Installation Restoration Program

Draft Final Decision Document

FLW-035, Directorate of Engineering and Housing Used Transformer Area 2222, 2221

Fort Leonard Wood, Missouri

Prepared for:

US Army Corps of Engineers
Louisville District

Prepared by:

Conti and CH2MHILL

July 2010

STATEMENT OF TECHNICAL REVIEW

Performance Work Statement for Multi-Site Performance Based Contract, Installation Restoration Program, Fort Leonard Wood. MO

Draft Final Decision Document for
FLW-035, Directorate of Engineering and Housing Used Transformer Area 2222, 2221

The Conti/CH2M HILL Team has completed the technical review of the (Draft Final) submittal of the Decision Document for FLW-035, Directorate of Engineering and Housing Used Transformer Area 2222, 2221. Notice is hereby given that an independent technical review has been conducted that is appropriate to the level of risk and complexity inherent in the project, as defined in the Quality Control Plan. During the independent technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of assumptions; methods, procedures and material used in analyses; the appropriateness of data used and level of data obtained; and reasonableness of the results including whether the product meets the customer's needs consistent with the law and existing USACE policy.

Technical Reviewer	Signature	Date of Review
Catherine Barnett		7/12/2010

Quality Control System Manager (for QCP) or Project Manager	ITR Leader
Luis Seijido	Catherine Barnett
Signature	Signature
	

Draft Final Decision Document

FLW-035, Directorate of Engineering and Housing Used Transformer Area 2222, 2221 Fort Leonard Wood, Missouri

Prepared by

Conti and CH2MHILL

July 2010

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Acronyms and Abbreviations

CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DERP	Defense Environmental Restoration Program
DoD	Department of Defense
DTL	Default Target Level
ELCR	excess lifetime cancer risk
HI	hazard index
IRP	Installation Restoration Program
LOAEL	lowest observed adverse effect level
LUCs	land use controls
LUCIP	Land Use Control Implementation Plan
MDNR	Missouri Department of Natural Resources
mg/kg	milligrams per kilogram
MRBCA	Missouri Risk-based Corrective Action
NOAEL	no observed adverse effect level
PCB	polychlorinated biphenyl
PCOC	potential contaminant of concern
RBTL	Risk-Based Target Level
RCRA	Resource, Conservation, and Recovery Act
RFA	RCRA Facility Assessment
SARA	Superfund Amendments and Reauthorization Act
SWMU	solid waste management unit
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Decision Document Declaration

Site Name and Location

This decision document addresses FLW-035, Directorate of Engineering and Housing Used Transformer Area 2222, 2221 and a second area adjacent to Building 2224, approximately 200 feet to the southeast of Buildings 2222 and 2221, located at Fort Leonard Wood, Missouri.

Statement of Basis and Purpose

This decision document presents the selected remedy for FLW-035 at Fort Leonard Wood in Pulaski County, Missouri. The lead agency—the United States Army—and the Missouri Department of Natural Resources have worked together to select the remedy presented in this decision document. This decision document is based on the Administrative Record file for FLW-035, which is maintained at Fort Leonard Wood and available for public review.

Description of Selected Remedy

Because of potential risk to residents, the Army intends to establish land use controls (LUCs) prohibiting future residential land use within the northern and southern spill areas of FLW-035.

Authorizing Signatures

United States Army	Date

1. Introduction

This decision document summarizes the site management decision for FLW-035, Directorate of Engineering and Housing Used Transformer Area 2222, 2221 and a second area adjacent to Building 2224, approximately 200 feet to the southeast of Buildings 2222 and 2221, at Fort Leonard Wood, Missouri. This section provides a brief description of Fort Leonard Wood and presents the regulatory framework and risk-based screening levels for the subject site.

1.1 Installation Location and Description

Fort Leonard Wood is located in south-central Missouri and encompasses 62,910 acres (Figure 1-1). The installation is located in Pulaski County, with smaller portions in Texas and Laclede counties. Fort Leonard Wood is about 120 miles southwest of St. Louis, 85 miles northeast of Springfield, and 30 miles southwest of Rolla along Interstate 44.

Fort Leonard Wood lies near the center of the Houston-Rolla Ranger District of the Mark Twain National Forest. Fort Leonard Wood is surrounded by the national forest, except on its northern boundary. Land use in the area primarily consists of forestry and agriculture with intermittent, low-density commercial, industrial, and residential uses. Most of the commercial and residential areas are clustered near the interchanges along Interstate 44.

1.2 Regulatory Framework

1.2.1 Defense Environmental Restoration Program

In 1984, the United States Congress formally established the Defense Environmental Restoration Program (DERP) and codified it in Title 10 United States Code §2701 through §2707 and §2810. The DERP provides for the cleanup of Department of Defense (DoD) sites at active installations, Formerly Used Defense Sites, and Base Realignment and Closure sites (Department of the Army 2004). The statutory goals of DERP are:

- Take appropriate response actions to investigate and, where necessary, address releases of hazardous substances or pollutants and contaminants, and correct other environmental damage that creates an imminent and substantial endangerment to the public health or welfare, or to the environment
- Protect public safety through the demolition and removal of unsafe DoD buildings and structures, including those at sites formerly used by or under the jurisdiction of the Secretary of Defense (Office of the Under Secretary of Defense 2001)

Cleanup activities under DERP are consistent with the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA); the National Oil and Hazardous Substances Pollution Contingency Plan; and Executive Order 12580, Superfund Implementation.

SARA authorizes the Secretary of Defense to carry out the DERP. The Office of the Deputy Under Secretary of Defense for Installations and Environment establishes program goals and provides program management oversight. The Army, Navy, Air Force, and Defense Agencies manage individual transfer accounts that fund DERP activities. The Army transfer account is known as Environmental Restoration, Army.

DERP establishes three program categories to describe the types of environmental restoration activities that occur under the DERP framework. The program categories are:

- Installation Restoration Program (IRP)
- Military Munitions Response
- Building Demolition/Debris Removal

FLW-035 has been managed under the IRP program category, which refers to environmental responses (e.g., investigation and cleanup) associated with hazardous substances, pollutants, contaminants, and petroleum, oil, and lubricants (Department of the Army 2004). Figure 1-1 shows the location of FLW-035.

1.2.2 Fort Leonard Wood Installation Restoration Program

Fort Leonard Wood originally managed its environmental sites under a framework consistent with the Resource Conservation and Recovery Act of 1976 (RCRA). The United States Environmental Protection Agency (USEPA) performed a RCRA Facility Assessment (RFA) in 1991 and issued an RFA report in 1992. Sites identified in the RFA form the basis of the current IRP at Fort Leonard Wood.

The Army serves as the lead agency for the Fort Leonard Wood IRP, while the Missouri Department of Natural Resources (MDNR) acts as the lead agency for the state. Through a DoD State Memorandum of Agreement, the Army works with the MDNR to address sites covered under the IRP. The Federal Facilities Section of the MDNR coordinates all state agencies for sites covered under the IRP. Although Fort Leonard Wood is not a site on the National Priorities List, the installation follows the CERCLA process to move IRP sites through investigation, remedy selection, and remedy implementation.

Because Fort Leonard Wood originally followed a RCRA framework and shifted to CERCLA, IRP site names vary among historical documents. Many of the IRP site names were assigned solid waste management unit (SWMU) numbers in the 1992 RFA Report. The site names subsequently were given "FLW" designations.

1.3 Risk-based Screening Levels

Conservative screening levels were developed for FLW-035 using the Missouri Risk-Based Corrective Action (MRBCA) framework. Specifically, Default Target Levels (DTLs) provided a starting point for developing screening levels for soil, the medium that was investigated at FLW-035. Chemicals present at concentrations that exceed screening levels in one or more samples at FLW-035 were identified as preliminary chemicals of concern (PCOCs). Identified PCOCs are discussed in nature and extent (Section 3.4), fate and transport (Section 3.5), and are evaluated in human health and ecological assessments (Section 3.7).

