI for the medium. ILCRs and HIs are summed also across media to estimate a total ILCR and a total HI for the receptor (Table 5-3).

As noted in Table 5-3, a resident would be exposed to surface soil and groundwater, and also to surface water and sediment if these media are present on the site. The assumptions for recreational site user exposure to surface water and sediment, on which the SSSLs are based, are selected intentionally to be sufficiently conservative to apply to a residential scenario. Although the definitions of the resident and the recreational site user are not identical (the resident may be age-adjusted, adult or child; the recreational site user is a 7- to 16-year-old youth), ILCRs and HIs for recreational site user exposure to surface water and sediment may be added to ILCRs and HIs for residential exposure to soil and groundwater to provide a conservative estimate of total ILCRs and HIs for the resident across all four media. ILCRs and HIs for fish consumption can also be included in the sum for the resident if the surface water body can support sport fishing. Venison ingestion is not likely to be included because it is doubtful that a site could be used as residential and simultaneously exist as favorable habitat for game animals.

The ILCR for each COPC is estimated as follows:

$$ILCR = \frac{STC \bullet TR}{SSSL_c} \qquad \textbf{Eq. 5-43}$$

where:

ILCR	=	incremental lifetime cancer risk (unitless, calculated)
STC	=	source-term concentration

Table 5-3

Site Evaluation Step Two:
Estimating Medium and Receptor ILCRs and HIs
Fort McClellan, Calhoun County, Alabama

Receptor	Medium*	Comment
Resident	Surface soil	No comment.
	Groundwater	No comment.
	Surface water	ILCR and HI estimates for the recreational site user are included if residential site use is evaluated and resident exposure to this medium is plausible.
	Fish consumption (COPCs in surface water)	ILCR and HI estimates are included if residential site use is evaluated and the surface water body on site can support sport fishing.
	Sediment	ILCR and HI estimates for the recreational site user are included if residential site use is evaluated and resident exposure to this medium is plausible.
	Fish consumption (COPCs in sediment)	ILCR and HI estimates are included if residential site use is evaluated and the surface water body on site can support sport fishing.
Groundskeeper	Surface soil	No comment.
	Groundwater	No comment.
Recreational site user	Surface soil	No comment.
	Surface water	No comment.
	Fish consumption (COPCs in surface water)	ILCR and HI estimates are included if the surface water body on site can support sport fishing.
	Sediment	No comment.
	Fish consumption (COPCs in sediment)	ILCR and HI estimates are included if the surface water body on site can support sport fishing.
Construction worker	Subsurface soil	No comment.
	Groundwater	No comment.

ILCR = incremental lifetime cancer risk; HI = hazard index; COPC = chemical of potential concern; SSSL = site-specific screening level.

*ILCRs and HIs are estimated for a given receptor exposed to a given medium only if COPC were selected for that medium and that receptor.

TR	=	target cancer risk (unitless, 1E-6)
$SSSL_c$	=	cancer-based site-specific screening level.

STC and $SSSL_c$ have the same units.

The HI for each COPC is estimated as follows:

$$HI = \frac{STC \bullet THI}{SSSL_n} \qquad \textbf{Eq. 5-44}$$

where:

HI	=	hazard index (unitless, calculated)
STC	=	source-term concentration
THI	=	target hazard index (unitless, 1E-1)
$SSSL_n$	=	noncancer-based site-specific screening level.

STC and $SSSL_n$ have the same units.

Chemical-specific ILCRs and HIs are summed across chemicals and media as previously described to obtain total ILCR and HI for each receptor.

5.2.5.3 Future Groundwater Conditions

In addition to the evaluations described above, a future groundwater conditions evaluation will be considered for sites where exposure to groundwater is evaluated. The future groundwater conditions evaluation addresses the potential for contaminants to leach from subsurface soil resulting in groundwater concentrations exceeding residential SSSLs. The evaluation consists of comparing concentrations of chemicals in soil with site-specific soil screening levels (SSSSL) developed using site-specific values for several geologic and hydrogeologic parameters. As a practical matter, conservative default values are available (EPA, 2001d) so that SSSSLs can be developed without site-specific data for the geological parameters. The resulting SSSSLs, however, may be unnecessarily conservative or restrictive. Certain site characteristic and hydrogeologic variables, however, must be filled with site-specific data for the SSSSLs to be meaningful. The required site-specific characteristic and hydrogeologic variables include:

- Aquifer hydraulic conductivity (K) (m/year)
- Hydraulic gradient (i) (m/m)
- Mixing depth (d) (m)

- Infiltration rate (I) (m/year)
- Source length parallel to flow (m).

Soil concentrations of chemicals are screened as follows:

- Evaluation is limited to the chemicals included in Table A-1 of EPA, 2001d.

- Chemical concentrations in soil are compared with background concentrations; chemicals whose concentrations do not exceed background are considered to have no potential for future effects on groundwater and are not evaluated further. Chemicals whose concentrations exceed background or for which background concentrations are not available are carried to the next screening step.

- Chemical concentrations in soil are compared with generic soil screening levels based on a dilution-attenuation factor (DAF) of 20 (EPA, 2001d); chemicals whose concentrations do not exceed the generic soil screening levels are considered to have minimal potential for future effects on groundwater and are not evaluated further. Chemicals whose concentrations exceed the generic soil screening levels are carried to the next screening step.

- Most chemical releases at FTMC are old; therefore, it is expected that leaching, if indeed it represents a future threat to groundwater, would already be evident. Therefore, chemicals that exceed previous screening criteria are subjected to a final screening step. The current concentrations of these chemicals in groundwater are compared with groundwater background concentrations and residential groundwater SSSLs. Chemicals whose concentrations in groundwater do not exceed background or residential SSSLs are considered to have minimal potential for future effects on groundwater and are not evaluated further. Chemicals whose concentrations exceed background and residential groundwater SSSLs are selected for development of SSSSLs.

SSSSLs are concentrations of chemicals in soil that may, at some point in the future, occur in groundwater at a concentration equal to the residential SSSL as a result of leaching from soil. The transport conceptual model (tcm) for estimating SSSSLs consists of:

- Formation of leachate by equilibrium partitioning of contaminant in soil and infiltrating water

- Mixing of the leachate with groundwater

- Transport of groundwater from source to exposure point.

The overall soil-to-groundwater leaching model, rearranged to estimate SSSSLs from groundwater SSSLs, is given by (EPA, 1996; ASTM, 1995):

$$SSSSL = \frac{(SSSL_{GWRES})\ (SSDAF)}{PF}$$ **Eq. 5-45**

where:

SSSSL	=	site-specific soil screening level (mg/kg, calculated)
$SSSL_{GW\text{-}RES}$	=	site-specific screening level, groundwater, resident (mg/L)
SSDAF	=	site-specific dilution-attenuation factor (unitless)
PF	=	soil-water partition factor (kg/L).

This transport equation is expressed in terms of a site-specific dilution-attenuation factor (unitless) (SSDAF) to be consistent with the default DAF recommended in EPA, 2001d. The leaching and groundwater transport algorithms (steps 2 and 3 of the tcm) are included in the SSDAF.

For organic chemicals, the soil-water partition factor accounts for the fraction of chemical that partitions to water, soil, or gas phase in the vadose zone (step 1 of the tcm) and is given by (ASTM, 1995):

$$PF = \frac{\rho_{soil}}{H' \bullet \theta_a + \theta_w + \rho_{soil} \bullet K_d}$$ **Eq. 5-46**

where:

PF	=	soil-water partition factor (kg/L, calculated)
ρ_{soil}	=	soil bulk density (unitless)
H'	=	unitless Henry's law constant
θ_a	=	air-filled soil porosity (0.13 unitless, default, or site-specific estimated as n-θ_w; EPA, 2001d)
n	=	total soil porosity (unitless, site-specific estimated as 1-[ρ_b/ρ_s])
θ_w	=	water-filled soil porosity (0.3 unitless, default, or site-specific; EPA, 2001d)
ρ_b	=	dry soil bulk density (1.5 g/cm^3, default, or site-specific; EPA, 2001d)

ρ_s	=	true soil or particle density (2.65 g/cm^3, default, or site-specific)
K_d	=	soil-water distribution coefficient (L/kg).

For organic chemicals, K_d is given by EPA, 1996:

$$K_d = f_{oc} \bullet K_{oc} \quad \textbf{Eq. 5-47}$$

where:

K_d	=	soil-water distribution coefficient (L/kg, calculated)
f_{oc}	=	organic carbon content of soil (0.002 unitless, default, or site-specific; EPA, 2001d)
K_{oc}	=	soil organic carbon-water partition coefficient (L/Kg, chemical-specific).

Organic carbon-water partition coefficients are documented in the toxicity profiles appended to the latest compilation of SSSLs (IT, 2000a).

For inorganic chemicals, PF is equal to K_d. Values for K_d for inorganic chemicals are documented in the toxicity profiles mentioned above.

A critical part of the SSSSL model is the estimation of a SSDAF. The SSDAF is used to estimate the extent to which the chemical concentration in the leachate will diminish before it reaches the receptor well. Steps 2 and 3 of the tcm, the leaching and groundwater transport algorithms, are imbedded within the SSDAF.

The leachate-to-groundwater dilution factor (step 2 of the tcm) is computed as the ratio of the volume of infiltrating leachate (precipitation minus runoff and evapotranspiration) to the total volume of groundwater moving through the mixing zone beneath the source area:

$$\gamma = 1 + \frac{K \bullet i \bullet d}{I \bullet L} \quad \textbf{Eq. 5-48}$$

where:

γ	=	leachate-to-groundwater dilution (unitless, calculated)
K	=	aquifer hydraulic conductivity (site-specific, m/yr)
i	=	hydraulic gradient (site-specific, m/m)
d	=	mixing depth (site-specific, m)
I	=	infiltration rate (site-specific, m/yr)
L	=	source length parallel to flow (site-specific, m).

The groundwater leachate concentration under the source area is given by:

$$C_{leacheate} = \frac{SSSSL \bullet PF}{\gamma} \qquad \textbf{Eq. 5-49}$$

where:

$C_{leachate}$	=	groundwater leachate concentration under source (mg/L)
SSSSL	=	site-specific soil screening level (mg/kg)
PF	=	soil-water partition factor (kg/L)
γ	=	leachate-to-groundwater dilution (unitless).

The transport of the contaminant in groundwater (step 3 of the tcm) is then estimated from the Domenico solute transport model assuming vertical transverse dispersion (ASTM, 1995; Tennessee Department of Environment and Conservation [TDEC], 1996) without degradation:

$$C_{gw} = C_{leachate}\, erf\left(\frac{L}{4\sqrt{\alpha_y\, x}}\right) erf\left(\frac{d}{4\sqrt{\alpha_z\, x}}\right) \qquad \textbf{Eq. 5-50}$$

Substituting $C_{leachate}$ into the Domenico model yields:

$$C_{gw} = \frac{SSSSL \bullet PF}{\gamma}\, erf\left(\frac{L}{4\sqrt{\alpha_y x}}\right) erf\left(\frac{d}{4\sqrt{\alpha_z x}}\right) \qquad \textbf{Eq. 5-51}$$

where:

C_{gw}	=	future groundwater concentration at exposure point (mg/L)
$C_{leachate}$	=	groundwater leachate concentration under source (mg/L)
erf	=	error function taken from error function table (TDEC, 1996)
L	=	source length parallel to flow (m)
d	=	source depth = depth of aquifer (m)
SSSSL	=	site-specific soil screening level (mg/kg)
PF	=	soil-water partition factor (kg/L)
γ	=	leachate-to-groundwater dilution (unitless).
x	=	distance to exposure point (m)
α_y	=	transverse dispersivity = $\alpha_x/3$
α_z	=	vertical dispersivity = $\alpha_x/2$
α_x	=	longitudinal dispersivity = x/10.

Substituting C_{gw} from Equation 5-51 for $SSSL_{GW\text{-}RES}$ in Equation 5-45 yields:

$$SSDAF = \frac{\gamma}{erf\left(\frac{L}{4\sqrt{\alpha_y x}}\right) erf\left(\frac{d}{4\sqrt{\alpha_z x}}\right)} \qquad \textbf{Eq. 5-52}$$

where:

SSDAF	=	site-specific dilution-attenuation factor (unitless, calculated)
γ	=	leachate-to-groundwater dilution (unitless)
L	=	source length parallel to flow (m)
d	=	source depth = depth of aquifer (m)
x	=	distance to exposure point (m)
α_y	=	transverse dispersivity = $\alpha_x/3$
α_z	=	vertical dispersivity = $\alpha_x/20$
α_x	=	longitudinal dispersivity = x/10.

5.2.5.4 Remedial Goal Option Development

EPA Region IV requires development of RGOs as part of the baseline risk assessment (EPA, 2001a). RGOs are site-specific concentrations that reflect the exposure and toxicity assumptions applied in the baseline risk assessment. Consequently, the risk-based RGOs are source medium-, receptor-, and chemical-specific.

The first step in RGO development is selection of chemicals of concern (COC). Either of two conditions result in designation of a COPC as a COC:

- The concentration of the COPC exceeds its ARAR. ARARs for the media of interest at FTMC are limited to EPA (2000b) MCL in drinking water, which are applied to groundwater. The MCLs are not risk-based values. They are presented only as a matter of interest.

- The COPC contributes significantly to unacceptable cancer risk (total receptor ILCR greater than 1E-4) or hazard (total receptor HI greater than 1.0).

In those cases where the total HI for a given receptor exceeds the threshold level of 1, individual HI values may be estimated for each target organ, as explained in Section 5.2.4.3. Only if the HI exceeds the threshold level of 1 for one or more target organs would a chemical be identified as a noncancer-based COC.

Significant contribution to cancer risk is defined as contributing an ILCR across all exposure pathways for a given source medium exceeding 1E-6; significant contribution to hazard is defined as contributing an HI across all exposure pathways for a given source medium exceeding 0.1. The COC, therefore, may be selected because of their cancer risk (cancer COC) or non-cancer hazard (noncancer COC).

RGOs are risk- or hazard-specific concentrations of chemicals developed only for the COC in media that are associated with unacceptable risk. RGOs for cancer are based on target ILCRs of 1E-6, 1E-5, and 1E-4. The cancer-based SSSLs are adopted as the cancer-based RGOs for a target ILCR of 1E-6. RGOs for target ILCRs of 1E-5 and 1E-4 are obtained by multiplying the SSSL by 10 and 100, respectively. RGOs for noncancer are based on target HIs of 0.1, 1.0 and 3.0. The noncancer-based SSSLs are adopted as the noncancer-based RGOs for a target HI of 0.1. RGOs for target HIs of 1.0 and 3.0 are obtained by multiplying the SSSL by 10 and 30, respectively.

5.2.6 Uncertainty Analysis

This section briefly introduces the evaluation of uncertainties inherent in the risk assessment process. Uncertainty is a factor in each step of the exposure and toxicity assessments presented in the preceding sections. Uncertainties associated with earlier stages of the process become magnified when they are concatenated with other uncertainties in the latter stages of the process. Such uncertainty includes variations in sample analytical results, the values of variables used as input to a given model, the accuracy with which the model itself represents actual environmental processes, the manner in which the exposure scenarios are developed, and the high-to-low dose and interspecies extrapolations for dose-response relationships. It is not possible to eliminate all uncertainty; however, a recognition of the uncertainties is fundamental to the understanding and reasonable use of risk assessment results.

Generally, risk assessments carry two types of uncertainty. Measurement uncertainty refers to the usual variance that accompanies scientific measurements, e.g., instrument uncertainty (accuracy and precision) associated with contaminant concentrations. The results of the risk assessment reflect the accumulated variances of the individual measured values used to develop them. A different kind of uncertainty stems from data gaps, i.e., additional information needed to complete the database for the assessment. Often, the data gap is significant, such as the absence of information on the effects of human exposure to a chemical or on the biological mechanism of action of an agent (EPA, 1992e).

EPA (1992e) guidance on risk assessment urges risk assessors to address or provide descriptions of individual risk to include the "high end" portions and central tendency ("CT") of the risk distribution. In contrast to the RME evaluation, which prevails in EPA risk assessments, and uses upper-end values for intake or contact rates, EF, and ED, the CT evaluation chooses average or midrange values for these variables. The intent is to present a quantified risk/hazard estimate more nearly typical for the receptor of interest.

The CT exposure evaluation, however, falls short of its stated intent for several reasons. First, the same source-term concentration is usually used for the CT evaluation that is used for the RME evaluation. EPA (1993) considers that the UCL or MDC selected as a conservative estimate of average for the RME is appropriate for the CT estimates. Second, there is little information available as to what constitutes a reliable CT estimate for most exposure scenarios and variables, with the possible exception of a simple on-site residential scenario. Hence, RME values are still used. Third, almost no CT toxicity values are available, so the uncertainty about the toxicity assessment is not included. A CT evaluation, therefore, usually provides little additional perspective, compared with the RME, particularly for exposure scenarios such as the youthful visitor and sportsman, for which no reliable CT estimation of most exposure variable values can be made.