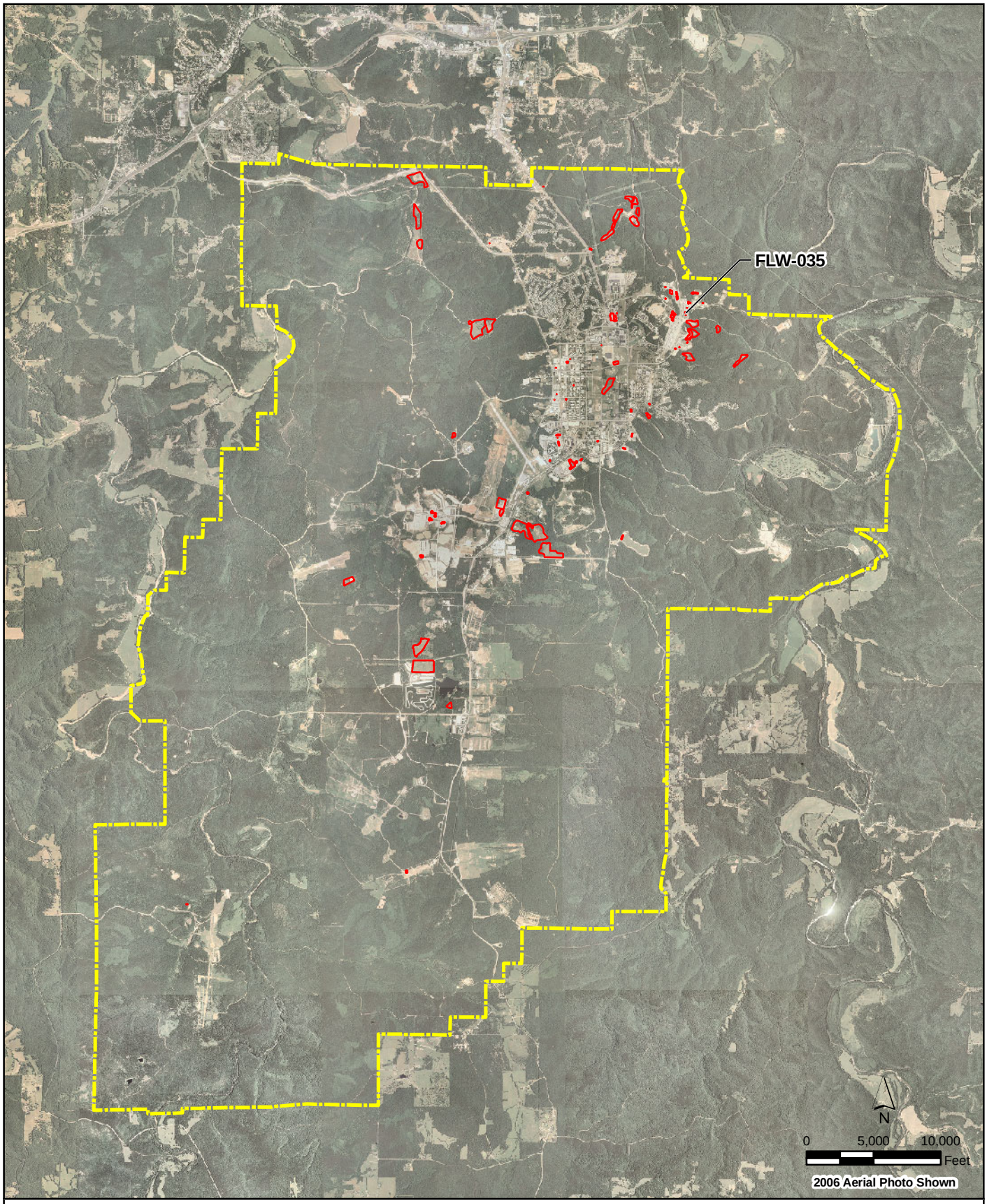
1.3.1 Adjusted Default Target Levels

In MRBCA, DTLs to protect the domestic use of groundwater are based on a 1×10^{-5} excess lifetime cancer risk (ELCR) level and on a noncancer hazard index (HI) of 1.0 for residential exposure to the chemicals. An ELCR of 1×10^{-5} is an upper-bounded estimate of the probability that one additional case of cancer will occur in 100,000 people over a 70-year lifetime as a result of individual exposure to the chemical. Aggregate exposures below an HI of 1.0 will likely not result in adverse noncancer health effects over a lifetime of exposure.

For screening level development on this project, DTLs in MRBCA were adjusted downward by a factor of 10 to reflect an ELCR of 1×10^{-6} and an HI of 0.1. As a conservative and consistent approach, the DTLs that are based on protection of groundwater were also adjusted downward by a factor of 10.

1.3.2 Screening Levels for Chemicals without Published DTLs

For chemicals without published DTLs, appropriate surrogate chemicals with DTLs were identified where possible and their DTLs were used. The values were adjusted downward by a factor of 10 to reflect an ELCR of 1×10^{-6} and an HI of 0.1.



Legend

- Installation Boundary
- IRP Site Boundary

Figure 1-1
Fort Leonard Wood Installation Map
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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2. Fort Leonard Wood Characteristics

2.1 Topography

Fort Leonard Wood is located within the Salem Plateau of the Ozark Plateaus Physiographic Province (U.S. Geological Survey [USGS] 2000). The area is characterized by rugged terrain of thin soils and narrow steep-walled valleys. Most of Fort Leonard Wood is located on a broad upland ridge between the northerly flowing Big Piney River to the east and the northerly flowing Roubidoux Creek to the west. Streams tributary to the Big Piney River and Roubidoux Creek drain the upland areas and are deeply incised into the sides of the ridges. Stream incision of nearly horizontal bedrock strata has produced a dendritic drainage pattern (USGS 2003).

Area relief generally is the result of gradual uplift of the Ozark Dome in southern Missouri and erosion of the uplifted rocks by precipitation runoff and stream flow. The regional ground surface elevation ranges from 1,150 feet above mean sea level along the central ridge to 750 feet at the Big Piney River near the northeastern corner of Fort Leonard Wood (USGS 1996).

2.2 Climate

Fort Leonard Wood has hot, humid summers and cold winters, receiving cold air moving south from Canada and warm, moist air moving north from the Gulf of Mexico, classifying its climate as continental. Annual temperatures range from below 0°F in winter to above 100°F in summer (Midwestern Regional Climate Center 2006). The estimated mean annual evapotranspiration for south-central Missouri is on the order of 30 inches (Hu et al. 2005).

2.3 Geology

Fort Leonard Wood lies on the western flank of the Ozark Uplift of Southern Missouri. The Ozark Uplift is part of a large Precambrian rhyolite-granite basement complex. Through a series of depositional and erosional cycles extending from Cambrian through Pennsylvanian time, progressively younger geologic formations crop out in roughly concentric rings around the core of Precambrian rocks (USGS 2000).

Bedrock exposed at Fort Leonard Wood is part of the Ozark Aquifer. The Ozark Aquifer was formed between late Cambrian and Ordovician time and consists of, in order of increasing age, the Cotter Dolomite, Jefferson City Dolomite, Roubidoux Formation, Gasconade Dolomite, Eminence Dolomite, and Potosi Dolomite. The Ozark Aquifer is underlain by the St. Francois confining unit and St. Francois aquifer. The St. Francois confining unit impedes the vertical movement of groundwater between the Ozark and St. Francois aquifers. The basement confining unit, which comprises Precambrian-age igneous and metamorphic rocks, underlies the St. Francois aquifer (USGS 2003).

The permeability of bedrock units within the Fort Leonard Wood area has been greatly increased through the dissolution of dolomitic bedrock units (USGS 1996). Karst features at

Fort Leonard Wood commonly are well-developed and include sinkholes, springs, losing streams, and caves (USGS 2000). These features are more common in the central and northern parts of the site, where the Roubidoux Formation and Gasconade Dolomite crop out.

2.4 Hydrogeology

The regional groundwater table generally occurs within the lower Roubidoux Formation or upper Gasconade Dolomite within the Fort Leonard Wood area (USGS 2000). Both geologic units are productive, water-bearing units with well yields ranging from several tens to several hundreds of gallons per minute. The underlying Potosi Dolomite is the most productive water-bearing unit in the Ozark Aquifer, with well yields ranging from several hundred to as much as 1,000 gallons per minute. The Gasconade Dolomite and Potosi Dolomite are separated by the Eminence Dolomite, which forms a weak hydraulic barrier between the two geologic units (USGS 1996).

Recharge to groundwater at Fort Leonard Wood occurs through percolation of rainfall through permeable residuum and bedrock. Groundwater flow patterns at Fort Leonard Wood are the result of a complex combination of diffuse flow through porous residual material and bedrock and conduit flow through solution-enlarged openings along bedding planes and interconnected fractures. Depths to groundwater may range from 130 to 300 feet below ground surface in the upland areas to less than 25 feet in the Big Piney River or Roubidoux Creek valleys (USGS 2000). Groundwater levels and groundwater flow directions are similar under conditions of high base flow and low base flow (USGS 1996).

A north-trending groundwater divide occurs in Fort Leonard Wood with groundwater flowing away from the uplands along the axis of this divide east towards Big Piney River or west towards Roubidoux Creek (Figure 2-1). Karst features alter the movement of groundwater from flow patterns commonly associated with rock of more uniform permeability. Lateral separation between the groundwater and topographic divides in the central and northern parts of Fort Leonard Wood (between Bloodland Lake and the north part of the cantonment area) indicate larger bedrock permeability in the east-central rather than the west-central part of the installation. Groundwater that would normally flow west to Roubidoux Creek has been captured by a zone of large secondary permeability and redirected east toward the Big Piney River. Vertical groundwater flow generally moves downward from the Gasconade Dolomite to Potosi Dolomite, but it may move upward in areas of highly permeable karst terrain where groundwater levels in the Roubidoux Formation and Gasconade Dolomite are lowered because of rapid flow of groundwater through conduits to nearby springs (USGS 1996).

Previous studies have identified a connection between sinkholes and losing streams located at Fort Leonard Wood with four known perennial springs including Miller Spring, Sandstone Spring, Roubidoux Spring, and Shanghai Spring. A recharge area for Roubidoux Spring has not been defined (USGS 1996). The boundary between the recharge basins of the other three springs may overlap with each other or encompass a larger area within or outside the installation boundary (Figure 2-2).

Shanghai Spring is located along the Big Piney River about 2.5 miles northeast of the northern installation boundary (USGS 2000). The spring lies within the Gasconade

Dolomite. The Shanghai Spring recharge basin is 27 square miles in area and encompasses a substantial part of the north-central and northeastern parts of Fort Leonard Wood. The estimated average base-flow discharge of Shanghai Spring is 18 cubic feet per second. Previous dye-trace tests have indicated a subsurface connection between losing streams within the Fort Leonard Wood/St. Robert area and Shanghai Spring. As a result of this connection, the water quality of the spring has been affected by activities within the town and military installation.

2.5 Receptors

2.5.1 Population and Land Use

Fort Leonard Wood comprises 62,910 acres of land, of which 58,436 acres are unimproved. Additionally, 9,700 acres of U.S. Forest Service land lie within its boundaries (Burns and McDonnell 1995). Fort Leonard Wood is bordered on the east, south, and west by the Houston-Rolla Ranger District of the Mark Twain National Forest, on the east by the Big Piney River, and on the west by Roubidoux Creek. On the north, the towns of Waynesville and St. Robert, with an estimated combined population of 6,200 (U.S. Census Bureau 2006), border the installation. As of May 2002, the Missouri Research Park indicates the average daily population as being more than 30,000 people.

Fort Leonard Wood has established a cantonment area in the north-central part of the installation. The area is highly developed and contains most of the buildings and structures within the facility. Areas outside the cantonment area are operational ranges for small arms training, vehicle maneuvers, heavy equipment training, aerial strafing, and bombardment training (CDM 2005).

2.5.2 Potable Water Supply

Although the Ozark Aquifer is used extensively for domestic and public water supply, Fort Leonard Wood obtains 98 percent of its drinking water from a pumping station on the Big Piney River near Sandstone Spring (Figure 2-3) (USGS 2003). Between 1993 and 1997, the average annual volume of water pumped from the river was 1,260,000,000 gallons.

A smaller quantity of groundwater is supplied from eight public water supply wells at Fort Leonard Wood (USGS 2003). A public water supply well, DW-015, also known as Indiana Avenue well, is located on the northern part of the installation and used only during peak demand. The remaining wells supply drinking water to training facilities scattered across the installation. Those wells provide a much smaller quantity of water than the DW-015. Pumping records are not maintained for these wells (USGS 2000).

2.5.3 Ecology

Fort Leonard Wood is situated in the Osage/Gasconade Hills section of the Ozark Highlands ecoregion of the Eastern Temperate Forest (Chapman et al. 2002) Major habitat types found on the site are forests, grasslands, and wetlands/riparian zones.

Twenty-five species of plants and animals known or suspected to inhabit Fort Leonard Wood are listed as species of concern. Table 2-1 summaries the listed species and their

federal and state listing status. Two federal-listed species have been recorded on Fort Leonard Wood: Indiana bat (*Myotis sodalis*) and gray bat (*M. grisescens*). The Indiana bat uses the caves of Fort Leonard Wood for winter hibernation. The current winter population on or adjacent to the installation is roughly 500 individuals (Fort Leonard Wood 2006). Gray bats are found throughout much of the southern half of Missouri. Fort Leonard Wood is near the center of the species range in Missouri. One maternity colony of gray bats inhabits Fort Leonard Wood.

Six rare plant species have been documented on Fort Leonard Wood. The only species currently federal- or state-listed is the narrowleaf rushfoil (*Crotonopsis linearis*), which has a state rank of S1 (critically imperiled in the state). Narrowleaf rushfoil has been identified only once—in 1932—on the western side of Roubidoux Creek, south of Cookville. Subsequent surveys have failed to detect any further occurrences (Fort Leonard Wood 2006).

TABLE 2-1
Threatened, Endangered, and Species of Conservation Concern of Fort Leonard Wood, Missouri
FLW-035 Decision Document, Fort Leonard Wood, Missouri

Common Name	Scientific Name	Federal Status [a]	State Status/ Rank [b]	FLW Habitat
Mammals				
Gray bat	*Myotis grisescens*	E	E	Saltpeter No. 3, Davis No. 2, Freeman, and Wolf Den caves
Indiana bat	*Myotis sodalis*	E	E	Brooks, Davis No. 2, Wolf Den, and Joy caves
Long-tailed weasel	*Mustela frenata*		S2	Brushy riparian areas
Eastern small-footed myotis	*Myotis leibii*		SU	Northwest Roubidoux Creek and Ballard Hollow
Golden mouse	*Ochrotomys nuttalli*		S3?	Brushy riparian areas
Northern myotis	*Myotis septentrionalis*		S3	Caves—winter; Trees/rock crevices—summer
Birds				
Bald eagle	*Haliaeetus leucocephalus*		E	Perch along Big Piney Riverand Roubidoux Creek
Brown creeper	*Certhia americana*		SU	Riparian areas
Cerulean warbler	*Dendroica cerulea*		S2S3	Riparian areas
Loggerhead shrike	*Lanius lodovicianus*		S2	Brushy old fields
Sharp-shinned hawk	*Accipiter striatus*		S2	Upland areas
Great egret	*Casmerodius albus*		S3	Big Piney River
Marsh wren	*Cistothorus palustris*		S3	Marshes, wet fields, and brush piles
Chestnut-sided warbler	*Dendroica pensylvanica*		S3	Woodland and forested areas
Osprey	*Pandion haliaetus*		SU	Big Piney River and Roubidoux Creek
Amphibians and Reptiles				
Grotto salamander	*Typhlotriton spelaeus*		S2S3	Martin and Henshaw Caves
Ringed salamander	*Ambystoma annulatum*		S3	Dry-mesic upland forests and foxholes on Range 12
Eastern hellbender	*Cryptobranchus*		E/S1	Big Piney River is marginal habitat
Bluestripe darter	*Percina cymatotaenia*		S2	Big Piney River/Roubidoux Creek, quiet pools and backwaters
Blacknose shiner	*Notropis heterolepis*		S2	The losing portion of Roubidoux Creek
Plains topminnow	*Fundulus sciadicus*		S3	Falls Hollow tributary and Big Piney River
Mooneye	*Hiodon tergisus*		S3	Big Piney River
Mussels				
Elktoe	*Alasmidonta marginata*		S2?	Roubidoux Creek
Spectaclecase	*Cumberlandia monodonta*		S3	Possibly in Big Piney River and Roubidoux Creek
Crustaceans				
Central Missouri cave amphipod	*Allocrangonyx hubrichti*		S1S2	Killman Cave

TABLE 2-1

Threatened, Endangered, and Species of Conservation Concern of Fort Leonard Wood, Missouri

FLW-035 Decision Document, Fort Leonard Wood, Missouri

Common Name	Scientific Name	Federal Status [a]	State Status/ Rank [b]	FLW Habitat
Plants				
Narrowleaf rushfoil	*Crotonopsis linearis*		S1	Roubidoux Creek

[a] Federal status:

E: Endangered. Endangered throughout range.