Another method of quantifying uncertainty, called Monte Carlo simulation, provides a more graphic illustration of the uncertainty about a risk/hazard estimate, because it presents the risk as a range with probability densities. To be meaningful, however, Monte Carlo simulation requires that the nature of the distributions of the variables that drive the risk assessment should be well characterized. Well characterized distributions are available for few variables, in which case the Monte Carlo simulation provides an incomplete, if not misleading, illustration of the magnitude of the uncertainty.

The streamlined approach toward risk assessment developed herein does not readily lend itself to the CT approach or to Monte Carlo simulation. Therefore, the uncertainty sections of the SRAs performed according to this work plan will consist of qualitative discussions that identify the sources of uncertainty and describe their effect (e.g., a more or less conservative impact) on the risk/hazard estimates.

5.3 Ecological Risk Assessment

5.3.1 Introduction

Assessment of potential ecological risk is one component of a comprehensive environmental evaluation of sites at FTMC, and, if necessary will be used to develop, evaluate, and select potential remedial alternatives. Although FTMC is not a National Priority List site, ERA at FTMC will follow the statutory guidance found in CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986. Through this authority, the EPA seeks to protect wildlife, fisheries, endangered and threatened species, and critical habitats. The goal of the USACE for FTMC is property transfer following base closure. Before transfer of any property can occur, however, the USACE seeks to ensure and demonstrate that future property owners/users and ecological entities associated with the property will not be at risk from conditions caused by or related to past military activities conducted by the Army. To meet this goal, ERA activities at FTMC will be conducted in accordance with the EPA *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final* (called the *Process Document*; EPA 1997d). Throughout this Work Plan, the major sections will be identified with the corresponding step from the Process Document (EPA, 1997d).

5.3.1.1 Assessment Strategy at Fort McClellan

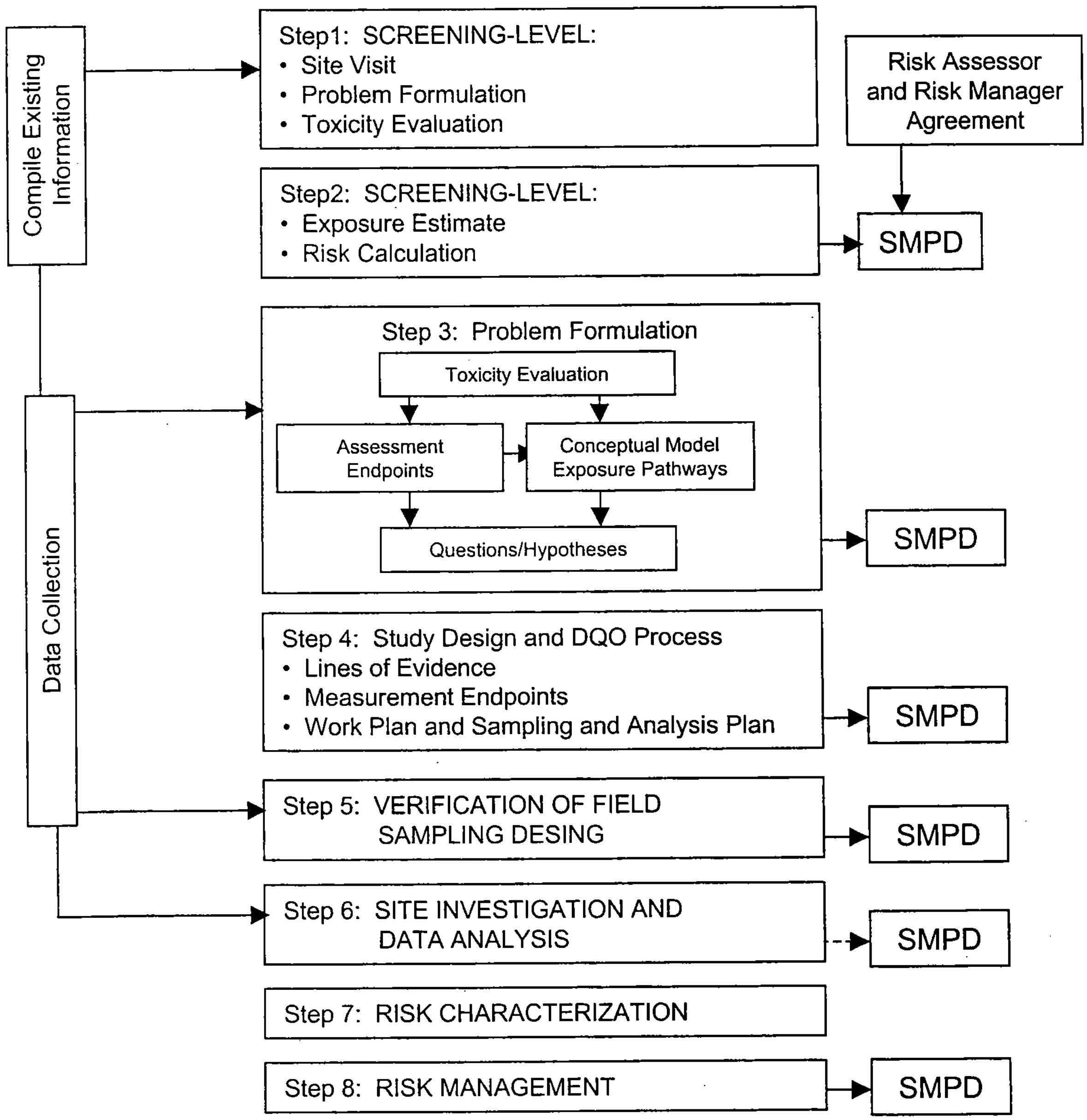
The primary objective of an ERA is to evaluate whether unacceptable impacts to ecological receptors have occurred or are currently occurring as a result of exposure to chemical stressors released at a site. In general, this objective is met by characterizing the ecological communities in the vicinity of the site, identifying the chemical substances associated with the site, identifying applicable pathways for receptor exposure, and quantifying or describing the potential for adverse effects to exposed receptors. Ecological communities of interest in ERAs generally include vegetation, wildlife, aquatic life (including both fish and aquatic macroinvertebrates), endangered and threatened species, and wetlands or other sensitive habitats associated with a site.

The ERA activities at FTMC will be performed using the Eight-Step Process as presented in the *Process Document* (Figure 5-1; EPA, 1997d). Steps 1 and 2 will consist of a screening-level ERA (SLERA), which will consist of a direct comparison of maximum detected chemical concentrations to ecological screening values (ESV) to identify chemicals in surface water, sediment, and soil that may be of potential harm to the environment. Results of the SLERA (in the form of screening hazard quotient; HQ_{screen}) will indicate if a potential for ecological risk exists.

A Scientific Management Decision Point (SMDP) will occur at the conclusion of the SLERA. If the SLERA identifies chemicals with a HQ_{screen} value corresponding to unacceptable risk, SMDP discussions will focus on whether a Baseline Ecological Risk Assessment (BERA) is warranted. The BERA corresponds to Steps 3 through 8 of the eight-step ERA Process and will be performed in conjunction with RI activities for a given site. If the decision is made at the SMDP to initiate a BERA, work plans and sampling plans for those activities will be submitted for review and approval prior to beginning any BERA work.

The decision/process flow diagram (Figure 5-2) presents the expected sequence of activities to be followed during ERAs at FTMC. This diagram includes expected deliverables, SDMPs, and decisions to be made at the SMDP. Throughout the ERA process at FTMC, the risk assessor will frequently communicate assessment results to regulatory agencies, risk managers, and stakeholders to ensure appropriate understanding and interpretation of the ecological risk activities. This communication will occur at each of the SMDPs.

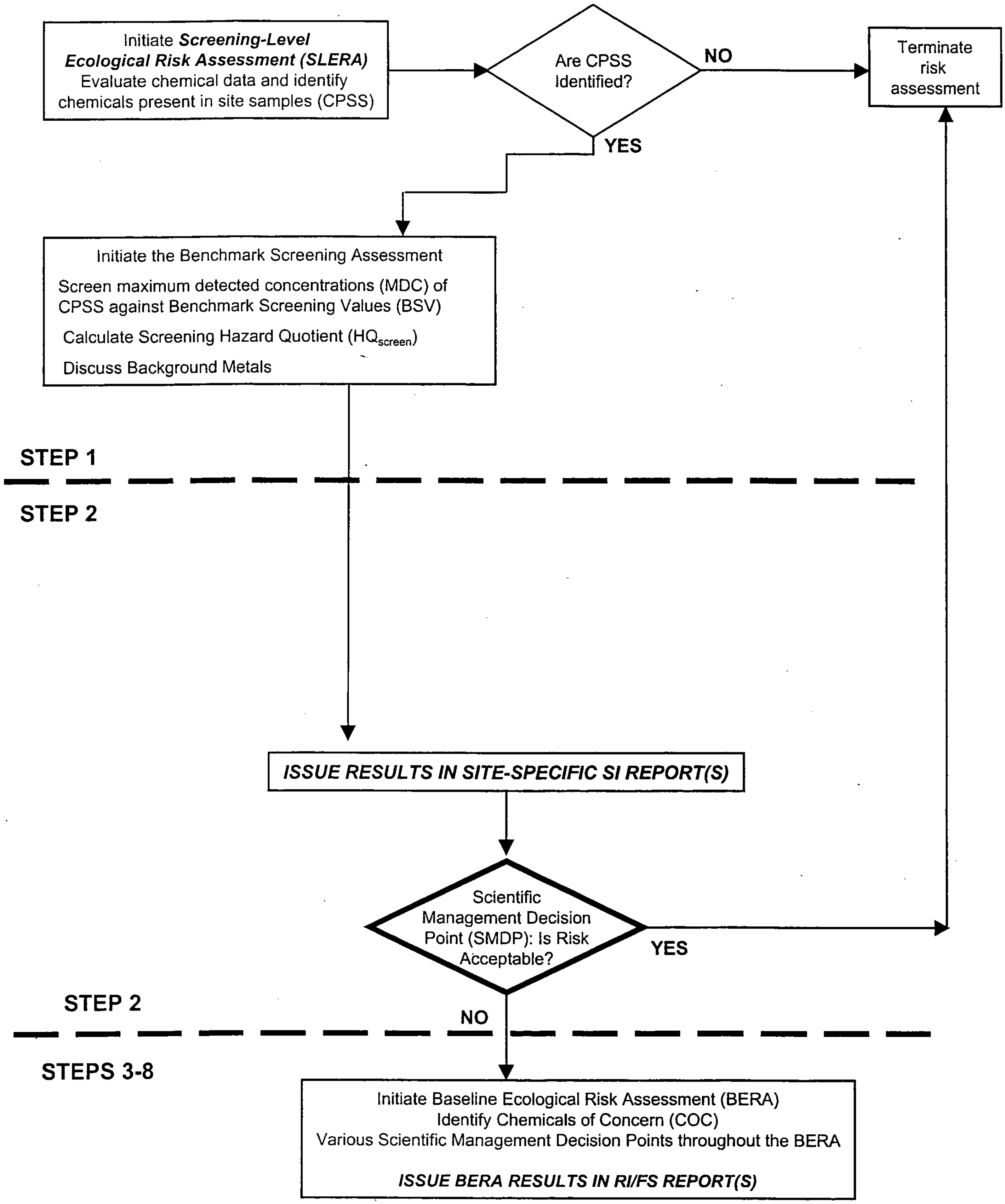
Figure 5-1
Eight-step Ecological Risk Assessment Process for Superfund
Fort McClellan, Calhoun County, Alabama



Source:
U.S. Environmental Protection Agency (EPA), 1997, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final, EPA/540/R-97/006.

Figure 5-2

Decision Diagram/Flow Chart for Ecological Risk Assessment at Fort McClellan Fort McClellan, Calhoun County, Alabama



5.3.1.2 Spatial Scale

Initially, the potential for risk to ecological receptors from exposure to chemical stressors will be assessed in the SLERA for individual sites at small spatial scales. The site-specific areas have been defined as individual sites and/or parcels for the SIs currently being conducted at FTMC. These FTMC sites or parcels correspond to sites as large as former landfills, or as small as an underground storage tank.

If BERAs are required at sites or parcels that are adjacent or spatially near, SLERA results from all applicable sites and/or parcels within the given area may be integrated into an area-wide BERA. Clustering of adjacent parcels, and use of larger ecological areas in BERAs at FTMC, however, may occur only by mutual agreement between risk assessors, regulatory agencies, and FTMC during appropriate SMDPs. The criteria used to define these larger ecological areas may include watershed and drainage areas, sensitive ecological habitats, and/or other areas of special concern. Results of an example of ecological area delineation within FTMC are detailed in Appendix C.

Site-specific SLERA results will provide direct information for action/closure decisions for each FTMC parcel or site. Risk managers will be provided with information regarding the potential for risk to each site or parcel's local ecological community as documented in the SLERA section of each SI report. If BERAs become necessary, they may incorporate the parcel cluster/ ecological area concept, and they may integrate the site-specific SLERA results. Implementation of this approach will be discussed and decided during appropriate SMDPs.

5.3.1.3 Work Plan Outline

This ERA work plan addresses the SLERA activities at FTMC and is organized according to the major tasks in the SLERA process (EPA, 1997d). In addition, generic discussions regarding activities associated with potential BERAs are provided. The following is an outline of the ERA work plan sections with the corresponding EPA ERA process step in parenthesis:

- Section 5.3.2 - Environmental Setting (Step 1)

- Section 5.3.3 – Constituents Detected On-Site (Step 1)

- Section 5.3.4 – Site Conceptual Model (Step 1)

- Section 5.3.5 – Screening-Level Risk Estimation (Step 2)

- Section 5.3.6 – Identification of Constituents of Potential Ecological Concern (Step 2)

- Section 5.3.7 - Uncertainty Analysis (Step 2)

- Section 5.3.8 - Scientific Management Decision Point 1

- Section 5.3.9 - Baseline Ecological Risk Assessment (Steps 3 through 8).

5.3.2 Environmental Setting (Step 1)

A large body of information exists regarding the ecological characterization of FTMC. This information was obtained from a number of sources, including:

- Previous studies published in existing historical documents

- Historical data and information gathered by interview process

- Direct field observation recorded during ecological site reconnaissance visits of Main Post, Pelham Range, and Choccolocco Corridor.

A thorough review and evaluation of the environmental setting at FTMC was completed, and is documented in Appendix B as the Ecological Survey and Habitat Characterization Report for Fort McClellan.

5.3.2.1 Installation-Wide Ecological Setting

As expected for a region as large as FTMC, significant ecological and environmental resources are located within its boundaries. These natural resources are more completely described and documented in Appendix B of this work plan. Various watershed resources, such as the Cane Creek/Cave Creek corridor that drains the majority of Main Post and Pelham Range, as well as Choccolocco Creek that passes through the Choccolocco Corridor are located on site. Associated with these watershed resources are several wetland communities located throughout Main Post and Pelham Range. The following is a brief summation of some of the natural resources associated with FTMC.

Forest. Pine, pine-hardwoods, and upland hardwoods predominate within Calhoun County (Valley and Ridge Province within the Oak-Pine Forest Region). While these cover types constitute the majority of forests on FTMC, a variety of other forest types can also be found on the Installation. Forest types on FTMC are closely associated with successional stage, topography, and soils. In addition, FTMC contains one of the remaining examples of a naturally maintained, mountain longleaf pine ecosystem (Garland 1997; Maceina et al. 1997; Garland 1996). Approximately 12,000 acres of FTMC's Main Post are covered by this forest community.

Vegetation. A floral inventory of FTMC was completed in 1996 (Whetstone et al., 1996). The inventory focused on vascular flora and identified vegetation communities and sensitive species. Two federally-listed plant species are located on Pelham Range, Tennessee yellow-eyed-grass (endangered) and Mohr's Barbara's buttons (threatened). Other plant species of concern include Fraser's loosestrife and the white fringeless orchid, former C2 candidate species, and the southern rein orchid, a former C3 candidate species (Reisz, 1998).

Vegetation communities occur under three broad forest systems: wetland broadleaf; terrestrial broadleaf; and terrestrial needleleaf

Wetlands. Fort McClellan has an estimated 3,424 acres of delineated wetlands. Major wetland communities were originally characterized and mapped in 1984. However, regulatory criteria for identifying wetlands have significantly changed since this original study was performed. Thus, the USACE performed a supplementary mapping and evaluation study in 1992 to identify larger wetland complexes (Reisz, 1998). The following are recognized wetland communities located within FTMC (Reisz, 1998): Bottomland Hardwoods; Depressions; Mixed Shrub Communities; Shrub Depression; and Herbaceous Wetlands.

The wetland habitats found within the Installation's boundaries are generally located in various topographical depressions, near stream seepages, and in valleys along creek flood plains (Weston, 1990; SAIC 1993). The indicator plant species that assist in defining a wetland include water oaks, sweet gum, bulrush, needlerush, and cattail. The Main Post, Pelham Range, and the Choccolocco Corridor have an abundance of wetlands representing important habitats for a wide variety of plants and animals. Wetland communities found on the Main Post (Figure B-5 in Appendix B) are the Marcheta Hill Orchard Seep, Cane Creek Seep, South Branch of Cane Creek, and 200 acres west of the airstrip that comprise the tributary to Victoria Creek (Garland, 1996; USACE, 1992). Pelham Range wetland communities occur along the banks of Cane Creek, Willett Spring, and Cabin Creek Spring (ADCNR, 1994a and 1994b). Additionally, wetland habitat potentially exists at or around the Installation's lakes, namely Lake Reilly, Lake

Conteras, Lake Yahou, and Lake Willett, and along the nearly 10 miles of creeks, namely Cane and Cave Creeks (Weston, 1990).

Fauna. Fort McClellan ecosystems support a diversity of natural fauna. The Alabama Natural Heritage Program identified 12 ecosystem community types on Main Post and seven community types on Pelham Range. Approximately 35 species of mammals and 240 species of birds have been reported to be residing within the Installation's habitat. The predominant mammals found are the white-tailed deer, cottontail and swamp rabbits, gray squirrel, raccoon, opossum, fox, and beaver (Weston, 1990). The bird species population includes wood duck, quail, and turkey. Species designated as game within the State of Alabama occur on FTMC. However, not all are actively managed as game as part of the FTMC hunting or fishing program. Lakes and streams of FTMC support numerous species of fish. Game species include largemouth bass, bluegill, and catfish. Nongame fish species include the blacknose dace *(Rhinichthys atratulus)*, creek chub *(Semotilus atromaculatus)*, and stoneroller *(Campostoma anomalum)*. Fort McClellan supports a moderate diversity of amphibians. In addition, numerous species of reptile occur on the Installation.

Special Interest Natural Areas. The ESMP for FTMC identifies 16 SINAs at FTMC (Garland, 1996). SINAs are locations where the habitat fosters one or more rare, threatened, or endangered species. Because these species are sensitive to environmental degradation, SINAs require management practices that promote the continued well being of these ecosystems (ESE, 1998) According to the ESMP, 16 SINAs are located on the Main Post and Pelham Range.

Threatened, Endangered, or Special Concern Fauna (Federally Protected Wildlife). Two species of fauna listed as endangered or threatened by the USFWS have been recorded on FTMC. They are the gray bat (*Myotis grisescens*) that uses the Cane Creek Corridor as foraging habitat, and the blue shiner (*Cyprinella caerulea*) located within the Choccolocco Creek watershed. An additional endangered species, the red-cockaded woodpecker, historically has inhabited the Installation.

5.3.2.2 Site-Specific Ecological Setting of Sites and Parcels

The environmental setting of each site or parcel will be described. Information included in the installation-wide environmental setting report (Appendix B) may be referenced if a site or parcel is associated with these ecological features.

Site-specific environmental setting will be described based on the Installation-wide information and on site-specific field reconnaissance observations. Site-specific habitat maps will be prepared showing the type and extent of biological communities and the type and extent of non-ecological (i.e., industrial/commercial) development present within and around the immediate vicinity of each site or parcel.

5.3.3 Constituents Detected On-Site (Step 1)

A preliminary list of chemicals was identified during research and investigation activities performed at the SI planning stage of the FTMC project. Information regarding historical site uses, chemical use and disposal practices, and other site-related activities was researched in existing documents (such as environmental baseline survey reports and environmental impact statement reports) or by interview with base personnel. Sample-specific analyte lists were developed for each site or parcel from this research. The media to be sampled include surface soil sampled between 0 and 1 foot below ground surface, surface water, and sediment. The presence or absence of these chemicals of interest will be confirmed by the sample analytical results for each site or parcel. The analytes that are detected in site-specific samples will be called CPSS, and will form the chemical database for the SLERA. The results of the sampling and analysis and the resulting statistical summaries of the CPSS will be presented in tables for each medium sampled.

5.3.4 Site Conceptual Model (Step 1)

The ecological site conceptual model (SCM) is a simplified, schematic diagram of possible exposure pathways and the means by which contaminants are transported from the primary contaminant source(s) to ecological receptors. The exposure scenarios include the sources, environmental transport, partitioning of the contaminants amongst various environmental media, potential chemical/biological transformation processes, and identification of potential routes of exposure for the ecological receptors. The SCM will be described in relation to constituent fate and transport properties, the ecotoxicity of the detected constituents, potential ecological receptors at the site(s) being studied, and the complete exposure pathways expected to exist at the site(s). A generalized SCM is presented in Figure 5-3.

5.3.4.1 Constituent Fate and Transport

The potential fate and transport processes that control the disposition of CPSS in the various environmental media will be discussed in general and specifically for each CPSS. This section

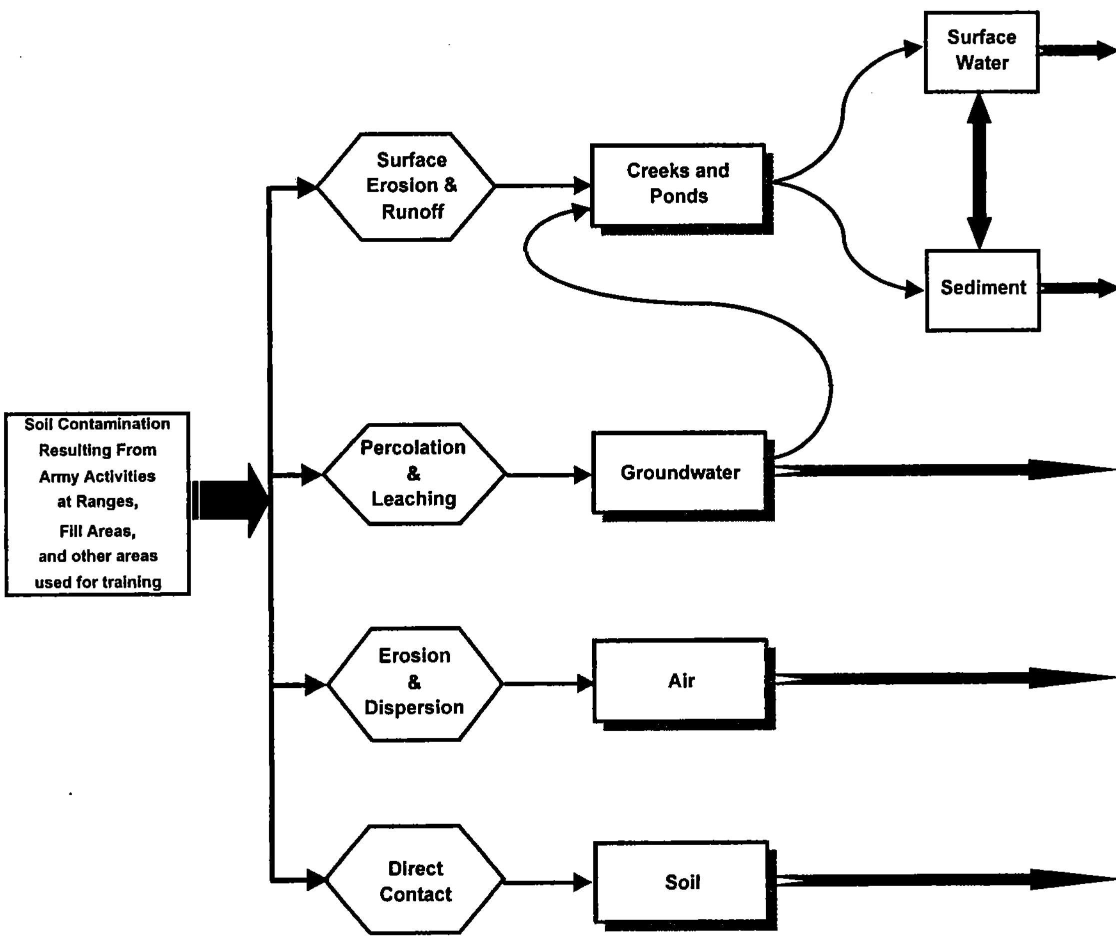
Figure 5-3

Generalized Site Conceptual Model
for Screening-Level Ecological Risk Assessment
Fort McClellan, Calhoun County, Alabama

(Page 1 of 2)

GENERALIZED SITE CONCEPTUAL MODEL

CONTAMINANT SOURCE	*RELEASE/TRANSPORT MECHANISM*	*PRIMARY RECEPTOR*	*ENVIRONMENTAL MEDIA*	*Exposure Pathway*	Potential For Exposure – Ecological Receptors



Surface Water

Exposure Pathway	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Root Uptake	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Foliar Deposition	√	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Direct Contact	√	√	✗	√	√	√	√	√	√	√	√	√	□	√	□	√	√
Ingestion	✗	✗	✗	√	√	√	√	√	√	√	√	√	□	√	□	√	√
Inhalation	✗	✗	✗	✗	✗	□	□	✗	□	□	□	□	□	□	□	□	□
Food Chain Magnification	✗	✗	✗	✗	✗	√	√	√	√	√	√	√	□	√	□	√	√

Sediment

Exposure Pathway	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Root Uptake	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Foliar Deposition	✗	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Direct Contact	√	✗	✗	√	✗	√	√	√	√	√	√	√	□	√	□	√	√
Ingestion	✗	✗	✗	√	✗	√	√	√	√	√	√	√	□	√	□	√	√
Inhalation	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Food Chain Magnification	✗	✗	✗	✗	✗	√	√	√	√	√	√	√	□	√	□	√	√

Groundwater

Exposure Pathway	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Root Uptake	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Foliar Deposition	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Direct Contact	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Ingestion	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Inhalation	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*
Food Chain Magnification	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*NA*

Air

Exposure Pathway	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Root Uptake	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Foliar Deposition	√	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Direct Contact	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Ingestion	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Inhalation	✗	✗	□	✗	✗	□	□	□	□	□	□	□	□	□	□	□	□
Food Chain Magnification	✗	✗	✗	✗	✗	□	□	□	□	□	□	□	□	□	□	□	□

Soil

Exposure Pathway	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Root Uptake	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Foliar Deposition	√	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Direct Contact	√	✗	√	✗	✗	√	√	✗	√	√	√	√	□	√	✗	√	√
Ingestion	✗	✗	√	✗	✗	√	√	✗	√	√	√	√	□	√	✗	√	√
Inhalation	✗	✗	□	✗	✗	□	□	✗	□	□	□	□	□	□	✗	□	□
Food Chain Magnification	✗	✗	✗	✗	✗	√	√	✗	√	√	√	√	□	√	✗	√	√

Note: See key on following page for descriptions of receptors and pathways

Figure 5-3

Generalized Site Conceptual Model
for Screening-Level Ecological Risk Assessment
Fort McClellan, Calhoun County, Alabama

Key To Potential Receptors

1 - Rooted plants
2 - Floating aquatic plants
3 - Terrestrial invertebrates
4 - Benthic invertebrates
5 - Water column invertebrates
6 - Herbivorous mammals
7 - Herbivorous birds
8 - Planktivorous fish
9 - Omnivorous mammals
10 - Omnivorous birds
11 - Invertivorous mammals
12 - Invertivorous birds
13 - Piscivorous mammals
14 - Piscivorous birds
15 - Piscivorous fish
16 - Carnivorous mammals
17 - Carnivorous birds

Key To Potential Exposure Routes

√	- Potentially complete exposure pathway
✗	- Incomplete exposure pathway
□	- Potentially complete exposure pathway but insignificant
NA	- Not applicable

will focus on how the CPSS behave in the various environmental media under various conditions expected at the site.

5.3.4.2 Ecotoxicity

The ecotoxicological properties of each of the constituents detected in the various environmental media at a given site will be discussed in this section of the SLERA. The mechanisms by which constituents assert their toxic affects, the target organs and systems on which they act, and the levels in environmental media that may cause toxicity to various animal and plant groups will be discussed.

5.3.4.3 Potential Receptors

Potential ecological receptors will be identified for each of the habitat types found at the various sites. Potential ecological receptors at each site fall into two general categories: terrestrial and aquatic. These receptors will be identified by feeding guild, which generally include the following:

- Primary Producers (aquatic and terrestrial)
- Herbivores (aquatic and terrestrial)
- Omnivores (aquatic and terrestrial)
- Carnivores (aquatic and terrestrial)
- Invertivores (aquatic and terrestrial)
- Piscivores.

All of these feeding guilds could be directly exposed to various combinations of surface soil at a site and surface water and sediment in surface water bodies associated with a site via various activities (e.g., feeding, drinking, grooming, bathing, etc.). These feeding guilds may also be exposed to site-related chemicals via food web transfers.

5.3.4.4 Complete Exposure Pathways

For exposures to occur, complete exposure pathways must exist between the contaminant and the receptor. A complete exposure pathway requires the following four components:

- A source mechanism for contaminant release
- A transport mechanism
- A point of environmental contact
- A route of uptake at the exposure point (EPA, 1989b).

If any of these four components are absent, then a pathway is generally considered incomplete. Potentially complete exposure pathways are depicted in the SCM as Figure 5-3.

Ecological receptors may be exposed to constituents in soils via direct and/or secondary exposure pathways. Direct exposure pathways include soil ingestion, dermal absorption, and inhalation of volatile COPECs or COPECs adsorbed to fugitive dust. Significant exposure via dermal contact is limited to organic constituents which are lipophilic and can penetrate epidermal barriers. Mammals are less susceptible to exposure via dermal contact with soils because their fur prevents skin from coming into direct contact with soil. However, soil ingestion may occur while grooming, preening, burrowing, or consuming plants, insects, or invertebrates resident in soil.

Ecological receptors may be exposed to constituents in surface water via direct contact or through consumption of water. Aquatic organisms inhabiting contaminated waters would be in constant contact with COPECs.

Exposure via inhalation of fugitive dust is limited to contaminants present in surface soils at areas that are devoid of vegetation. The inherent moisture content of the soil and the frequency of soil disturbance also play important roles in the amount of fugitive dust generated at a particular site.

Exposure via inhalation of volatile COPECs is limited to sites with volatile COPECs present. The "age" of the volatile contamination decreases overtime and exposure would become less significant overtime.

Constituents present in the sediment may result from erosion or adsorption of water-borne constituents onto sediment particles. If sediments are present in an area that is periodically inundated with water, then previous exposure pathways for soils would be applicable during dry periods. Water overlying sediments prevents contaminants from being carried by wind erosion. Exposure via dermal contact may occur, especially for benthic organisms and wading birds. Some aquatic organisms consume sediment and ingest organic material from the sediment. Inadvertent ingestion of sediments may also occur as the result of feeding on benthic organisms and plants.

While constituents in soils may leach into groundwater, environmental receptors generally will not come into direct contact with constituents in groundwater since there is no direct exposure route.

Secondary exposure pathways involve constituents that are transferred through different trophic levels of the food chain and may be bioaccumulated/bioconcentrated. This may include constituents bioaccumulated from soil into plant tissues or into terrestrial species ingesting soils. These plants or animals may, in turn, be consumed by animals at higher trophic levels. Water-borne and sediment-borne COPECs may bioaccumulate into aquatic organisms, aquatic plants, or animals which frequent surface waters and then be passed through the food chain to impact organisms at higher trophic levels.

5.3.5 Screening-Level Risk Estimation (Step 2)

A screening-level assessment of potential risk can be accomplished by comparing the exposure-point concentration of each detected constituent in each environmental medium to a corresponding screening-level toxicity value. In order to conduct the screening-level risk estimation, the following steps must be followed:

- Determine appropriate screening assessment endpoints
- Determine the ecological toxicity values that are protective of the selected assessment endpoints
- Determine the exposure point concentrations of constituents detected at the site
- Calculate screening-level hazard quotients.

Most ecological risk assessments focus on population measures as endpoints since population responses are more well-defined and predictable than are community or ecosystem responses. For SLERA, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments.

Adverse effects on populations can be inferred from measures related to impaired reproduction, growth, and survival. Adverse effects on communities can be inferred from changes in community structure or function. Adverse effects on habitats can be inferred from changes in composition and characteristics that reduce ability of the habitat to support plant and animal populations and communities.

5.3.5.1 Ecological Screening Assessment Endpoints

Due to the nature of the SLERA process, most of the screening assessment endpoints are generic in nature (i.e., protection of sediment benthic communities from adverse changes in structure or function).