T: Threatened. Threatened throughout range.

[b] State status/rank (www.mdc.missouri.gov/nathis/endangered/index.htm):

E: Endangered. Survival of species in Missouri is in immediate jeopardy.

S1: Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state (typically 5 or fewer occurrences or very few remaining individuals).

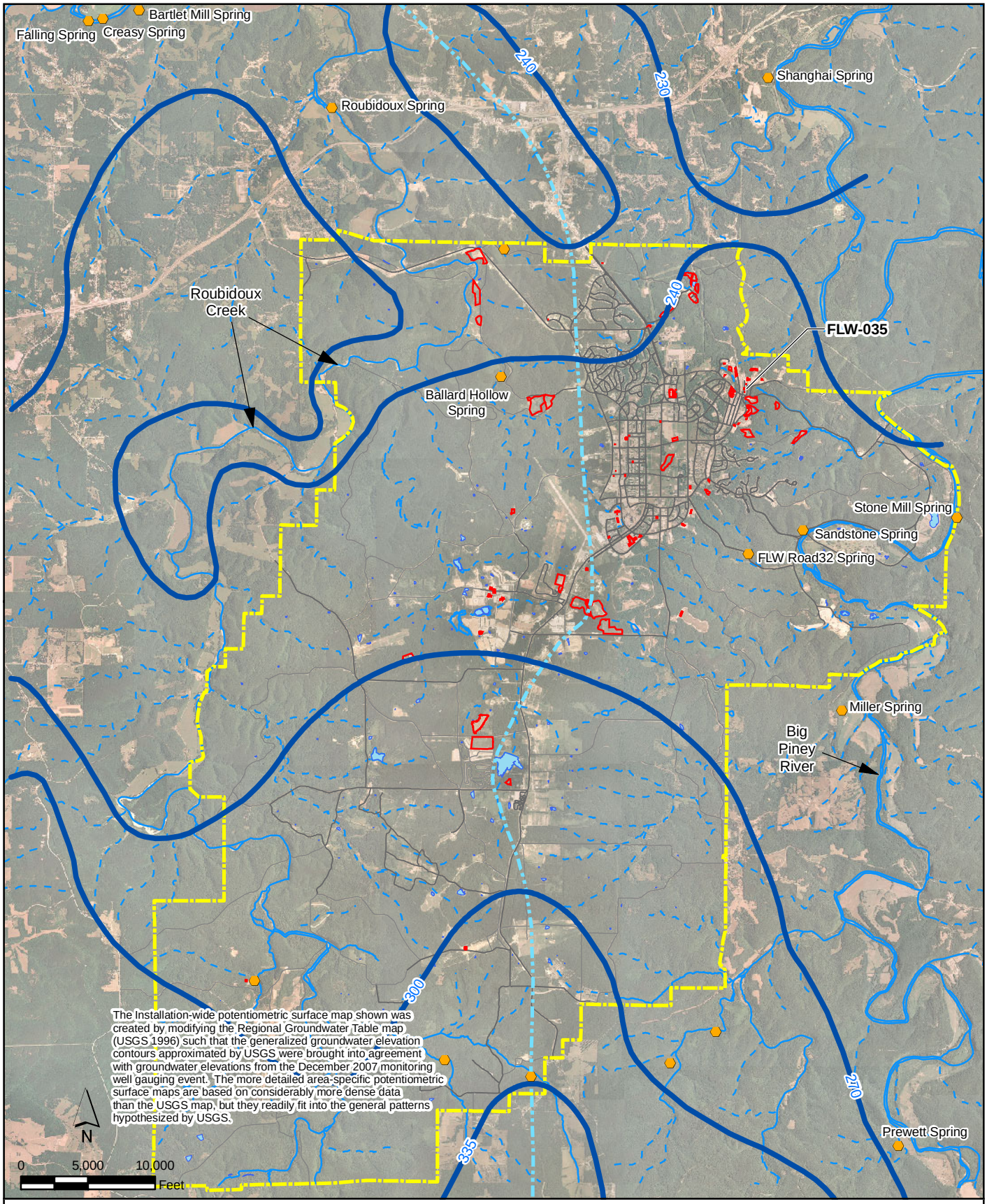
S2: Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state (6 to 20 occurrences or few remaining individuals or acres).

S3: Rare and uncommon in the state (21 to 100 occurrences).

SU: Unrankable, species is not yet ranked in the state.

SX: Extirpated, element is believed to be extirpated from the state.

?: (Qualifier) – Inexact or uncertain; for numeric ranks, denotes inexactness.



Legend

- Installation Boundary
- IRP Site Boundary
- Permanent Waterbody
- Primary Roads
- Secondary Roads
- Groundwater Divide
- Potentiometric Surface (meters)
- Ephemeral Stream
- Major River/Creek
- Spring

Figure 2-1
Regional Groundwater Table
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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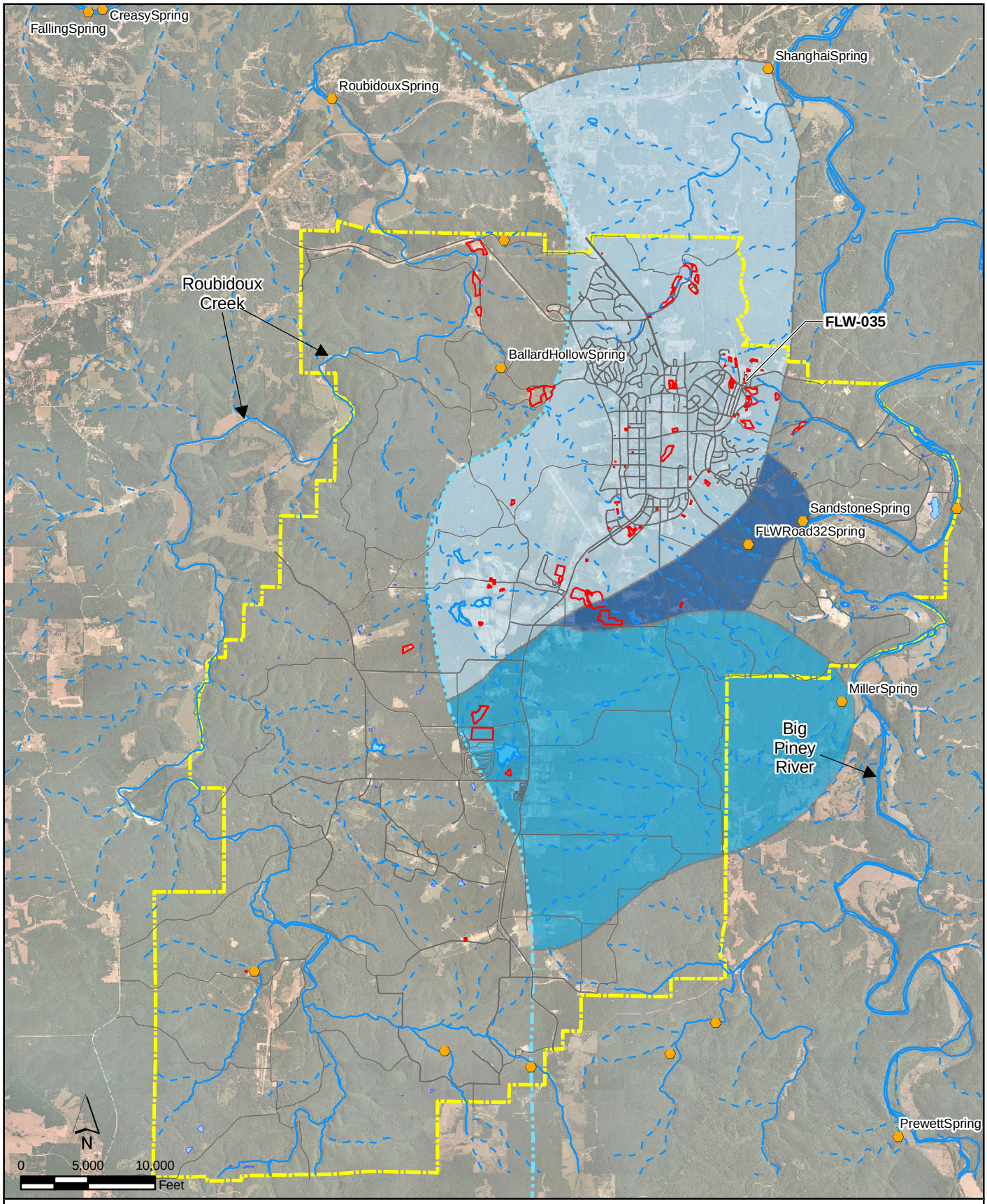