Examples of screening-level assessment endpoints that will be used in the SLERAs at FTMC are as follows:

- ***Soil***
  - Protection of the terrestrial invertabrate community from adverse changes in structure and function
  - Protection of the terrestrial plant community from adverse changes in structure and function
- ***Surface Water***
  - Protection of the aquatic community from adverse changes in structure and function
- ***Sediment***
  - Protection of the benthic community from adverse changes in structure and function.

5.3.5.2 Ecological Screening Values

The ESVs used in SLERAs at FTMC represent the most conservative values available from various literature sources and have been selected to be protective of the assessment endpoints described above. These ESVs have been developed specifically for FTMC in conjunction with USEPA Region IV and are presented in the *Final Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000a). These ESVs are based on no-observed-adverse-effect-levels (NOAEL), when available. If a NOAEL-based ESV was not available for a certain COPEC, then the most health-protective value available from the scientific literature was used.

A hierarchy has been developed which presents an orderly method for selection of ESVs. The hierarchy for selecting ESVs for soil is as follows:

- EPA Region IV constituent-specific ecological screening values
- EPA Region IV ecological screening values for general class of constituents
- EPA Region V ecological data quality levels (EDQL)
- EPA Region III Biological Technical Advisory Group (BTAG) values
- Ecological screening values from Talmage, et al., 1999.

The hierarchy for selecting ESVs for surface water is as follows:

- EPA Region IV constituent-specific ecological screening values

- National Oceanic and Atmospheric Administration Screening Quick Reference Tables (SQRT), chronic freshwater ambient water quality criteria

- EPA Region V EDQLs

- Office of Solid Waste and Emergency Response (OSWER) Ecotox Threshold values

- EPA Region III BTAG values

- Lowest chronic value from Suter and Tsao, 1996

- Ecological screening values from Talmage, et al., 1999.

The hierarchy for selecting ESVs for sediment is as follows:

- EPA Region IV constituent-specific ecological screening values

- NOAA SQRTs, chronic freshwater ambient water quality criteria

- EPA Region V EDQLs

- OSWER ecotox threshold values

- EPA Region III BTAG values

- Lowest effect levels from Ontario Ministry of the Environment (1992) presented in Jones, et al., (1997)

- Ecological screening values from Talmage, et al., 1999

- Sediment quality adverse effect threshold (AET) values from the Puget Sound Estuary Program.

A summary of the ESVs developed for FTMC is presented in Table 5-4.

5.3.5.3 Determination of Exposure Point Concentrations

Exposure point concentrations represent the chemical concentrations in environmental media that a receptor may contact. Since the exposure point concentration is a value that represents the most likely concentration to which receptors could be exposed, a value that reflects the central tendency of the data set is most appropriate to use. However, at the screening-level stage, the data sets are generally not robust enough for statistical analysis and the level of conservatism in the exposure estimates is high to account for uncertainties. Therefore, in the screening-level stage, the maximum detected constituent concentration in each environmental medium is used as the exposure point concentration. The use of the maximum detected constituent concentration as the exposure point concentration ensures that the exposures will not be under-estimated, and therefore, constituents will not be inadvertently eliminated from further assessment.

Statistical summaries of the data sets used in the SLERA for each site will be presented in tabular form and will include the maximum detected concentration, minimum detected concentration, frequency of detection, and other pertinent statistics for each constituent in each environmental medium.

5.3.5.4 Screening-Level Hazard Quotients

In order to estimate whether constituents detected in environmental media at a site have the potential to pose adverse ecological risks, screening-level hazard quotients will be developed. The screening-level hazard quotients will be developed via a three-step process as follows:

- Comparison to ESVs
- Identification of essential macro-nutrients
- Comparison to naturally-occurring background concentrations.

Constituents that are detected in environmental media at a given site will be evaluated against the ESVs by calculating a screening-level hazard quotient (HQ_{screen}) for each constituent in each

Table 5-4

Ecological Screening Values for Screening-Level Ecological Risk Assessment Fort McClellan, Calhoun County, Alabama

Constituents	Soil [1] (mg/kg)		Surface Water [2] (mg/L)		Sediment [3] (mg/kg)	
Inorganics						
Aluminum	5.00E+01		8.70E-02		no data	
Antimony	3.50E+00		1.60E-01		1.20E+01	
Arsenic	1.00E+01		1.90E-01		7.24E+00	
Barium	1.65E+02		3.90E-03	g	no data	
Beryllium	1.10E+00		5.30E-04		no data	
Cadmium	1.60E+00		6.60E-04		1.00E+00	
Calcium	no data		1.16E+02	h	no data	
Chromium	4.00E-01		1.10E-02		5.23E+01	
Cobalt	2.00E+01		3.00E-03	g	5.00E+01	m
Copper	4.00E+01		6.54E-03		1.87E+01	
Iron	2.00E+02		1.00E+00		no data	
Lead	5.00E+01		1.32E-03		3.02E+01	
Magnesium	4.40E+05	b	8.20E+01	h	no data	
Manganese	1.00E+02		8.00E-02	g	no data	
Mercury (inorganic)	1.00E-01		1.20E-05		1.30E-01	
Methyl mercury	6.70E-01		3.00E-06	g	2.45E-05	m
Molybdenum	2.00E+00		2.40E-01	g	no data	
Nickel	3.00E+01		8.77E-02		1.59E+01	
Potassium	no data		5.30E+01	h	no data	
Selenium	8.10E-01		5.00E-03		no data	
Silver	2.00E+00		1.20E-05		2.00E+00	
Sodium	no data		6.80E+02	h	no data	
Thallium	1.00E+00		4.00E-03		no data	
Vanadium	2.00E+00		1.90E-02	g	no data	
Zinc	5.00E+01		5.89E-02		1.24E+02	
Cyanide	5.00E+00		5.20E-03		no data	
Volatile Organic Compounds (VOCs)						
1,1,1,2-Tetrachloroethane	1.00E-01		2.40E+00	f	1.09E-02	m
1,1,1-Trichloroethane	1.00E-01		5.28E-01		1.70E-01	g
1,1,2,2-Tetrachloroethane	1.00E-01		2.40E-01		9.40E-01	g
1,1,2-Trichloroethane	1.00E-01		9.40E-01		6.74E-01	m
1,1-Dichloroethene	1.00E-01		3.03E-01		2.33E-02	m
1,1-Dichloroethane	1.00E-01		4.70E-02	g	5.75E-04	m
1,1-Dichloropropene	1.00E-01		2.44E-01	b	2.96E-03	m
1,2,3-Trichlorobenzene	1.00E-02		6.92E-02	j	6.40E-02	l
1,2,3-Trichloropropane	1.00E-01		1.21E-02	j	8.35E-03	m
1,2,3-Trimethylbenzene	1.00E-01		no data		no data	
1,2,4-Trichlorobenzene	1.00E-02		4.49E-02		6.40E-02	l
1,2,4-Trimethylbenzene	1.00E-01		no data		no data	
1,2-Dibromo-3-chloropropane	1.00E-01		1.12E-01	j	2.00E-02	m
1,2-Dibromoethane	1.23E+00	e	2.25E-02	j	1.24E-02	m
1,2-Dichlorobenzene	1.00E-02		1.58E-02		5.00E-02	l
1,2-Dichloroethane	4.00E-01		2.00E+00		5.42E-02	m
1,2-Dichloroethene (Total)	1.00E-01		3.10E-01	j	2.09E-01	m
1,2-Dichloropropane	7.00E+02		5.25E-01		3.52E-01	m
1,3,5-Trichlorobenzene	1.00E-02		5.00E-02	b	6.40E-02	l
1,3,5-Trimethylbenzene	1.00E-01		no data		no data	
1,3-Dichlorobenzene	1.00E-02		5.02E-02		1.70E-01	l
1,3-Dichloropropane	7.00E+02		5.21E-01		3.52E-01	m
1,4-Dichlorobenzene	1.00E-02		1.12E-02		1.20E-01	l
2,2-Dichloropropane	7.00E+02		5.21E-01		3.52E-01	m
2-Butanone (MEK)	8.96E+01	e	7.10E+00	j	1.37E-01	m
2-Chlorotoluene	1.00E-01		no data		no data	
2-Hexanone (MBK)	1.26E+01	e	1.71E+00	j	1.01E+00	m
3-Chlorotoluene	1.00E-01		no data		no data	
4-Chlorotoluene	1.00E-01		no data		no data	
4-methyl-2-Pentanone (MIBK)	4.43E+02	e	3.68E+00	j	5.44E-01	m
Acetone	2.50E+00	e	7.80E+01	j	4.53E-01	m
Benzene	5.00E-02		5.30E-02		5.70E-02	g
Bromobenzene	1.00E-01		no data		no data	
Bromochloromethane	1.00E-01		1.10E+01	b	no data	
Bromodichloromethane	1.00E-01		1.10E+01	b	1.13E-03	m

Table 5-4

Ecological Screening Values
for Screening-Level Ecological Risk Assessment
Fort McClellan, Calhoun County, Alabama

Constituents	Soil [1] (mg/kg)		Surface Water [2] (mg/L)		Sediment [3] (mg/kg)	
Bromoform	1.59E+01	e	2.93E-01		9.96E-01	m
Bromomethane	no data		no data		no data	
Carbon disulfide	9.40E-02	e	8.40E-02	j	1.34E-01	m
Carbon tetrachloride	1.00E+03		3.52E-01		3.57E-02	m
Chlorobenzene	5.00E-02		1.95E-01		6.19E-02	m
Chloroethane	1.00E-01		2.30E+02	j	5.86E+01	m
Chloroform	1.00E-03		2.89E-01		2.70E-02	m
Chloromethane (methyl chloride)	1.00E-01		5.50E+00		7.85E-05	m
cis-1,2-Dichloroethene	1.00E-01		1.16E+01	b	2.09E-01	m
cis-1,3-Dichloropropene	1.00E-01		2.44E-02		2.96E-03	m
Dibromochloromethane	1.00E-01		6.40E+00	j	2.68E-01	m
Dibromomethane	1.23E+00	e	2.25E-02	j	1.24E-02	m
Dichlorodifluoromethane	1.00E-01		1.10E+01	b	1.33E-03	m
Ethyl benzene	5.00E-02		4.53E-01		3.60E+00	g
Hexachlorobutadiene	3.98E-02	e	9.30E-04		1.38E+00	m
Isopropylbenzene (cumene)	no data		no data		no data	
m,p-Xylene	5.00E-02		1.17E-01	j	2.50E-02	g
Methylene chloride	2.00E+00		1.93E+00		1.26E+00	m
Naphthalene	1.00E-01		6.20E-02		3.46E-02	m
n-Butylbenzene	no data		no data		no data	
n-Propylbenzene	no data		no data		no data	
o-Xylene	5.00E-02		1.17E-01	j	1.88E+00	m
p-Isopropyltoluene (p-cymene)	no data		no data		no data	
sec-Butylbenzene	no data		no data		no data	
Styrene	1.00E-01		5.60E-02	j	4.45E-01	m
tert-Butylbenzene	no data		no data		no data	
Tetrachloroethene	1.00E-02		8.40E-02		1.96E-01	m
Toluene	5.00E-02		1.75E-01		6.70E-01	g
trans-1,2-Dichloroethene	1.00E-01		1.35E+00		2.09E-01	m
trans-1,3-Dichloropropene	1.00E-01		2.44E-02		2.96E-03	m
Trichloroethene	1.00E-03		2.19E+01	f	1.80E-01	m
Trichlorofluoromethane	1.00E-01		1.10E+01	b	3.07E-03	m
Vinyl chloride	1.00E-02		9.20E-03	j	2.00E-03	m
Xylenes (total)	5.00E-02		1.17E-01	j	1.88E+00	m
Semivolatile Organic Compounds (SVOCs)						
1,2,4-Trichlorobenzene	1.00E-02		4.49E-02		6.40E-02	l
1,2-Dichlorobenzene	1.00E-02		1.58E-02		5.00E-02	l
1,3-Dichlorobenzene	1.00E-02		5.02E-02		1.70E-01	l
1,4-Dichlorobenzene	1.00E-02		1.12E-02		1.20E-01	l
2,4,5-Trichlorophenol	4.00E+00		6.30E-02	f	8.56E-02	m
2,4,6-Trichlorophenol	1.00E+01		3.20E-03		8.48E-02	m
2,4-Dichlorophenol	2.00E+01		3.65E-02		1.34E-01	m
2,4-Dimethylphenol	1.00E-02	e	2.12E-02		3.05E-01	m
2,4-Dinitrophenol	2.00E+01		6.20E-03		1.33E-03	m
2,4-Dinitrotoluene	1.28E+00	e	3.10E-01		7.51E-02	m
2,6-Dichlorophenol	2.00E+01		3.65E-02		3.94E-03	m
2,6-Dinitrotoluene	3.28E-02	e	4.20E-02	j	2.06E-02	m
2-Chloronaphthalene	1.00E+00		3.96E-04	j	4.17E-01	m
2-Chlorophenol	7.00E+00		4.38E-02		1.17E-02	m
2-Methylnaphthalene	no data		3.30E-01	j	3.30E-01	
2-Methylphenol (o-cresol)	5.00E-01		4.89E-01	h	6.30E-02	b
2-Nitroaniline	3.16E+00	e	no data		2.00E-04	m
2-Nitrophenol	7.00E+00		3.50E+00		7.77E-03	m
3,3'-Dichlorobenzidine	6.46E-01	e	9.98E-02	j	2.82E-02	m
3-Nitroaniline	2.19E+01	e	no data		2.00E-04	m
4,6-Dinitro-2-methylphenol	no data		no data		no data	
4-Bromophenyl-phenylether	no data		1.50E-03	j	1.55E+00	m
4-Chloro-3-methylphenol	no data		3.00E-04		no data	
4-Chloroaniline	2.00E+01		5.00E-02	f	1.46E-01	m
4-Chlorophenyl-phenylether	no data		no data		6.56E-01	m
4-Methylphenol (p-cresol)	5.00E-01		4.89E-01		6.70E-01	b
4-Nitroaniline	3.16E+00	e	no data		2.00E-04	m
4-Nitrophenol	7.00E+00		8.28E-02		7.78E-03	m

Table 5-4

Ecological Screening Values
for Screening-Level Ecological Risk Assessment
Fort McClellan, Calhoun County, Alabama

Constituents	Soil [1] (mg/kg)		Surface Water [2] (mg/L)		Sediment [3] (mg/kg)	
Acenaphthene	2.00E+01		1.70E-02		3.30E-01	
Acenaphthylene	6.82E+02	e	4.84E+00	j	3.30E-01	
Anthracene	1.00E-01		2.90E-05	j	3.30E-01	
Benzo(a)anthracene	5.21E+00	e	8.39E-04	j	3.30E-01	
Benzo(a)pyrene	1.00E-01		1.40E-05	j	3.30E-01	
Benzo(b)fluoranthene	5.98E+01	e	9.07E-03	j	6.55E-01	
Benzo(g,h,i)perylene	1.19E+02	e	7.64E-03	j	6.55E-01	
Benzo(k)fluoranthene	1.48E+02	e	5.60E-06	j	6.55E-01	
Benzoic acid	no data		no data		6.50E-01	b
bis(2-Chloroethoxy)methane	no data		1.10E+01	b	no data	
bis(2-Chloroethyl)ether	2.37E+01	e	2.38E+00		2.12E-01	m
bis(2-Chloroisopropyl)ether	no data		no data		no data	
bis(2-Ethylhexyl)phthalate	9.26E-01	e	3.00E-04		1.82E-01	
Butyl benzyl phthalate	2.39E-01	e	2.20E-02		4.19E+00	m
Carbazole	no data		no data		no data	
Chrysene	4.73E+00	e	3.30E-05	j	3.30E-01	
Dibenzo(a,h)anthracene	1.84E+01	e	1.60E-06	j	3.30E-01	
Dibenzofuran	no data		2.00E-02	j	1.52E+00	m
Diethyl phthalate	1.00E+02		5.21E-01		8.04E-03	m
Dimethylphthalate	2.00E+02		3.30E-01		2.50E-02	m
Di-n-butylphthalate	2.00E+02		9.40E-03		1.11E-01	m
Di-n-octylphthalate	7.09E+02	e	3.00E-02	j	4.06E+01	m
Fluoranthene	1.00E-01		3.98E-02		3.30E-01	
Fluorene	1.22E+02	e	3.90E-03	j	3.30E-01	
Hexachlorobenzene	2.50E-03		3.68E-03	f	2.00E-02	m
Hexachlorobutadiene	3.98E-02	e	9.30E-04		1.38E+00	m
Hexachlorocyclopentadiene	1.00E+01		7.00E-05		9.01E-01	m
Hexachloroethane	5.96E-01	e	9.80E-03		2.23E+00	m
Indeno(1,2,3-cd)pyrene	1.09E+02	e	4.31E-03	j	6.55E-01	
Isophorone	1.39E+02	e	1.17E+00		4.22E-01	m
Naphthalene	1.00E-01		6.20E-02		3.30E-01	
Nitrobenzene	4.00E+01		2.70E-01		4.88E-01	m
n-Nitroso-di-n-propylamine	no data		no data		no data	
n-Nitrosodiphenylamine	2.00E+01		5.85E-02		1.55E-01	m
Pentachlorophenol	2.00E-03		1.30E-02		6.90E-01	l
Phenanthrene	1.00E-01		6.30E-03	f	3.30E-01	
Phenol	5.00E-02		2.56E-01		2.73E-02	m
Pyrene	1.00E-01		3.00E-04	j	3.30E-01	
Diisopropylmethylphosphonic Acid	no data		no data		no data	
Dimethylmethylphosphonic Acid	no data		no data		no data	
Ethylmethylphosponic Acid	no data		no data		no data	
Isopropylmethylphosphonic Acid	no data		no data		no data	
Methylphoshonic Acid	no data		no data		no data	
Thiodiglycol	no data		no data		no data	
1,4-Dithiane	no data		no data		no data	
1,4-Oxathiane	no data		no data		no data	
p-Chlorophenylmethylsulfone	no data		no data		no data	
p-Chlorophenylmethylsulfoxide	no data		no data		no data	
Propane, 2,2'-Oxybis[1-Chloro-	no data		no data		no data	
Dioxins and Furans [c]						
2,3,7,8-TCDD	1.00E-02	b	1.00E-08	j	2.50E-06	m
Total TCDD	1.00E-02		1.00E-08		2.50E-06	
2,3,7,8-TCDF	1.00E-02		1.00E-08		2.50E-06	
Total TCDF	1.00E-02		1.00E-08		2.50E-06	
1,2,3,7,8-PeCDD	1.00E-02		1.00E-08		2.50E-06	
Total PeCDD	1.00E-02		1.00E-08		2.50E-06	
1,2,3,7,8-PeCDF	1.00E-01		1.00E-07		2.50E-05	
2,3,4,7,8-PeCDF	1.00E-02		1.00E-08		2.50E-06	
Total PeCDF	1.00E-02		1.00E-08		2.50E-06	
1,2,3,4,7,8-HxCDD	1.00E-01		2.00E-08		2.50E-05	
1,2,3,6,7,8-HxCDD	1.00E-01		1.00E-07		2.50E-05	
1,2,3,7,8,9-HxCDD	1.00E-01		1.00E-07		2.50E-05	
Total HxCDD	1.00E-01		2.00E-08		2.50E-05	

Table 5-4

Ecological Screening Values for Screening-Level Ecological Risk Assessment Fort McClellan, Calhoun County, Alabama

Constituents	Soil [1] (mg/kg)		Surface Water [2] (mg/L)		Sediment [3] (mg/kg)	
1,2,3,4,7,8-HxCDF	1.00E-01		1.00E-07		2.50E-05	
1,2,3,6,7,8-HxCDF	1.00E-01		1.00E-07		2.50E-05	
1,2,3,7,8,9-HxCDF	1.00E-01		1.00E-07		2.50E-05	
2,3,4,6,7,8-HxCDF	1.00E-01		1.00E-07		2.50E-05	
Total HxCDF	1.00E-01		1.00E-07		2.50E-05	
1,2,3,4,6,7,8-HpCDD	1.00E+00		1.00E-06		2.50E-04	
Total HpCDD	1.00E+00		1.00E-06		2.50E-04	
1,2,3,4,6,7,8-HpCDF	1.00E+00		1.00E-06		2.50E-04	
1,2,3,4,7,8,9-HpCDF	1.00E+00		1.00E-06		2.50E-04	
Total HpCDF	1.00E+00		1.00E-06		2.50E-04	
Total OCDD	1.00E+02		1.00E-04		2.50E-02	
Total OCDF	1.00E+02		1.00E-04		2.50E-02	
PCBs/Nitroexplosives/Pesticides/Herbicides						
Aroclor 1016	2.00E-02		1.40E-05		3.30E-02	
Aroclor 1221	2.00E-02		1.40E-05		6.70E-02	
Aroclor 1232	2.00E-02		1.40E-05		3.30E-02	
Aroclor 1242	2.00E-02		1.40E-05		3.30E-02	
Aroclor 1248	2.00E-02		1.40E-05		3.30E-02	
Aroclor 1254	2.00E-02		1.40E-05		3.30E-02	
Aroclor 1260	2.00E-02		1.40E-05		3.30E-02	
PCBs (total)	2.00E-02		1.40E-05		3.30E-02	
2,4,5-T	1.00E-01		no data		no data	
2,4,5-TP (Silvex)	1.00E-01		3.27E-01	j	7.35E+00	m
2-Nitrotoluene	no data		no data		no data	
3-Nitrotoluene	no data		no data		no data	
4,4'-DDD	2.50E-03		6.40E-06		3.30E-03	
4,4'-DDE	2.50E-03		1.05E-02		3.30E-03	
4,4'-DDT	2.50E-03		1.00E-06		3.30E-03	
Aldrin	2.50E-03		3.00E-04		2.00E-03	m
alpha-BHC	2.50E-03		5.00E+00		6.00E-03	m
beta-BHC	1.00E-03		5.00E+01		5.00E-03	m
Chlordane (technical)	1.00E-01		4.30E-06		1.70E-03	
delta-BHC	9.94E+00	e	6.67E-01	j	7.15E+01	m
Dieldrin	5.00E-04		1.90E-06		3.30E-03	
Endosulfan I	1.19E-01	e	5.60E-05		1.75E-04	m
Endosulfan II	1.19E-01	e	5.60E-05		1.04E-04	m
Endosulfan sulfate	3.58E-02	e	2.22E-03	j	3.46E-02	m
Endrin	1.00E-03		2.30E-06		3.30E-03	
Endrin aldehyde	1.05E-02	e	1.50E-04	j	3.20E+00	m
Endrin ketone	1.05E-02	e	1.50E-04	j	3.20E+00	m
gamma-BHC (Lindane)	5.00E-05		8.00E-05		3.30E-03	
Heptachlor	1.00E-01		3.80E-06		6.00E-04	m
Heptachlor epoxide	1.52E-01	e	3.80E-06		6.00E-04	k
Methoxychlor	1.99E-02	e	3.00E-05		3.59E-03	m
Toxaphene	1.19E-01	e	2.00E-07		1.09E-04	m
Dalapon	1.00E-01		no data		no data	
2,4-D	1.00E-01		no data		no data	
2,4-DB	1.00E-01		no data		no data	
Dicamba	1.00E-01		no data		no data	
Dichloroprop	1.00E-01		no data		no data	
Dinoseb	1.00E-01		3.90E-04	j	1.18E-02	m
MCPA	1.00E-01		no data		no data	
MCPP	1.00E-01		no data		no data	
1,3,5-Trinitrobenzene	3.76E-01	e	1.10E-02	i	2.40E-03	i
1,3-Dinitrobenzene	6.55E-01	e	2.00E-02	i	6.70E-03	i
2,4,6-Trinitrotoluene	no data		9.00E-02	i	9.20E-02	i
2,4-Dinitrotoluene	1.28E+00	e	2.30E-01	j	7.51E-02	m
2,6-Dinitrotoluene	3.28E-02	e	4.20E-02	j	2.06E-02	m
2-Amino-4,6-dinitrotoluene	no data		2.00E-02	i	no data	
4-Amino-2,6-Dinitrotoluene	no data		no data		no data	
HMX	no data		3.30E-01	i	4.70E-03	i
Nitrobenzene	1.31E+00	e	7.40E-01	j	4.88E-01	m
RDX	no data		1.90E-01	i	1.30E-02	i

Table 5-4

Ecological Screening Values
for Screening-Level Ecological Risk Assessment
Fort McClellan, Calhoun County, Alabama

Constituents	Soil [1] (mg/kg)	Surface Water [2] (mg/L)		Sediment [3] (mg/kg)	
Tetryl	no data	no data		no data	
p-Nitrotoluene	no data	no data		no data	
Azinphosmethyl	1.00E-01	no data		no data	
Bolstar	1.00E-01	no data		no data	
Chlorpyrifos	1.00E-01	4.10E-05		no data	
Coumaphos	1.00E-01	no data		no data	
Demeton	1.00E-01	1.00E-04		no data	
Diazinon	1.00E-01	4.30E-05	g	1.90E-03	g
Dichlorvos	1.00E-01	no data		no data	
Dimethoate	1.00E-01	4.12E-02	j	1.90E-01	m
Disulfoton	1.00E-01	4.02E-05	j	3.24E-01	m
Ethoprop	1.00E-01	no data		no data	
Famphur	1.00E-01	no data		1.78E-03	m
Fensulfothion	1.00E-01	no data		no data	
Fenthion	1.00E-01	no data		no data	
Malathion	1.00E-01	1.00E-04		no data	
Merphos	1.00E-01	no data		no data	
Methyl Parathion	1.00E-01	1.30E-05		7.55E-04	m
Mevinphos	1.00E-01	no data		no data	
Naled	1.00E-01	no data		no data	
O,O,O-Triethyl Phosphorothioate	1.00E-01	no data			
Parathion	1.00E-01	1.30E-05		3.40E-04	m
Phorate	1.00E-01	3.62E-03	j	8.61E-04	m
Ronnel	1.00E-01	no data		no data	
Stirophos	1.00E-01	no data		no data	
Sulfotep	1.00E-01	no data		no data	
Thionazin	1.00E-01	no data		no data	
Tokuthion	1.00E-01	no data		no data	
Trichloronate	1.00E-01	no data		no data	

Notes:

[1] USEPA, Region IV, 1999. Waste Management Division Soil Screening Values for Hazardous Waste Sites. Online

[2] USEPA, Region IV, 1999. Waste Management Division Freshwater Surface Water Chronic Screening Values for Hazardous Waste Sites. Online

[b] USEPA, Region III, 1995, BTAG Screening Levels.

[c] Screening values for PCDD/PCDFs were calculated using the TEF methodology presented in:
Van den Berg, et. al., 1998. Toxic Equivalency Factors for PCBs, PCDDs, PCDFs for Humans and Wildlife. Environ. Health Perspect. 106: 775-792.

[d] Talmage, et. al., 1999. Nitroaromatic Munition Compounds: Environmental Effects and Screening Values. Rev Environ Contam Toxicol 161:1-156.

[e] USEPA Region V Ecological Data Quality Levels (EDQL). Online. Based on the most conservative NOAELs for plants, earthworms, voles, and shrews.

[f] NOAA, 1999. Screening Quick Reference Tables. Freshwater chronic ambient water quality criteria.

[g] OSWER Ecotox Thresholds. Presented in: ECO Update, January, 1996. EPA 540/F-95/038.

[h] Lowest chronic value for all species tested. Referenced from:
Suter and Tsao, 1996. Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 1996 Revision.

[i] Talmage, et. al., 1999. Nitroaromatic Munition Compounds: Environmental Effects and Screening Values. Rev Environ Contam Toxicol 161:1-156.

[j] USEPA Region V Ecological Data Quality Levels (EDQL). Online. Based on the most conservative NOAELs for mink and kingfishers.

[k] NOAA, 1999. Screening Quick Reference Tables. Threshold Effects Level (TEL) for freshwater sediments.

[l] Barrick, R., S. Becker, L. Brown, H. Beller, and R. Pastorok, 1988. Sediment Quality Values Refinement: 1988 Update and Evaluation of Puget Sound AET. Vol. 1. Prepared for the Puget Sound Estuary Program, Office of Puget Sound.

[m] USEPA Region V Ecological Data Quality Levels (EDQL). Online. Based on the most conservative NOAELs for fish, birds, and mammals

environmental medium. A hazard quotient will be calculated by dividing the maximum detected constituent concentration in each environmental medium by its corresponding ESV as follows:

$$HQ_{screen} = \frac{MDCC}{ESV} \qquad \textbf{Eq.5-53}$$

where:

HQ_{screen}	=	screening-level hazard quotient;
$MDCC$	=	maximum detected constituent concentration; and
ESV	=	ecological screening value.

A calculated HQ_{screen} value of one indicates the MDCC is equal to the chemical's conservative ESV and will be interpreted as a constituent that does not pose the potential for adverse ecological risk. A HQ_{screen} value less than one indicates the MDCC is less than the conservative ESV, and that the chemical is not likely to pose adverse ecological hazards to most receptors. Conversely, a HQ_{screen} value greater than one indicates the MDCC is greater than the ESV and that the chemical might pose adverse ecological hazards to one or more receptors.

In order to better understand the potential risks posed by chemical constituents at various sites, a mean hazard quotient will also be calculated by comparing the arithmetic mean constituent concentration in each environmental medium to the corresponding ESV.

The USEPA recognizes several constituents in abiotic media that are necessary to maintain normal function in many organisms. These essential macro-nutrients are iron, magnesium, calcium, potassium, and sodium. Most organisms have mechanisms designed to regulate nutrient fluxes within their systems; therefore, these nutrients are generally only toxic at very high concentrations. Although iron is an essential nutrient and is regulated within many organisms, it may become increasingly bioavailable at lower pH values, thus increasing its potential to elicit adverse affects. Therefore, iron will not be evaluated as an essential nutrient in the SLERA process. Essential macro-nutrients will only be considered COPECs if they are present in site samples at concentrations ten times the naturally-occurring background concentration.

A study of the natural geochemical composition associated with FTMC (SAIC, 1998) determined the mean concentrations of 24 metals in surface soil, surface water, and sediment samples collected from presumably unimpacted areas. Per agreement with USEPA Region IV, the background threshold value (BTV) for each metal was calculated as two times the mean background concentration for that metal. The BTV for each metal is used to represent the upper boundary of the range of natural background concentrations expected at FTMC, and is used as the basis for evaluating metal concentrations measured in site samples in SI-level assessments.

In order to determine whether metals detected in site samples are the result of site-related activities or are indicative of naturally-occurring conditions, the maximum metal concentrations measured in site samples will be compared to their corresponding BTV. Site sample metal concentrations less than or equal to the corresponding BTV represent the natural geochemical composition of media at FTMC, and not contamination associated with site activity. Site sample metal concentrations greater than the corresponding BTV represent contaminants that may be the result of site-related activities and require further assessment. Comparison of maximum detected metals concentrations to BTVs will be completed for SI-level assessments. RI-level assessments will employ a more rigorous examination of naturally occurring background concentrations of metals.

In order to discern between naturally occurring background concentrations of metals and site-related metals in RI-level assessments, an integrated multi-step approach will be taken. The multi-step approach will consist of box-plots, the hot measurement test, and the non-parametric Wilcoxon rank sums (WRS) test, all of which will be performed in tandem as an initial screening step. Each analyte that fails one or both statistical tests will undergo geochemical evaluation. The purpose of the geochemical evaluation is to examine the site-related data within the context of natural elemental associations, geochemical indicators, and organic contaminants, as appropriate. Naturally high background levels of constituents can thus be differentiated from potentially contaminated samples. A detailed discussion of this integrated multi-step approach is presented in Section 4.5 of this report.

Thus, the first step in determining screening-level hazard quotients will be a comparison of maximum detected constituent concentrations to appropriate ESVs. Constituents with HQ_{screen} values less than one will be considered to pose insignificant ecological risk and will be eliminated from further consideration. Constituents with HQ_{screen} values greater than one will be eliminated from further consideration if they are identified as macro-nutrients. Those constituents that have HQ_{screen} values greater than one and are not considered macro-nutrients will then be compared to their corresponding BTVs in SI-level assessments or will undergo the integrated statistical and geochemical background assessment discussed in Section 4.5. If constituent concentrations are determined to be less than their naturally-occurring background concentration, then a risk management decision could result in eliminating these constituents from further assessment.

5.3.6 Identification of Constituents of Potential Ecological Concern (Step 2)

Constituents will be identified as COPECs if the following conditions are met:

- The maximum detected constituent concentration exceeds the ESV

- The constituent is not identified as a macro-nutrient

- The maximum detected constituent concentration exceeds the BTV for inorganics in SI-level assessments, or the integrated statistical and geochemical approach indicates an inorganic constituent is not naturally occurring in RI-level assessments.

If a constituent in a given environmental medium does not meet these conditions, then it is not considered a COPEC at the particular site in question and will not be considered for further assessment. If a constituent meets these conditions, then it will be considered a COPEC. Identification of a constituent as a COPEC indicates that further assessment of that particular constituent in a given environmental medium is appropriate. It does not imply that a particular constituent poses risk to ecological receptors.

5.3.7 Uncertainty Analysis (Step 2)

Uncertainties are inherent in any risk assessment, and even more so in a SLERA due to the nature of the assessment process and the assumptions used in the process. Because a SLERA is a screening-level assessment, a number of assumptions used in the process are biased to be conservative so as not to underestimate potential risks at the SLERA stage. The uncertainties in the assumptions used in the SLERA and how they affect the resultant risk estimates will be discussed qualitatively in the SLERA report.