Legend

- Installation Boundary
- IRP Site Boundary
- Shanghai Spring Recharge Basin
- Miller Spring Recharge Basin
- Sandstone Spring Recharge Basin
- Permanent Waterbody
- Primary Roads
- Secondary Roads
- Ephemeral Stream
- Major River/Creek
- Groundwater Divide
- Spring

Figure 2-2
Spring Recharge Basins
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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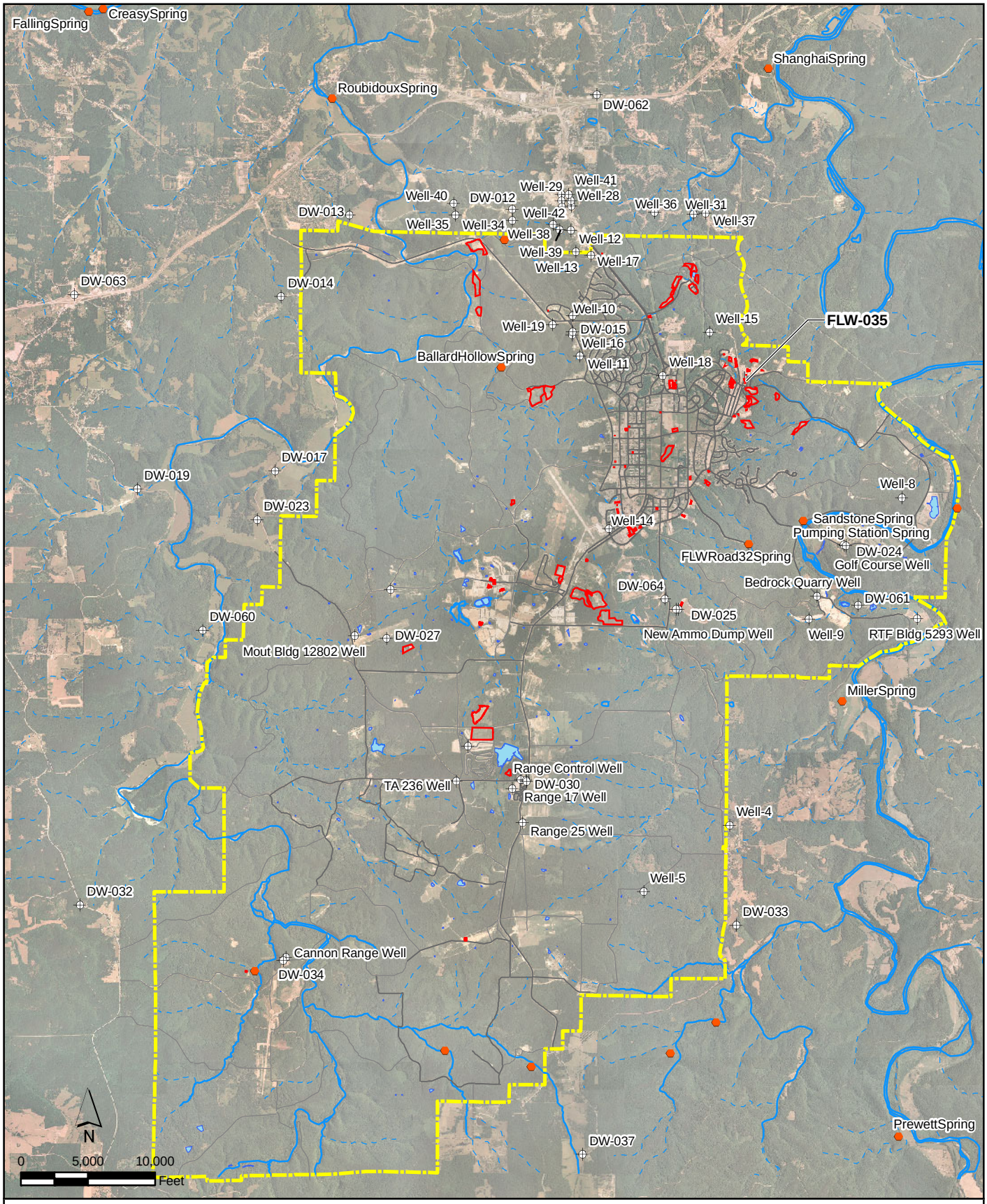

Legend

- Installation Boundary
- IRP Site Boundary
- Primary Roads
- Secondary Roads
- Permanent Waterbody
- Ephemeral Stream
- Perennial Stream
- Drinking Water Well
- Spring

Figure 2-3
Public and Domestic Water Supply Wells
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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3. Decision Summary for FLW-035

This section summarizes the selected remedy for FLW-035.

3.1 Site Name, Location, and Description

FLW-035 consists of two separate locations. One area is a loading dock located between Buildings 2221 and 2222, and the second area is behind Building 2224 (Figure 3-1). Both areas are inside the Directorate of Public Works yard, in the northeastern part of the post (Figure 3-1). Based on a review of historical records, FLW-035 first appeared as a site in the 1988 Interim Final Report (U.S. Army Environmental Hygiene Agency 1988). The site was designated SWMU-010 in a 1992 RFA Report (Black & Veatch 1992).

3.2 Site History and Enforcement Activities

3.2.1 Site Historical Operations

The transformer storage area, located on the loading dock between Buildings 2221 and 2222, is a 100- by 75-foot concrete pad that is not covered or surrounded by berms (Black & Veatch 1992). Transformers were stored in this area while waiting on testing to determine the presence of polychlorinated biphenyls (PCBs). This continued until the mid-1980s, when Building 2398, the PCB storage building, was put into use. During the time the area was used for transformer storage, a spill occurred at the warehouse dock. The exact location was not clearly described in historical documentation.

The second area, behind Building 2224, is a spill from Transformer 110 that occurred in October 1983 (Black & Veatch 1992). The spill was from the transformer used there. The transformer was located on a concrete pad, roughly 4 feet square, surrounded by a grassy area. The pad is still present.

3.2.2 Previous Remedial Actions

In October 1983, the affected areas from the two documented oil spills were cleaned with soap and water, and contaminated soil was remediated. Concrete blocks affected by the spill at the warehouse dock were also removed. There is no information available as to the depth or volume of soil removed during remediation activities. Soil samples and wipe samples were collected at both spill locations during the remedial action in October 1983. Analytical results from these samples are discussed in the following subsection.

3.2.3 Site Investigation Activities

Samples were collected at both spill location in 1983 and 2008. The sampling locations from the 1983 and 2008 investigations are shown on Figure 3-2. Investigation activities are discussed in the following subsections.