5.3.8 Scientific Management Decision Point 1

The results of the SLERA will be used to determine whether to proceed with further ecological assessment at a given site or conclude that ecological risks are minimal and that no further ecological assessment is necessary. If, based on a risk management decision, the potential ecological risks at a given site are determined to be "unacceptable" at this screening-level stage, then a BERA will be conducted.

5.3.9 Baseline Ecological Risk Assessment (Steps 3 through 8)

If a baseline ecological risk assessment is deemed necessary at a given site, it will follow the procedures set forth in the EPA's Process Document (EPA, 1997d). The goals of the BERA, if deemed necessary, will be to reduce the levels of uncertainty and conservatism in the assessment process and to determine the potential for ecological risk at a given site through a number of lines-of-evidence.

In the event that risk assessors and risk managers decide that the assessment of a site or parcel should proceed to the BERA phase, assessment details and methods will be defined and documented in a Problem Formulation and Study Design Plan. This Plan will be submitted for review and comment by appropriate FTMC risk managers, State and Region 4 regulators, and stakeholders. No BERA activities will be initiated prior to approval of the Problem Formulation and Study Design plan. The structure of a typical BERA might include the following elements:

- ***Baseline Ecological Risk Assessment Problem Formulation***
  - Refinement of Constituents of Potential Ecological Concern
  - Literature Search on Known Ecological Effects
  - Refinement of Conceptual Site Model
    - Migration Mechanisms
    - Potential Receptors
    - Complete Exposure Pathways
    - Selection of Assessment Endpoints
  - Risk Questions
  - Scientific Management Decision Point

- ***Study Design and Data Quality Objective Process***
  - Establishing Measurement Endpoints
  - Study Design
  - Data Quality Objectives and Statistical Considerations
    - Contents of the BERA Work Plan and Sampling and Analysis Plan
    - Scientific Management Decision Point

- ***Field Verification of Sampling Design***
  - Sampling Feasibility
  - Scientific Management Decision Point

- ***Site Investigation and Analysis Phase***
  - Site Investigation
  - Analysis of Ecological Exposures and Effects
  - Scientific Management Decision Point

- ***Risk Characterization***
  - Risk Estimation
  - Risk Description
  - Uncertainty Analysis.

6.0 Feasibility Study Approaches

This chapter discusses both standard and focused feasibility study (FS) processes.

6.1 The Standard Feasibility Study Process

The objective of the FS will be to develop and evaluate potential remedial alternatives for FTMC sites to determine appropriate remedies that are protective of human health and the environment. The FS will be conducted in accordance with Section 300.430 of the National Oil and Hazardous Substances Pollution Contingency Plan. It will follow EPA guidance for conducting an RI/FS under CERCLA (EPA, 1988). The RI/FS guidance for preparing an FS follows nine steps:

- Develop remedial action objectives (RAO)
- Develop general response actions
- Identify volumes or areas of media to which response actions might be applied
- Identify and screen technologies
- Identify and evaluate technology process options
- Assemble selected representative processes into alternatives
- Evaluate the alternatives
- Compare the final alternatives.

During the RI, preliminary RAOs and general response actions, along with potential technologies, will be identified based on available knowledge of the sites and COC. Information from the RI will be used to refine the preliminary RAOs and develop specific remedial response actions.

6.1.1 Remedial Action Objectives

RAOs will be developed early in the RI/FS process. They are chemical-specific and medium-specific goals aimed at the protection of human health and the environment. RAOs will include COC, exposure routes, receptors, and acceptable contaminant levels. They are dependent on the identification of ARARs, as well as on the baseline risk assessment. A major objective of the RAOs is to protect human health to a cancer risk range of 10^{-6} to 10^{-4} for carcinogens and to meet a threshold dose limit for noncarcinogenic chemical toxicants. RAOs will be developed following specific guidance in the EPA Part B of the Risk Assessment Guidance for Superfund series (EPA, 1991b).

At FTMC, the RAOs will be considered on a site-specific basis and will be determined based on identified contaminants, exposure pathways and receptors, media of interest, and remedial action goals. The development of these RAOs will start with the refinement of the preliminary objectives outlined during the RI, with objectives being added or eliminated, as appropriate.

RAOs with regard to human receptors will concentrate on both the COC and the potential exposure pathways. The elimination of potential exposure pathways, as well as the reduction of contaminants, will be considered as viable alternatives for the protection of human health. Environmental concerns will be viewed more with respect to the medium of interest coupled with applicable target cleanup levels.

6.1.2 Identification and Screening of Remedial Technologies

The remedial technology identification and screening process will be used to: (1) provide a broad range of potential remedial technologies, (2) eliminate as early as possible those technologies that are not likely to meet RAOs, and (3) develop candidate alternatives that will likely meet defined objectives for detailed analysis. Remedial actions at Installation Restoration Program sites are required to meet state or federal standards, requirements, criteria, or limitations that are determined to be legally ARARs. The process will begin once the first phase of field data from the RI is received and will start with the development of RAOs.

6.1.2.1 General Response Actions

During the RI, the range of possible response actions initially being considered for the FTMC sites will be developed. The second step in the development and screening of remedial alternatives will consist of updating these following an evaluation of data gathered during the RI. The response actions will be revised by deleting those not capable of meeting the objectives, revising existing ones as necessary, and adding new ones as appropriate. Previous investigation results and the RI will be the primary mechanisms used to formulate an understanding of the individual sites and contaminants and to identify chemical-specific and location-specific ARARs. The general response actions will be evaluated on a medium-specific basis and on their capacity to address the RAOs either singularly or in combination with other responses. Once a response is determined not to be able to meet the set objectives, it will be deleted from the list to devote more resources to in-depth evaluation of those actions that are more promising. General response actions that are potentially applicable to FTMC sites have been identified. Although general response actions for individual sites must be evaluated under consideration of site-specific conditions, the following actions may be appropriate at FTMC:

- No action
- Institutional controls
- Containment
- Excavation/removal/disposal
- Treatment (ex situ and in situ).

The general response actions applicable to an individual site will be identified in the SFSP. Remedial technologies will be identified for each general response action, and one or more process options will be identified for each remedial technology (SAIC, 2000).

No Action. Under the no-action option, site conditions would vary only as a result of natural processes. Implementation of the no-action option at a site may be viable if the RAOs are met under current conditions, current and future human health and ecological risks are within acceptable criteria, and/or significant contaminant migration from the site is unlikely (SAIC, 2000).

Institutional Controls. Institutional controls consist of indirect actions that restrict current and/or future activity at a site. Access restrictions, frequently consisting of a chain-link fence enclosing a site, are often readily implemented and can eliminate exposure pathways. Increased reliability can be achieved when coupled with surveillance equipment and regular military patrols. Institutional controls may be appropriate when the site presents only low-level risks and there are no threats to human health or the environment outside of the site (SAIC, 2000).

Containment. Containment actions are those actions that significantly reduce or prevent the migration of contaminants from the source. Examples of containment methods are capping, including geosynthetic membranes, multimedia caps, and vegetative cover and storage such as surface impoundments, lagoons, and tanks. Containment may be appropriate when migration potential is already low or when there are minimal nearby receptors. Containment can also be appropriate as a short-term measure to reduce imminent threats until a long-term remedy can be put into place. Containment actions generally require long-term maintenance to ensure continued effectiveness. Monitoring may also be required to verify control of contaminant migration (SAIC, 2000).

Excavation, Removal, and Disposal. Removal and disposal of hazardous materials is performed extensively for site remediation. Treatment (see below) may be required prior to disposal. Excavation is a relatively simple process with defined procedures. It employs the use of bulldozers, front-end loaders, backhoes, and other earth-moving equipment to physically remove soil and buried materials. There are no absolute limitations on the types of waste that can be excavated and removed. However, worker health and safety must be protected. Other factors to be considered include the mobility of the wastes, the feasibility of on-site containment, and the cost of disposing the waste or rendering it nonhazardous once it has been excavated. A frequent practice at hazardous waste sites is to excavate and remove contaminant "hot spots" and to use other remedial measures for less contaminated soils.

Excavation and removal can almost totally eliminate the contamination (and the future liability) at a site and the need for long-term monitoring. The time to achieve beneficial results can be short, relative to such process options as in situ bioremediation.

Drawbacks associated with excavation include worker safety and cost. Where highly hazardous or unknown materials are present, excavation can pose a substantial risk to worker safety due to the generation of fugitive emissions.

Treatment. Treatment actions involve physical, chemical, thermal, or biological methods to reduce the volume, toxicity, or mobility of contaminants. Treatment can be conducted in situ or can be conducted on excavated materials. Treatment of excavated materials can be performed on site or at an off-site commercial treatment facility.

Numerous treatment technologies are currently in use, and many more are under development. Physical treatment methods include solidification/stabilization, mechanical aeration, oxidation technologies, soil flushing, soil vapor extraction, carbon adsorption, air stripping, and sedimentation reverse osmosis. Incineration and low-temperature thermal desorption are two examples of thermal treatment. Chemical treatment methods include in situ chemical oxidation, ion exchange, clarification, and metals precipitation. Examples of biological treatment include in situ biodegradation, composting/windrowing, soil slurry technology, and bioventing. Treatment costs are generally higher than containment costs, but treatment usually results in a greater reduction in contaminant toxicity and volume and greater long-term effectiveness.

6.1.2.2 Identification and Screening of Technology Types and Process Options

Once response actions are developed, potentially applicable technologies and process options will be identified and screened. The screening of technologies requires that the expected quantity of the media that will be affected by the various proposed remedial actions be assessed. This evaluation will be initiated once the first phase of RI data have been evaluated. The data for each media will be evaluated to determine if contamination has been sufficiently delineated. Data gaps will be defined at this point and the follow-up phase of the RI will be designed to fill these gaps. Any additional work conducted to fill identified data gaps will be completed in accordance with the requirements of this WP, and the SAP, SHP, SFSPs, and SSHPs. For the sites included in the FS, the areas and volumes of the media of concern will be evaluated as a function of the nature and extent of contamination, potential exposure pathways, acceptable exposure levels, and physical site conditions.

Once a reasonable estimate as to the volume of each medium of concern is determined, the identified technology types and process options will be screened. The preliminary list of technology types and process options identified during the RI will be modified in accordance with the initial results from the RI. For the purpose of the FS, general technologies are considered such as chemical treatment, barriers, physical treatment, stabilization, and biological treatment. Process options are methods within a given technology type such as neutralization, chemical oxidation, and photolysis under chemical treatment.

Preliminary screening of applicable technologies and process options will be conducted based on technical implementability, which refers to the feasibility of applying a particular technology type or process option to address the COC at the specific site. Those technologies and process options that cannot reasonably be implemented will be eliminated from further consideration.

Screening will be performed by the FS staff through technical consultation and support from professionals experienced in the various technologies that will be considered. These professionals may include chemists, biologists, toxicologists, geologists, hydrogeologists, and engineers with civil, mechanical, electrical, or chemical backgrounds.

A table will be prepared to summarize the results of the initial screening and identify why a process option is not retained.

The second screening will be a more detailed evaluation of those process options that passed the technical implementability criteria. One purpose of this step will be to determine a representative process for each of the different technology types to be considered for the later development and evaluation of remedial alternatives. This screening is intended to reduce the number of candidate process options, and thus allow more prudent expenditures of resources to perform in-depth studies of the most appropriate processes. During this step, the process options will be evaluated individually on the basis of: (1) short-term and long-term effectiveness, (2) implementability, and (3) relative cost.

Added emphasis at this time will be placed on the effectiveness of the process option, which will include, as appropriate:

- The effectiveness of handling the volumes/areas of media being considered with respect to the RAOs

- The possible impact to human health and the environment during construction and implementation

- The reliability of the process with regard to the type of contamination and site conditions.

Certain characteristics of the media, including physical and chemical parameters that are not related to contaminants at the site, may need to be measured to conclude whether a process will be technically effective.

Implementability will be addressed in more detail during the second screening. Both technical and administrative feasibility of implementing potential technologies will be considered at this point. An emphasis will be placed on administrative issues, which encompass such activities as the availability of services and materials, equipment and trained personnel, and off-site disposal facilities.

Cost evaluation for the remedial alternative development will concentrate on the relative cost of the different processes and technologies rather than actual costs, which will be determined during later stages of the FS process. Relative capital and operation and maintenance (O&M) costs will be considered. Cost will be categorized as high, average, or low, with respect to other processes being considered for the same action.

A summary table will be developed indicating which process options passed the second stage of screening and commenting on their observed effectiveness and implementability.

The RI will be the primary source for data to evaluate the effectiveness of potential processes. It may be necessary at this point in the FS to initiate additional RI tasks to acquire more specific data related to a particular process. Any additional RI tasks required at FTMC will be completed in accordance with the requirements of this WP, and the SAP, SHP, SFSPs, and SSHPs.

In the next stage of the FS process, one or more technology types will be combined as appropriate to develop remedial action alternatives. For the sites at FTMC, it is anticipated that a combination of technology types and corresponding process options will be required to meet the probable RAOs.

6.1.3 Development and Screening of Remedial Alternatives

Following the screening of technology types and process options on a medium specific basis, the general response actions will be combined to create site-wide remedial alternatives. Each alternative will be described as part of the FS report. After assembling alternatives, further refinements will be performed, as necessary, in consideration of the interaction among media of the different alternatives and for sitewide protective requirements. Screening of the alternatives will focus on the protection of human health and the environment for the site as a whole and take into consideration potential contaminant exposure pathways. If it is determined that a proposed alternative is not fully protective, risk levels for specific media may have to be further reduced to achieve acceptable risk levels for the site as a whole.

At this point in the FS, consideration will be given to refining the estimated volumes of contamination should it appear that one action (for one media) may directly affect other actions (for other media). Such would be the case of removing a source that had been leaching to the groundwater, thereby eliminating the potential for continued contamination and, in turn, reducing the level of contamination in the groundwater requiring remediation.

6.1.4 Detailed Analysis of Remedial Alternatives

A detailed analysis will be conducted for each of the remedial alternatives, including the "no-action" alternative, to provide a basis for selection of a preferred alternative for remediation. The evaluation will consist of technical, environmental, and cost evaluations, as well as an analysis of other factors as appropriate. Sufficient detail will be included to determine how each alternative addresses the following EPA evaluation criteria:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Short-term effectiveness
- Reduction of toxicity, mobility, and volume
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first seven criteria will be evaluated by the contractor during the FS; the final criteria, state and community acceptance, are addressed by FTMC with support from ADEM and EPA following the FS. Following the detailed analysis of each alternative, a comparative analysis between the alternatives will be performed. A brief description of each evaluation criterion follows.

6.1.4.1 Overall Protection of Human Health and the Environment

This criterion is used to assess the degree of protection to human health and the environment provided by an alternative. The evaluation should determine if the alternative achieves RAOs and explain how the alternative reduces, eliminates, and/or controls risks posed by each of the potential exposure pathways identified for the site. This criterion provides an overall assessment of protection based on a composite of factors such as long-term and short-term effectiveness and compliance with ARARs.

6.1.4.2 Compliance with ARARs

Compliance with ARARs will be used to assess how each alternative complies with federal and state ARARs as defined by CERCLA and as identified during the RI/FS process. As part of this evaluation, each alternative will be matched with specific requirements that are applicable or relevant and appropriate to the alternative. Sufficient detail will be provided to establish that the alternative meets the requirements. Chemical-specific, location-specific, and action-specific ARARs will be considered as required to ensure thorough compliance.

6.1.4.3 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence addresses the results of a remedial action in terms of the risk remaining at the site after the response objectives have been met. The primary focus of this evaluation will be to determine the extent and effectiveness of controls proposed to manage the risk posed by treatment residuals and/or untreated wastes. The factors to be evaluated include the magnitude of residual risk and the adequacy and reliability of controls. Residual risk will be evaluated in terms of numerical standards or volumes of residuals remaining at the site, as required. Adequacy and reliability of controls may include, as appropriate, the effectiveness of equipment, barriers, institutional measures, or other controls for achieving long-term protection.

6.1.4.4 Short-Term Effectiveness

Short-term effectiveness will address the impact of the alternatives during the construction and implementation phase. The time period considered will begin at the start of the remediation and continue until the remedial actions have been completed and the required levels of protection have been achieved. Each alternative will be evaluated with respect to community and on-site worker exposure during the remedial action, the environmental impacts resulting from implementation, and the amount of time until adequate protection is achieved.

6.1.4.5 Reduction of Toxicity, Mobility, and Volume

Reduction of toxicity, mobility, and volume will address the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the contaminants. The factors to be evaluated include the treatment process proposed and materials to be handled, the amount of hazardous material to be destroyed or treated, the degree of reduction expected in toxicity, mobility and volume, and the type and quantity of treatment residuals along with the associated risk.