3.2.3.1 1983 Investigation Activities

After completing remedial actions in October 1983, the Army collected seven surface soil samples and two wipe samples from the spill locations. Samples were analyzed for PCBs.

3.2.3.2 2008 Investigation Activities

Based on the results 1983 investigation, further sampling was deemed necessary at FLW-035 to establish the LUC boundaries around each spill area. Samples were collected between August 4 and 6, 2008, and analyzed for PCBs, in accordance with the technical memorandum *Supplemental Investigation at FLW-035, Former Transformer Storage Area, Fort Leonard Wood, Missouri* (CH2M HILL 2008a). The additional samples were collected at locations where Aroclor-1254 exceeded the DTL of 1.1 mg/kg in the 1983 investigation samples collected from the two separate spill areas.

Five soil borings (SS-01, SS-02, SS-03, SS-04, and SS-05) were advanced in the northern spill area and logged continuously using direct-push technology sampling methods. Borings SS-01, SS-02, and SS-03 were advanced through asphalt and terminated roughly 6 inches under the bottom of the asphalt. Borings SS-04 and SS-05 were advanced through the concrete loading dock and terminated roughly 6 inches under the bottom of the concrete.

In the southern spill area, three soil borings (SS-06, SS-07, and SS-08) were advanced using a stainless steel hand-auger. The soil borings were advanced in grass-covered areas between Buildings 2224 and 2201. The borings were field-located with the use of a global positioning system. The borings were logged in accordance with the Unified Soil Classification System and screened the recovered soil cores for potential contamination (odor, discoloration, and elevated photoionization detector readings).

Soil samples were collected from 0 to 6 inches below either the asphalt or concrete in the northern spill area and from 0 to 6 inches below ground in the southern spill area. Engineered or fill material, including gravel, asphalt, and concrete, was excluded from the sample. Organic material, including surface vegetation and roots, was also excluded from the sample. The remaining soil was placed in a clean stainless steel bowl and homogenized, containerized, and shipped to the laboratory for analysis of PCBs by USEPA SW-846 Method 8082.

Step-out locations SS-09 through SS-17 were sampled in an alignment from the existing locations that exceeded DTLs. Step-out locations were sampled in case primary samples SS-01 through SS-08 yielded PCB concentrations exceeding DTLs. However, the samples were not analyzed since none of the primary samples yielded PCB concentrations exceeding DTLs.

3.2.4 Summary of Enforcement Actions

No enforcement actions have been taken at FLW-035. The Army has owned the property since 1941 and has been identified as the responsible party.

3.3 Site Geology and Hydrogeology

Site geology and hydrogeology are inferred from regional USGS maps and other publications. No site-specific subsurface data have been collected at FLW-035.

Unconsolidated materials beneath FLW-035 are of unknown thickness and are underlain by the Roubidoux Formation, which may be up to 100 feet thick. The Gasconade Dolomite, which lies beneath the Roubidoux Formation, may be up to 200 to 300 feet thick. No karst features are present in the immediate vicinity of the site.

The depth to regional groundwater beneath the site is estimated to be roughly 200 feet. Groundwater is present within the Gasconade Dolomite at a saturated thickness ranging from less than 10 to 100 feet. The site is located east of the groundwater divide (see Section 2.4) and within the Shanghai Spring recharge basin.

3.4 Nature and Extent of Site Contaminants

This section summarizes the nature and extent of contamination identified at FLW-035 from environmental investigations. As stated in Section 1, conservative screening levels were developed to identify PCOCs that may require further evaluation in a risk assessment, if the contaminants are associated with a release from the site.

3.4.1 Sample Results and Contaminant Selection

3.4.1.1 1983 Sample Results

In October 1983, seven soil samples and two wipe samples were analyzed for PCBs at two spill locations at FLW-035. Table 3-1 presents the analytical results for the samples. Chemicals with concentrations above screening levels were identified as PCOCs. Only one PCOC was identified: Aroclor-1254.

Four soil samples contained concentrations of the PCB Aroclor-1254 above the screening level of 0.110 milligrams per kilogram (mg/kg):

- Soil Sample 2 = 3.3 mg/kg
- Soil Sample 4 = 1.2 mg/kg
- Soil Sample 8 = 1.8 mg/kg
- Soil Sample 9 = 1.6 mg/kg

PCBs in wipe samples 6 and 7 were not measured at concentrations above the detection limit of 3 micrograms per square foot. Figure 3-2 shows the distribution of Aroclor-1254 detected in soil collected during the 1983 investigation.

3.4.1.2 2008 Sample Results

In the northern spill area, samples were needed to delineate the extent of the elevated concentrations observed in Soil Sample 8 and Soil Sample 9 collected in 1983, located northeast and southeast from the spill area designated by Wipe 7. In the southern spill area, additional samples were necessary to delineate the extent of the elevated concentrations to the north and east of the pad where the PCB release occurred. Sampling to the west of the former concrete pad, which is just south of Building 2224 was not necessary because the ground surface slopes up toward the east from the pad area.

The thickness of the asphalt encountered in the northern spill area at SS-01, SS-02, and SS-03 ranged from 12 to 20 inches. Concrete was 3 feet 5 inches thick at SS-04 and 3 inches thick at

SS-05, and underlain by 3 inches of gravel. SS-06, SS-07, and SS-08 were in grass-covered areas. Soil samples from SS-01 through SS-08 were analyzed for PCBs.

Table 3-2 presents the analytical results for the samples. None of the soil samples yielded PCB concentrations above residential Risk-Based Target Levels (RBTLs), so none of the step-out samples (SS-09 through SS-17) were analyzed.

3.5 Fate and Transport of Potential Contaminants

PCBs released to the environment are stable and slow to degrade. They persist because of the strong bond between the chlorine atom and the biphenyl structure that is characteristic of the individual PCB compounds. PCBs generally have a low solubility in water and do not readily dissolve. PCBs are highly adsorbable onto soil. This strongly limits the potential for PCBs to leach to groundwater. Given the relatively low concentrations of PCBs (less than 4 mg/kg) present in soil, the 200-foot depth to groundwater, and the minimal leachability of PCBs, migration to groundwater is not a pathway of concern. PCBs released to surface soil may migrate offsite through the transport of contaminated surface soils during precipitation runoff events, or through the windborne transport of PCB-contaminated surface soils.

3.6 Current Land and Resource Use

As noted, FLW-035 consists of two separate locations. One area is a loading dock between Buildings 2221 and 2222, the other is a concrete pad behind Building 2224. Adjacent to both areas are two buildings occupied by civilian personnel and contractors. The Army does not have plans to change the land use for the foreseeable future.

3.7 Summary of Site Risks

3.7.1 Human Health Risk Screening

An MRBCA Tier 1 risk assessment of FLW-035 was performed using the approach presented in the December 2007 Remedial Investigation Work Plan (CH2M HILL 2007). The risk assessment used the investigation results presented in Section 3.4. Tier 1 risk assessment findings are provided below.

3.7.1.1 Identification of Chemicals of Concern

One PCOC, the PCB Aroclor-1254, was identified in soil. This PCOC does not have a low frequency of detection, is not an essential nutrient, and has available toxicity data. Therefore, Aroclor-1254 was identified as the chemical of concern for the Tier 1 risk assessment.

3.7.1.2 Conceptual Exposure Model

FLW-035 consists of a concrete pad and a former concrete loading dock area. PCB-containing transformers once were present in both areas. Adjacent to the site are buildings occupied by civilian personnel and contractors. The current site use is expected to remain the same into the foreseeable future. Nonresidential land use and construction/excavation activities are

hypothetical future scenarios. Although the Army has no plans for future residential redevelopment of the site, the Tier 1 risk assessment also considered residential land use as a hypothetical future scenario.

Consistent with the current and reasonably foreseeable future land use, one type of onsite receptor was identified: post workers (civilian personnel and contractors) in the buildings adjacent to the site who may walk across the site when arriving at or leaving work each day. However, under future hypothetical development of the site and use of the site for residential purposes, future receptors would be construction workers and residents. The potential exposure scenarios and pathways associated with current and future site uses are described below and depicted in Figure 3-3. HHRA for the site addressed the exposure pathways.

Soil. Because the northern spill area is covered with concrete, there are no exposures to PCB residues in soil in that area. However, if construction workers breach the concrete pad during excavation work, they could be exposed to PCB residues in soil through incidental ingestion, dermal contact, and inhalation of outdoor air. If the concrete pad is removed from the site in the future and PCB residues are present in surface soil, hypothetical future residents and nonresidential workers could be exposed to PCBs in soil through incidental ingestion, dermal contact, and inhalation of outdoor air. Although unlikely, future receptors could also inhale PCBs in indoor air via vapor emissions from PCBs in soil.

The southern spill area is grass-covered around the concrete transformer pad, and PCB residues are present in surface soil. Hypothetical future residents and nonresidential workers could be exposed to the PCBs in the same manner as described above for the northern spill area.

Groundwater. Due to the chemical properties of PCBs, residual concentrations of Aroclor-1254 in soil are not expected to impact groundwater at the site.

3.7.1.3 Representative Concentrations

The maximum detected concentration of Aroclor-1254, regardless of sample depth, was identified and used in the comparison to RBTL and a target soil concentration protective of groundwater.

3.7.1.4 Risk-Based Target Levels

The predominant vadose zone soil type at the site is clayey. Initially, the Tier 1 RBTLs (adjusted to a target ELCR of 1×10^{-6} and a target HI of 0.1) were identified for residential and construction scenarios. In addition, the target soil concentration was identified for the protection of domestic use of groundwater.

The maximum detected concentration of Aroclor-1254 was compared to the adjusted Tier 1 RBTLs and target soil concentration protective of groundwater. The maximum detected concentration exceeded the adjusted RBTLs for residential and construction worker scenarios for ingestion, inhalation, and dermal contact of soil (Table 3-3). Therefore, the adjusted Tier 1 RBTLs were identified for nonresidential land use. However, the maximum detected concentration also exceeded the adjusted RBTL for nonresidential land use for ingestion, inhalation, and dermal contact of soil. The maximum detected concentration (3.3 mg/kg) also

exceeded the RBTL for the protection of domestic use of groundwater (2.42 mg/kg). Migration of Aroclor-1254 to groundwater is unlikely because of migration characteristics of the chemical and the depth of groundwater at roughly 200 feet below ground.

3.7.1.5 Cumulative Sitewide Risk

Maximum detected concentrations exceeded adjusted Tier 1 RBTLs for residential, nonresidential, and construction worker scenarios for ingestion, inhalation, and dermal contact of soil. Therefore, the cumulative sitewide ELCR or HQ was calculated for each scenario based on the ratio of the maximum detected concentration to the RBTL. As shown in Table 3-3, the following ELCRs or HIs were calculated:

- Residential: HI = 3
- Construction Worker: HI = 0.2
- Nonresidential: ELCR = 5×10^{-6}

According to MRBCA, the target ELCR is 1×10^{-5} for each chemical of concern and 1×10^{-4} for cumulative sitewide risk; in addition, the target cumulative HI is 1. Since there is only one chemical of concern at the site, 1×10^{-5} was used as the target ELCR and 1 was used as the target HI. As shown above, the construction worker and nonresidential scenarios meet the target HI and ELCR. However, the residential scenario HI of 3 exceeds the target HI of 1. For this reason, the Army intends to prohibit residential use of FLW-035, as described later in this document.

3.7.2 Ecological Risk Screening

Ecological risk screening was performed for FLW-035 in accordance with the Remedial Investigation Work Plan (CH2M HILL 2007). The following subsections present the findings of the screening effort.

3.7.2.1 Identification of Complete Exposure Pathways and Ecological Receptors

Figure 3-4 shows the potential exposures pathways and routes to ecological receptors at FLW-035 in the generalized ecological conceptual site model.

During site visits on October 18 and 19, 2006, Level 1 ecological checklists were completed at multiple IRP sites, including FLW-035. These correspond to Level 1 Checklists A and B in MRBCA Appendix F. Tables 3-4 and 3-5 present the results from the checklists. The results indicate that receptors and complete pathways are present at FLW-035. Based on the generalized conceptual site model, the ecological checklists, and site characteristics presented in Sections 3.4 and 3.5, the following are considered potential exposure media for ecological receptors:

- Air
- Surface soil
- Subsurface soil
- Perched groundwater

3.7.2.2 Comparison of Chemical Concentrations against Ecological Screening Values

In accordance with the Remedial Investigation Work Plan, chemical concentrations at FLW-035 were compared against MRBCA DTLs and supplemental ecological screening values corresponding to USEPA Region 5 ecological screening values (USEPA 2003). Aroclor-1254 was detected at concentrations above both the DTL and the supplemental screening values. Table 3-6 summarizes exceedances of supplemental ecological screening values. Exceedance ratios ranged from 1.5 to 9.9 times the ecological screening values. The average PCB concentration measured at FLW-035 exceeded the screening values by a factor of 4.0.

3.7.2.3 Evaluation of Potential Ecological Risks

The results of the ecological checklist and initial chemical screening indicate that additional ecological analysis may be required. Further analysis of the ecological exposure potential suggests that, although theoretically possible based on the checklist results, significant ecological exposure at site FLW-035 is unlikely. FLW-035 is a developed site, and although habitat is adjacent to the site, it is used for post operational purposes. Current activities at the site would limit its use by ecological receptors.

The nature of the release, a discrete spill, suggests that the potential area of exposure is also limited. The sampling that followed cleanup of the spill shows that the PCBs in soil exceed ecological screening levels. The exceedance ratios shown in Table 3-6 generally are low: 4.0 times the average PCB concentration.

The affected area is estimated to be 75 feet by 100 feet or 0.069 hectare. The home range for the short-tailed shrew is estimated to be 0.39 hectare (USEPA 1993). Given this, only 17 percent of the exposure to a short-tailed shrew is expected to be from the site. The white-footed mouse's home range is estimated to be 0.059 hectare (USEPA 1993), so it is possible that full exposure to an individual may come from the site. However, the white-footed mouse is an herbivore, and its exposure will be through plants. The estimated bioconcentration factor for total PCBs into terrestrial plants is 0.0068 (Travis and Arms 1988). Given this low bioconcentration factor, exposure through plants is expected to be minimal.

The estimated bioconcentration factor of 0.0068 reported by Travis and Arms (1988) represents the ratio between PCBs in terrestrial plant tissue and soil. A dietary exposure modeling approach was used to estimate the potential exposure from PCBs to a white-footed mouse at FLW-035. Dietary exposure was calculated using the mean PCB soil concentration of the seven samples collected from FLW-035. For sample locations with nondetected results, the reporting limit was used to calculate the mean soil concentration. Dietary exposure parameters used are provided in Table 3-7. An estimated dietary dose is provided in Table 3-8. That dose was compared to a dietary based toxicity values. A "no observed adverse effect level" (NOAEL), the highest dose at which no adverse effect was observed, and "lowest observed adverse effect level" (LOAEL), the lowest dose at which an adverse effect was observed were selected from a study by Hornshaw et al. (1983). In that study adverse reproductive effects (including reduced kit body weight, delay in the onset of estrus, and reduced whelping success) were observed in mink fed field-collected carp from the Great Lakes region over a chronic period (Hornshaw et al. 1983).

The estimated dose to a white-footed mouse at FLW-035 was compared to the NOAEL and LOAEL derived from the mink toxicity study. A hazard quotient was calculated as the ratio of the dose to the toxicity value. The results show no unacceptable risk to the white-footed mouse from exposure to PCBs in soil at FLW-035.

Terrestrial plants and soil invertebrates will experience exposure exclusively from the site; however, these receptor groups are not as sensitive to PCBs as vertebrates. The total PCB screening value is 40 mg/kg for terrestrial plants (Efroymson et al., 1997) and 500 mg/kg for terrestrial invertebrate communities (Parmelle et al., 1997).

Given the site characteristics, the size of the affected area at FLW-035, the sensitivity of selected receptor groups, the home range of key species, and the food habits and bioaccumulation potential in their primary food resources, significant ecological exposure is not expected, and further analysis is not warranted.