6.1.4.6 Implementability

Implementability will focus on the technical and administrative feasibility of executing the potential alternatives and the availability of various services and materials required during implementation. The technical feasibility will be considered to assess construction and operational difficulties and unknowns, reliability of selected technologies, flexibility to undertake additional remedial action, if required, and the ability to monitor the effectiveness of the alternative. The administrative feasibility will be considered to define the activities needed to coordinate the implementation with federal, state, and local agencies in regards to obtaining permits and approvals.

6.1.4.7 Cost

Cost will be addressed with respect to the capital costs, annual O&M costs, and present-worth costs of the alternative. Capital costs will include direct costs and indirect costs. Direct costs considered will include expenditures for the equipment, labor, material, and disposal necessary to perform proposed remedial actions. Indirect costs will include expenditures for engineering, financial, permits, and other services that are not part of actual installation activities, but that will be required to implement the remedial alternatives.

Annual O&M costs that will be necessary for the continued and effective operation of the remedial action will also be considered. Costs such as operating labor, maintenance materials and labor, disposal of residuals, and associated administrative costs will be considered as appropriate.

A present-worth analysis will be used to normalize expenditures that occur over different time periods to a common base year. This will allow the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that will be sufficient to cover all costs associated with the remedial action over the anticipated life of the remediation. For FTMC, the present worth will be evaluated with respect to the current calendar year.

6.1.4.8 Regulatory Acceptance

Regulatory acceptance evaluates the technical and administrative issues with respect to the preferences and concerns that the State of Alabama and the EPA may have with regards to each alternative. This criterion will be used to weigh the alternatives as to the state's and EPA's preferences, reservations, or oppositions. The state's and EPA's views will be considered throughout the FS.

6.1.4.9 Community Acceptance

Community acceptance incorporates public concerns into the evaluation of the remedial alternatives. Like state acceptance, community acceptance will be monitored and considered throughout the FS.

The final phase in the evaluation of remedial alternatives will involve a comparison of various alternatives against each other. The advantages and disadvantages of each alternative will be reviewed relative to each of the first seven EPA evaluation criteria used in the previous detailed analyses of individual alternatives. For each criterion, the apparent best alternative will be identified first, with the other alternatives presented in order relative to this alternative.

6.1.5 Selection of Preferred Remedial Action Alternatives

Following the detailed analysis of remedial alternatives, a recommendation will be made as to the most appropriate remedial alternatives to be utilized. The most appropriate remedial action will be recommended for a specific site and medium of concern. Remedial synergy between sites and media will also be considered when making the recommendation and will potentially reduce the diversity of recommended remedial actions. Recommendations will be presented in text and tabular formats to facilitate their future utilization during development of the PP and ROD.

6.2 The Focused Feasibility Study Process

A focused feasibility study (FFS) provides a more streamlined approach to developing and evaluating potential remedial alternatives for FTMC sites. This approach provides a more time- and cost-efficient method of evaluating remedial alternatives over the standard FS approach, particularly at sites where the COPC are such that conventional proven technologies may be efficiently selected, evaluated, and implemented, based on historical performance information. The FFS approach has been used at other U.S. Department of Defense installations in a variety of ways. For the purposes of its application to FTMC, an FFS consists of the following elements:

- Identification of ARARs and RAOs
- Identification and screening of remedial technologies for alternative development
- Development and detailed analysis of selected RA alternatives
- Comparative analysis of preferred RA alternatives.

In its application to FTMC, the FFS differs from the standard FS in two significant ways. First, chemical-specific, location-specific, and action-specific ARARs will be established by FTMC using past experience and available data; therefore, a significant ARAR compilation task will not be necessary for the contractor to undertake. Compilation of ARARs under the standard FS process can be a significant effort, particularly for facilities with a wide variety of COPC. The preprepared list of chemical-specific, location-specific, and action-specific ARARs for FTMC will be supplied by the installation and augmented, where necessary, by the contractor for those COPC that are not present on the installation's list.

Second, the FFS differs from the standard FS in that the three most appropriate remedial alternatives will be selected for detailed analysis based on their successful implementation at FTMC and other installations/sites. This differs significantly from the standard FS approach in that the list of alternatives being evaluated is focused at the beginning of the process to select those alternatives most likely to successfully achieve the RAOs. No attempt is made under this approach to provide an exhaustive evaluation of all potential remedial alternatives that may be applicable to a given site and/or medium of concern. One of the three alternatives being evaluated during the detailed analysis portion of the FFS will consist of a no-action scenario.

6.2.1 ARARs and Remedial Action Objectives

Identification/compilation of ARARs and the development of RAOs comprise the initial steps of the FFS process. Since a list of ARARs will be supplied by the installation and will only be augmented, where necessary, by the contractor for those COPC that are not present on the installation's list, ARARs identification should comprise a minimal part of the FFS effort. This streamlined approach capitalizes on previously compiled ARARs and requires much less effort than the exhaustive ARARs compilation task conducted during a standard FS.

RAOs will be developed for each site being evaluated under the FFS process. They will be developed using the same methodology as used for a standard FS, where chemical-specific and medium-specific goals are derived that are aimed at the protection of human health and the environment. RAOs will include COC, exposure routes, receptors, and acceptable contaminant levels.

6.2.2 Selection of Remedial Technologies for Evaluation

The process of screening remedial technologies and specific alternatives within the FFS process is the single most significant variation from the standard FS approach. Using a standard FS approach requires a more exhaustive search and evaluation of a broader spectrum of potential remedial technologies and alternatives. Under the FFS, as applied to FTMC, the screening/ selection process is streamlined to quickly reduce the number of potential remedial technologies and alternatives to three. The three most appropriate remedial alternatives are selected for detailed analysis based on their successful implementation at FTMC and other installations/sites. No attempt is made under this approach to provide an exhaustive evaluation of all potential remedial alternatives that may be applicable to a given site and/or medium of concern. One of the three alternatives being evaluated in the FFS will consist of a no-action scenario. The focused suite of three remedial alternatives is then carried through into a more detailed evaluation using the same criteria as used in the detailed evaluation of a standard FS.

6.2.3 Detailed Analysis of Selected Remedial Action Alternatives

Following the screening of remedial technologies and remedial action alternatives (described in Section 6.2.2), the three most appropriate remedial action alternatives are selected for detailed analysis. Of the three chosen alternatives, one consists of a no-action scenario. Detailed analysis of alternatives is performed in the same manner as during a standard FS. The evaluation will consist of technical, environmental, and cost evaluations, as well as an analysis of other factors as appropriate. Sufficient detail will be included to determine how each alternative addresses the EPA's evaluation criteria. The nine evaluation criteria to be considered for each alternative are:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Short-term effectiveness
- Reduction of toxicity, mobility, and volume
- Implementability
- Cost
- State acceptance
- Community acceptance.

The first seven criteria will be evaluated by the contractor during the FFS; the final criteria, state and community acceptance, are addressed by the regulatory agencies following the FFS. Following the detailed analysis of each alternative, a comparative analysis between the alternatives will be performed. A brief description of each evaluation criterion is provided in Section 6.1.4.

6.2.4 Selection of Preferred Remedial Action Alternatives

Following the detailed analysis of remedial alternatives, a recommendation will be made as to the most appropriate remedial alternatives to be utilized. The most appropriate remedial action will be recommended for a specific site and medium of concern. Remedial synergy between sites and media will also be considered when making the recommendation and will potentially reduce the diversity of recommended remedial actions. Recommendations will be presented in text and tabular formats to facilitate their future utilization during development of the Proposed Plan (PP) and Record of Decision (ROD).

7.0 Proposed Plan and Record of Decision

Following the issuance of the RI/FS report(s), Proposed Plan (PP) and Record of Decision (ROD) documents will be prepared. The PP and ROD are documents that carry the preferred remedy from the FS into planning, discussion, and implementation. The following sections describe the content, objective, and format of these documents, as adopted from EPA guidance (1988).

7.1 Proposed Plan

The PP is designed to be a public participation document that will be widely available and read by the public. Therefore, it will be written concisely, using nontechnical language. Although several elements of both the RI and FS documents will be included in the PP, the PP will not be a primary source of detailed information.

7.1.1 Objective of the PP

The objectives of the PP are to:

- Identify the preferred alternative for a remedial action and explain the reasons for the preference

- Describe other remedial actions that were considered in the FS

- Seek public review and comment on all alternatives

- Provide the public with information on how to be involved in the selection process.

The PP will emphasize that the preferred alternative is only an initial recommendation that may be altered based on additional information or public concern/comment. The PP will serve to facilitate public comment on all remedial alternatives so that the most appropriate alternative is selected, and later documented in the ROD.

7.1.2 Content of the PP

The following topics will be included in the PP:

- Introduction
- Site background
- Scope and role of operable unit

- Summary of site risks
- Summary of alternatives
- Evaluation of alternatives and the preferred alternative
- Community participation.

The introduction provides information on the site name and location, and includes all parties involved in site activities, identifying the lead agency. The goal of the PP will be included in the introduction.

Site background includes a history of the site(s), waste disposal practices or incidents, COC, contaminated media, and the extent of contamination.

The scope and role of the site includes the scope of the problem that is being addressed, and describes how the remedial action addresses the major threats of the problem. Also, a brief history of each site under consideration will be included in this section so that the overall strategy and its sequencing for the entire site is in perspective.

The summary of site risks will be an abbreviated discussion of the baseline risk assessment that was developed in the RI report. At a minimum, the summary will include contaminants and impacted media, exposure pathways and populations, risks, and how the risks will be lowered as a result of the remedial action. Appropriate explanations will also be included so that the standard numeric presentations of risks are more clearly understood by the public.

The summary of alternatives section provides a brief narrative of the alternatives studied in the detailed analysis phase of the FS report. This discussion will include engineering and treatment components, costs, and schedules for implementation.

The evaluation of alternatives will clearly identify the preferred alternative and discuss how the evaluation criteria were used to identify the preferred alternative. Comparisons between the preferred alternative and other alternatives against the evaluation criteria will be included to highlight the major differences among them.

The community participation section will provide a notice of the public comment period, identify the time and place of a public meeting, and identify the location of the administrative record and other information repositories.

7.1.3 Format of the PP

The PP may be issued in an expanded format, or in a fact sheet format, similar to a community relations fact sheet. Section 7.1.2 pertains primarily to the expanded PP format that will be used in the case of a highly complex or controversial site. A fact sheet format will satisfy the statutory requirement for the plan and, because of its length, may be organized differently or discuss information in a different manner than the expanded format. Regardless of the format decided upon, the PP will be written so that the information is readily understood by the general public.

7.2 Record of Decision

The ROD pertains specifically to a site for which a final remedial action is planned that will definitively address the principal threats posed by the site. The components of a final-remedy ROD are the declaration, decision summary, and responsiveness summary.

7.2.1 Objective of the ROD

Preparation of a ROD serves to:

- Certify that the remedy selection process has been carried out according to the requirements of CERCLA

- Outline engineering components and remediation goals of the selected remedy

- Provide the public with a consolidated source of information about the history, characteristics, and risks posed by site conditions, as well as a summary of cleanup alternatives considered, their evaluation, and the rationale behind the selected remedy.

7.2.2 Content of the ROD

A ROD that documents the final remedy for a site will include a declaration, decision summary, and responsiveness summary. The declaration is an abstract for key information in the ROD and is the section that is signed by the EPA. The decision summary provides an overview of site characteristics, evaluated alternatives, and an analysis of those alternatives. The decision summary will also identify the selected remedy and provide an explanation as to how the remedy fulfills statutory requirements. The responsiveness summary will address public comments that were received on the RI/FS reports, PP, and other documents within the administrative record.

The declaration contains the site name and location, and includes a statement of basis and purpose, a brief assessment of the site, a brief overview of the selected remedy, and a signature page for approval by all appropriate agencies.

The decision summary provides an overview of site-specific factors and analyses that led to selection of the remedy. Information contained in this section of the ROD will provide more detailed information than the declaration. In general, the decision summary will include a history of the site, nature and extent of contamination, remedial alternatives that were evaluated, an analysis leading to the selected remedy, and an explanation of how the remedy satisfies statutory requirements.

Key elements of the decision summary section include a site description, history and enforcement activities, site characteristics, summary of site risks, description of alternatives, comparative analysis of alternatives, a description of the selected remedy, statutory determinations, and documentation of significant changes. The statutory determinations section will be a brief, site-specific description of how the selected remedy satisfies each of the statutory requirements, which include protection of human health and the environment, and compliance with ARARs. Documentation of significant changes will present the reasons for any significant changes to the selected remedy from the time the RI/FS and PP were released for public comment to the final selection of the remedy.

The responsiveness summary presents information about community preferences regarding both the remedial alternatives and concerns about the site, demonstrating how public comments have been integrated in the decision-making process. It will be a concise and complete summary of significant comments received from the public, including potentially responsible parties, and will be accompanied by responses by the lead agency.

8.0 Implementation of Remedial Actions

Based on the nature and extent of contamination, an interim remedial action/response action may be warranted at an individual site to control or abate and/or minimize the further spread of contamination where an actual or imminent threat to human health, welfare, and/or the environment exists. By expeditious actions, the extent and incident of continued environmental impact from existing releases will be significantly reduced. In the event of off-site contaminant migration, corrective actions may be appropriate to stop or slow the migration. A delay in implementing an interim remedial/corrective action could potentially result in increasing the threat to public health and/or the environment through the prolonged exposure to contaminants.

Remedial measures that may be considered at a site include source control, contaminated media cleanup, and/or limiting exposure to contamination. Remedial actions may include treatment, containment, excavation, extraction, disposal, institutional actions, or a combination of these methods.

Site-specific WP addenda to the SAP addressing remedial actions specific to the individual sites will be developed in accordance with CERCLA as amended, and will be consistent with the NCP. All interim remedial/corrective action activities will be performed in accordance with the procedures described in this installation-wide WP, SAP, SHP, and QAP. In addition, all sampling to confirm that the potential threat to human health, welfare, and/or the environment has been removed will be conducted in accordance with the SAP.

Following completion of remedial efforts, a report of field activity will be prepared and submitted to USACE. The report will detail corrective action activities and other pertinent information or occurrences, including such documentation as field notes, sample locations, analytical data, and waste profiles and manifests.

Removal Actions. Criteria for consideration of the removal action will include human and ecological risks, costs of removal and disposal, technical aspects of removal, and planned future site reuse.

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ATTACHMENT 1

LIST OF ABBREVIATIONS AND ACRONYMS

List of Abbreviations and Acronyms

2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic acid
2,4,5-TP	silvex
3D	3D International Environmental Group
AbD3	Anniston and Allen gravelly clay loams, 10 to 15 percent slopes, eroded
Abs	skin absorption
ABS	dermal absorption factor
AC	hydrogen cyanide
AcB2	Anniston and Allen gravelly loams, 2 to 6 percent slopes, eroded
AcC2	Anniston and Allen gravelly loams, 6 to 10 percent slopes, eroded
AcD2	Anniston and Allen gravelly loams, 10 to 15 percent slopes, eroded
AcE2	Anniston and Allen gravelly loams, 15 to 25 percent slopes, eroded
ACGIH	American Conference of Governmental Industrial Hygienists
ADEM	Alabama Department of Environmental Management
ADPH	Alabama Department of Public Health
AEC	U.S. Army Environmental Center
AEL	airborne exposure limit
AET	adverse effect threshold
AF	soil-to-skin adherence factor
AHA	ammunition holding area
AL	Alabama
ALAD	-aminolevulinic acid dehydratase
amb.	Amber
amsl	above mean sea level
ANAD	Anniston Army Depot
AOC	area of concern
APEC	areas of potential ecological concern
APT	armor-piercing tracer
ARAR	applicable or relevant and appropriate requirement
AREE	area requiring environmental evaluation
ASP	Ammunition Supply Point
ASR	Archives Search Report
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	all-terrain vehicle
AWARE	Associated Water and Air Resources Engineers, Inc.
AWWSB	Anniston Water Works and Sewer Board
'B'	Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero)
BCF	blank correction factor; bioconcentration factor
BCT	BRAC Cleanup Team
BERA	baseline ecological risk assessment
BEHP	bis(2-ethylhexyl)phthalate
BFB	bromofluorobenzene
BFE	base flood elevation
BG	Bacillus globigii
bgs	below ground surface
BHC	betahexachlorocyclohexane
BHHRA	baseline human health risk assessment
bkg	background
bls	below land surface
BOD	biological oxygen demand
Bp	soil-to-plant biotransfer factors
BRAC	Base Realignment and Closure
Braun	Braun Intertec Corporation
BSAF	biota-to-sediment accumulation factors
BSC	background screening criterion
BTAG	Biological Technical Assistance Group
BTEX	benzene, toluene, ethyl benzene, and xylenes
BTOC	below top of casing
BTV	background threshold value
BW	biological warfare; body weight
BZ	breathing zone; 3-quinuclidinyl benzilate
C	ceiling limit value
Ca	carcinogen
CAB	chemical warfare agent breakdown products
CAMU	corrective action management unit
CBR	chemical, biological and radiological
CCAL	continuing calibration
CCB	continuing calibration blank
CD	compact disc
CDTF	Chemical Defense Training Facility
CEHNC	U.S. Army Engineering and Support Center, Huntsville
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERFA	Community Environmental Response Facilitation Act
CESAS	Corps of Engineers South Atlantic Savannah
CG	carbonyl chloride (phosgene)
CF	conversion factor
CFC	chlorofluorocarbon
CFDP	Center for Domestic Preparedness
ch	inorganic clays of high plasticity
CHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
CK	cyanogen chloride
cl	inorganic clays of low to medium plasticity
Cl.	chlorinated
CLP	Contract Laboratory Program
CN	chloroacetophenone
CNB	chloroacetophenone, benzene, and carbon tetrachloride
CNS	chloroacetophenone, chloropicrin, and chloroform
Co-60	cobalt-60
CoA	Code of Alabama
COC	chain of custody; contaminant of concern
COE	Corps of Engineers
Con	skin or eye contact
COPC	chemical(s) of potential concern
COPEC	chemical(s) of potential ecological concern
CPSS	chemicals present in site samples
CQCSM	Contract Quality Control System Manager
CRL	certified reporting limit
CRZ	contamination reduction zone
Cs-137	cesium-137
CS	ortho-chlorobenzylidene-malononitrile
CSEM	conceptual site exposure model
CSM	conceptual site model
CT	central tendency
ctr.	container
CWA	chemical warfare agent
CWM	chemical warfare material; clear, wide mouth
CX	dichloroformoxime
'D'	duplicate; dilution
DAF	dilution-attenuation factor
DANC	decontamination agent, non-corrosive
°C	degrees Celsius
°F	degrees Fahrenheit
DCE	dichloroethene
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethene
DDT	dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DEP	depositional soil
DI	deionized
DID	data item description
DIMP	di-isopropylmethylphosphonate
DM	dry matter
DMBA	dimethylbenz(a)anthracene
DMMP	dimethylmethylphosphonate
DOD	U.S. Department of Defense
DOJ	U.S. Department of Justice
DOT	U.S. Department of Transportation
DP	direct-push
DPDO	Defense Property Disposal Office
DPT	direct-push technology
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
DRO	diesel range organics
DS	deep (subsurface) soil
DS2	Decontamination Solution Number 2
DWEL	drinking water equivalent level
E&E	Ecology and Environment, Inc.
EBS	environmental baseline survey
EC_{50}	effects concentration for 50 percent of a population
ECBC	Edgewood Chemical/Biological Command

ED	exposure duration
EF	exposure frequency
EDQL	ecological data quality level
EE/CA	engineering evaluation and cost analysis
Elev.	elevation
EM	electromagnetic
EMI	Environmental Management Inc.
EM31	Geonics Limited EM31 Terrain Conductivity Meter
EM61	Geonics Limited EM61 High-Resolution Metal Detector
EOD	explosive ordnance disposal
EODT	explosive ordnance disposal team
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
EPIC	Environmental Photographic Interpretation Center
EPRI	Electrical Power Research Institute
ER	equipment rinsate
ERA	ecological risk assessment
ER-L	effects range-low
ER-M	effects range-medium
ESE	Environmental Science and Engineering, Inc.
ESMP	Endangered Species Management Plan
ESN	Environmental Services Network, Inc.
ESV	ecological screening value
ET	exposure time
EU	exposure unit
Exp.	explosives
E-W	east to west
EZ	exclusion zone
FAR	Federal Acquisition Regulations
FB	field blank
FD	field duplicate
FDA	U.S. Food and Drug Administration
FedEx	Federal Express, Inc.
FEMA	Federal Emergency Management Agency
FFE	field flame expedient
FFS	focused feasibility study
FI	fraction of exposure
Fil	filtered
Flt	filtered
FMDC	Fort McClellan Development Commission
FML	flexible membrane liner
FMP 1300	Former Motor Pool 1300
FOMRA	Former Ordnance Motor Repair Area
Foster Wheeler	Foster Wheeler Environmental Corporation
Frtn	fraction
FS	field split; feasibility study
FSP	field sampling plan
ft	feet
ft/ft	feet per foot
FTA	Fire Training Area
FTMC	Fort McClellan
FTRRA	FTMC Reuse & Redevelopment Authority
g	gram
g/m^3	gram per cubic meter
G-856	Geometrics, Inc. G-856 magnetometer
G-858G	Geometrics, Inc. G-858G magnetic gradiometer
GAF	gastrointestinal absorption factor
gal	gallon
gal/min	gallons per minute
GB	sarin
gc	clay gravels; gravel-sand-clay mixtures
GC	gas chromatograph
GCL	geosynthetic clay liner
GC/MS	gas chromatograph/mass spectrometer
GCR	geosynthetic clay liner
GFAA	graphite furnace atomic absorption
GIS	Geographic Information System
gm	silty gravels; gravel-sand-silt mixtures
gp	poorly graded gravels; gravel-sand mixtures
gpm	gallons per minute
GPR	ground-penetrating radar
GPS	global positioning system
GS	ground scar
GSA	General Services Administration; Geologic Survey of Alabama
GSBP	Ground Scar Boiler Plant
GSSI	Geophysical Survey Systems, Inc.
GST	ground stain
GW	groundwater
gw	well-graded gravels; gravel-sand mixtures
HA	hand auger
HCl	hydrochloric acid
HD	distilled mustard
HDPE	high-density polyethylene
HEAST	Health Effects Assessment Summary Tables
Herb.	herbicides
HHRA	human health risk assessment
HI	hazard index
HNO_3	nitric acid
HQ	hazard quotient
HQ_{screen}	screening-level hazard quotient
hr	hour
H&S	health and safety
HSA	hollow-stem auger
HTRW	hazardous, toxic, and radioactive waste
'I'	out of control, data rejected due to low recovery
ICAL	initial calibration
ICB	initial calibration blank
ICP	inductively-coupled plasma
ICRP	International Commission on Radiological Protection
ICS	interference check sample
ID	inside diameter
IDL	instrument detection limit
IDLH	immediately dangerous to life or health
IDM	investigative-derived media
IDW	investigation-derived waste
IEUBK	Integrated Exposure Uptake Biokinetic
IF	ingestion factor; inhalation factor
ILCR	incremental lifetime cancer risk
IMPA	isopropylmethyl phosphonic acid
IMR	Iron Mountain Road
in.	inch
Ing	ingestion
Inh	inhalation
IP	ionization potential
IPS	International Pipe Standard
IR	ingestion rate
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information Service
IRP	Installation Restoration Program
ISCP	Installation Spill Contingency Plan
IT	IT Corporation
ITEMS	IT Environmental Management System ™
'J'	estimated concentration
JeB2	Jefferson gravelly fine sandy loam, 2 to 6 percent slopes, eroded
JeC2	Jefferson gravelly fine sandy loam, 6 to 10 percent slopes, eroded
JfB	Jefferson stony fine sandy loam, 0 to 10 percent slopes have strong slopes
JPA	Joint Powers Authority
K	conductivity
K_{ow}	octonal-water partition coefficient
L	lewisite; liter
LC_{50}	lethal concentration for 50 percent of population tested
LD_{50}	lethal dose for 50 percent of population tested
l	liter
LBP	lead-based paint
LCS	laboratory control sample
LC_{50}	lethal concentration for 50 percent population tested
LD_{50}	lethal dose for 50 percent population tested
LEL	lower explosive limit
LOAEL	lowest-observed-advserse-effects-level
LT	less than the certified reporting limit
LUC	land-use control
LUCAP	land-use control assurance plan
LUCIP	land-use control implementation plan
max	maximum

MCL	maximum contaminant level
MCPA	4-chloro-2-methylphenoxyacetic acid
MDC	maximum detected concentration
MDCC	maximum detected constituent concentration
MDL	method detection limit
mg	milligrams
mg/kg	milligrams per kilogram
mg/kg/day	milligram per kilogram per day
mg/kgbw/day	milligrams per kilogram of body weight per day
mg/L	milligrams per liter
mg/m^3	milligrams per cubic meter
mh	inorganic silts, micaceous or diatomaceous fine, sandy or silt soils
MHz	megahertz
µg/g	micrograms per gram
µg/kg	micrograms per kilogram
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter
min	minimum
MINICAMS	miniature continuous air monitoring system
ml	inorganic silts and very fine sands
mL	milliliter
mm	millimeter
MM	mounded material
MMBtu/hr	million Btu per hour
MOGAS	motor vehicle gasoline
MP	Military Police
MPA	methyl phosphonic acid
MPM	most probable munition
MR	molasses residue
MS	matrix spike
mS/cm	millisiemens per centimeter
MSD	matrix spike duplicate
MTBE	methyl tertiary butyl ether
msl	mean sea level
MtD3	Montevallo shaly, silty clay loam, 10 to 40 percent slopes , severely eroded
mV	millivolts
MW	monitoring well
Na	sodium
NA	not applicable; not available
NAD	North American Datum
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NAS	National Academy of Sciences
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NCRP	National Council on Radiation Protection and Measurements
ND	not detected
NE	no evidence; northeast
ne	not evaluated
NEW	net explosive weight
NFA	No Further Action
NG	National Guard
NGP	National Guardsperson
ng/L	nanograms per liter
NGVD	National Geodetic Vertical Datum
Ni	nickel
NIC	notice of intended change
NIOSH	National Institute for Occupational Safety and Health
NLM	National Library of Medicine
NPDES	National Pollutant Discharge Elimination System
NPW	net present worth
No.	number
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no-observed-adverse-effects-level
NR	not requested; not recorded; no risk
NRC	National Research Council
NRCC	National Research Council of Canada
NRHP	National Register of Historic Places
ns	nanosecond
N-S	north to south
NS	not surveyed
NSA	New South Associates, Inc.
nT	nanotesla
NTU	nephelometric turbidity unit
nv	not validated
O&G	oil and grease
O&M	operation and maintenance
OB/OD	open burning/open detonation
OD	outside diameter
OE	ordnance and explosives
oh	organic clays of medium to high plasticity
ol	organic silts and organic silty clays of low plasticity
OP	organophosphorus
ORP	oxidation-reduction potential
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OWS	oil/water separator
oz	ounce
PA	preliminary assessment
PAH	polynuclear aromatic hydrocarbon
Parsons	Parsons Engineering Science, Inc.
Pb	lead
PC	permeability coefficient
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxins
PCDF	polychlorinated dibenzofurans
PCE	perchloroethene
PCP	pentachlorophenol
PDS	Personnel Decontamination Station
PEF	particulate emission factor
PEL	permissible exposure limit
PES	potential explosive site
Pest.	pesticides
PETN	pentarey thritol tetranitrate
PFT	portable flamethrower
PG	professional geologist
PID	photoionization detector
PkA	Philo and Stendal soils local alluvium, 0 to 2 percent slopes
POL	petroleum, oils, and lubricants
POW	prisoner of war
PP	peristaltic pump; Proposed Plan
ppb	parts per billion
PPE	personal protective equipment
ppm	parts per million
PPMP	Print Plant Motor Pool
ppt	parts per thousand
PR	potential risk
PRG	preliminary remediation goal
PSSC	potential site-specific chemical
pt	peat or other highly organic silts
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAP	installation-wide quality assurance plan
QC	quality control
QST	QST Environmental, Inc.
qty	quantity
Qual	qualifier
'R'	rejected data; resample
R&A	relevant and appropriate
RAO	removal action objective
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RD	remedial design
RDX	cyclonite
ReB3	Rarden silty clay loams
REG	regular field sample
REL	recommended exposure limit
RFA	request for analysis
RfC	reference concentration
RfD	reference dose
RGO	remedial goal option
RI	remedial investigation
RL	reporting limit

RME	reasonable maximum exposure
ROD	Record of Decision
RPD	relative percent difference
RRF	relative response factor
RSD	relative standard deviation
RTECS	Registry of Toxic Effects of Chemical Substances
RTK	real-time kinematic
SA	exposed skin surface area
SAD	South Atlantic Division
SAE	Society of Automotive Engineers
SAIC	Science Applications International Corporation
SAP	installation-wide sampling and analysis plan
sc	clayey sands; sand-clay mixtures
Sch.	Schedule
SCM	site conceptual model
SD	sediment
SDG	sample delivery group
SDZ	safe distance zone; surface danger zone
SEMS	Southern Environmental Management & Specialties, Inc.
SF	cancer slope factor
SFSP	site-specific field sampling plan
SGF	standard grade fuels
SHP	installation-wide safety and health plan
SI	site investigation
SINA	Special Interest Natural Area
SL	standing liquid
SLERA	screening-level ecological risk assessment
sm	silty sands; sand-silt mixtures
SM	Serratia marcescens
SMDP	Scientific Management Decision Point
SOP	standard operating procedure
sp	poorly graded sands; gravelly sands
SP	submersible pump
SQRT	screening quick reference tables
Sr-90	strontium-90
SRA	streamlined human health risk assessment
Ss	stony rough land, sandstone series
SS	surface soil
SSC	site-specific chemical
SSHO	site safety and health officer
SSHP	site-specific safety and health plan
SSL	soil screening level
SSSL	site-specific screening level
SSSSL	site-specific soil screening level
STB	supertropical bleach
STC	source-term concentration
STEL	short-term exposure limit
STOLS	Surface Towed Ordnance Locator System®
Std. units	standard units
SU	standard unit
SUXOS	senior UXO supervisor
SVOC	semivolatile organic compound
SW	surface water
SW-846	U.S. EPA's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*
SWMU	solid waste management unit
SWPP	storm water pollution prevention plan
SZ	support zone
TAL	target analyte list
TAT	turn around time
TB	trip blank
TBC	to be considered
TCA	trichloroethane
TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
TCDF	tetrachlorodibenzofurans
TCE	trichloroethene
TCL	target compound list
TCLP	toxicity characteristic leaching procedure
TDEC	Tennessee Department of Environment and Conservation
TDGCL	thiodiglycol
TDGCLA	thiodiglycol chloroacetic acid
TERC	Total Environmental Restoration Contract
THI	target hazard index
TIC	tentatively identified compound
TLV	threshold limit value
TN	Tennessee
TNT	trinitrotoluene
TOC	top of casing; total organic carbon
TPH	total petroleum hydrocarbons
TR	target cancer risk
TRADOC	U.S. Army Training and Doctrine Command
TRPH	total recoverable petroleum hydrocarbons
TSCA	Toxic Substances Control Act
TSDF	treatment, storage, and disposal facility
TWA	time-weighted average
UCL	upper confidence limit
UCR	upper certified range
'U'	not detected above reporting limit
UF	uncertainty factor
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEC	U.S. Army Environmental Center
USAEHA	U.S. Army Environmental Hygiene Agency
USACMLS	U.S. Army Chemical School
USAMPS	U.S. Army Military Police School
USATCES	U.S. Army Technical Center for Explosive Safety
USATEU	U.S. Army Technical Escort Unit
USATHAMA	U.S. Army Toxic and Hazardous Material Agency
USC	United States Code
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTL	upper tolerance level; upper tolerance limit
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Supervisor
UXOSO	UXO safety officer
V	vanadium
VOA	volatile organic analyte
VOC	volatile organic compound
VOH	volatile organic hydrocarbon
VQlfr	validation qualifier
VQual	validation qualifier
VX	nerve agent (O-ethyl-S-[diisopropylaminoethyl]-methylphosphonothiolate)
WAC	Women's Army Corps
Weston	Roy F. Weston, Inc.
WP	installation-wide work plan
WRS	Wilcoxon rank sum
WS	watershed
WSA	Watershed Screening Assessment
WWI	World War I
WWII	World War II
XRF	x-ray fluorescence
yd^3	cubic yards

<u>SAIC – Data Qualifiers, Codes and Footnotes, 1995 Remedial Investigation</u>

N/A – Not analyzed

ND – Not detected

Boolean Codes

- LT – Less than the certified reporting limit

Flagging Codes

- 9 – Non-demonstrated/validated method performed for USAEC
- B – Analyte found in the method blank or QC blank
- C – Analysis was confirmed
- D – Duplicate analysis
- I – Interfaces in sample make quantitation and/or identification to be suspicious
- J – Value is estimated
- K – Reported results are affected by interfaces or high background
- N – Tentatively identified compound (match greater than 70%)
- Q – Sample interference obscured peak of interest
- R – Non-target compound analyzed for but not detected (GC/MS methods)
- S – Non-target compound analyzed for and detected (GC/MS methods)
- T – Non-target compound analyzed for but not detected (non GC/MS methods)
- U – Analysis in unconfirmed

Z – Non-target compound analyzed for and detected (non-GC/MS methods)

Qualifiers

J – The low-spike recovery is low

N – The high-spike recovery is low

R – Data is rejected