3.8 Selected Remedy

Due to the potential risk to residents, the Army intends to establish LUCs prohibiting future residential land use within the northern and southern spill areas of FLW-035. The Army is taking this approach because the risks associated with the current and reasonably forseeable future land use (nonresidential) are acceptable and do not warrant the preparation of a feasibility study to evaluate remedial alternatives. The approach to proceed directly from investigation to a decision document is consistent with the Final Community Involvement Plan for Fort Leonard Wood (CH2M HILL 2008b) and meets the requirements of CERCLA. As stated in Section 3 of the Community Involvement Plan, The Fort Leonard Wood Environmental Program follows a non-National Priorities List CERCLA process for its sites. As compared to the traditional CERCLA process, the non- National Priorities List CERCLA process can end at any one of the early steps with a decision document.

LUC boundaries will be placed around each spill area to designate the area in which PCBs exceed DTLs, which correspond to the lowest residential RBTLs (ingestion, inhalation, dermal contact) for all soil types published in MRBCA. Analytical results from the 1983 and 2008 investigations were used to delineate LUC boundaries around each FLW-035 spill area (Figure 3-5). LUCs at the site will prohibit residential reuse in areas where PCBs exceed DTLs.

Soil or concrete removed from the areas within the FLW-035 LUC boundaries will be tested and managed appropriately based on analytical laboratory results. If analytical results reveal PBC levels above DTLs, then the materials will be disposed of in accordance with state and federal regulations. If PCB concentrations do not exceed DTLs, then the materials will either be disposed of as construction debris or possibly reused for purposes such as backfill or riprap.

Following this decision document, a Land Use Control Implementation Plan (LUCIP) will be prepared to document the location and restrictions associated with LUCs at FLW-035, monitoring and reporting (i.e. inspections), notifications, and 5-year reviews. The following elements will be incorporated into a LUCIP for the site:

- The LUC boundaries encompassing the areas around each FLW-035 spill area (Figure 3-5) where PCB concentrations exceed DTLs will be documented in the Installation Master Plan.

- The area within the LUC boundaries will not be used for residential purposes.
- Before a land use can be changed from restricted (industrial) to unrestricted (residential), approval must be obtained from the Fort Leonard Wood DPW–Environmental and other appropriate Army personnel, in consultation with MDNR.
- The LUC boundary will be incorporated into the Installation Master Plan and the Army Environmental Database Restoration.
- In the unlikely event that the Army sells or transfers the property, the restrictions must be incorporated into real property documents necessary for transferring ownership from the Army to another party.

Subsequent to preparation of the LUCIP, a letter report will be prepared documenting the successful implementation of LUCs at FLW-035. The report will summarize the remedy presented in this decision document and will document that LUCs have been implemented in accordance with the LUCIP.

TABLE 3-1
1983 Investigation Soil and Wipe Analytical Results
FLW-035 Decision Document, Fort Leonard Wood, Missouri

		Site>>	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035
		Data Quality>>	Definitive	Definitive	Definitive	Definitive	Definitive	Definitive	Definitive	Definitive	Definitive
		Sample ID>>	FLW-035-Soil 1	FLW-035-Soil 2	FLW-035-Soil 3	FLW-035-Soil 4	FLW-035-Soil 5	FLW-035-Soil 8	FLW-035-Soil 9	FLW-035-Wipe 6	FLW-035-Wipe 7
		Sample Location>>	Soil 1	Soil 2	Soil 3	Soil 4	Soil 5	Soil 8	Soil 9	Wipe 6	Wipe 7
		Sample Date>>	11/1/1983	11/1/1983	11/1/1983	11/1/1983	11/1/1983	11/1/1983	11/1/1983	11/1/1983	11/1/1983
		Sample Depth>>	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
PCBs	**Unit**	**Screening Level**									
PCB (Aroclor-1254)	mg/kg	0.110	< 1[a]	**3.3**	< 1[a]	**1.2**	< 1[a]	**1.8**	**1.6**	NS	NS
PCB (Aroclor-1254)	µg/ft^2	—	NS	NS	NS	NS	NS	NS	NS	< 3	< 3

Note:
Bold indicates a detected concentration above the method detection limit.
Bold on gray shading indicates a detected concentration above the screening level.
[a] reporting limit is above the screening level.
— = screening level not available for this chemical.
< = Chemical not detected above the method detection limit.
NS = not sampled.
mg/kg = milligrams per kilogram
µg/ft^2 = micrograms per square foot

TABLE 3-2

2008 Supplemental Investigation Soil Analytical Results

FLW-035 Decision Document, Fort Leonard Wood, Missouri

		Site>>	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035	FLW-035
		Sample Location>>	FLW035-SS01	FLW035-SS02	FLW035-SS03	FLW035-SS04	FLW035-SS05	FLW035-SS06	FLW035-SS06	FLW035-SS07	FLW035-SS08
		Sample ID>>	035-SS-01-0_0	035-SS-02-0_0	035-SS-03-0_0	035-SS-04-0_0	035-SS-05-0_0	035-SS-06-0_0	035-SS-06-0_0FD	035-SS-07-0_0	035-SS-08-0_0
		Sample Depth (ft)>>	0–0.5	0–0.5	0–0.5	0–0.5	0–0.5	0–0.5	0–0.5	0–0.5	0–0.5
		Sample Date>>	8/5/2008	8/5/2008	8/5/2008	8/4/2008	8/5/2008	8/6/2008	8/6/2008	8/6/2008	8/5/2008
PCBs	Units	Residential RBTL									
Aroclor-1016	mg/kg	3.86	< 0.0057	< 0.0059	< 0.0061	< 0.0059	< 0.012	< 0.0064	< 0.0065	< 0.0061	< 0.0054
Aroclor-1221	mg/kg	0.0975	< 0.012	< 0.012	< 0.013	< 0.012	< 0.025	< 0.013	< 0.014	< 0.013	< 0.011
Aroclor-1232	mg/kg	0.0557	< 0.0057	< 0.0059	< 0.0062	< 0.006	< 0.012	< 0.0065	< 0.0065	< 0.0062	< 0.0054
Aroclor-1242	mg/kg	0.0557	< 0.010	< 0.010	< 0.011	< 0.011	< 0.022	< 0.012	< 0.012	< 0.011	< 0.0096
Aroclor-1248	mg/kg	1.08	< 0.0038	< 0.0039	< 0.0041	< 0.004	< 0.0081	< 0.0043	< 0.0043	< 0.0041	< 0.0036
Aroclor-1254	mg/kg	1.1	< 0.0044	< 0.0046	< 0.0048	< 0.0046	< 0.0094	< 0.005	< 0.0051	< 0.0048	< 0.0042
Aroclor-1260	mg/kg	1.11	< 0.003	< 0.003	< 0.0032	< 0.0031	**0.65**	< 0.0033	< 0.0034	< 0.0032	< 0.0028
Aroclor-1262	mg/kg	0.0557	< 0.012	< 0.013	< 0.014	< 0.013	< 0.013	< 0.014	< 0.014	< 0.013	< 0.012
Aroclor-1268	mg/kg	0.0557	< 0.0044	< 0.0045	< 0.0048	< 0.0046	< 0.0094	< 0.005	< 0.005	< 0.0047	< 0.0042
Percent Moisture			10	13	17	14	16	21	22	17	5

Note:

Bold indicates a detected concentration above the method detection limit.

Published RBTLs are presented in MRBCA for Aroclor-1232, 1262, and 1268. Therefore the RBTL for Aroclor-1242 was used as a surrogate.

< = Chemical not detected above the method detection limit.

mg/kg = milligrams per kilogram

TABLE 3-3
Tier 1 Risk Evaluation
FLW-035 Decision Document, Fort Leonard Wood, Missouri

		Adjusted Tier 1 Risk-Based Target Levels Soil Type 3 (Clayey) [a]													
		Residential Land Use				**Construction Worker**				**Non-Residential Land Use**				**GW Protection**	
Chemical	Maximum Detected Conc.	Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact	C/NC	Exceed Adj. Tier 1 RBTL?	Adjusted HI Ratio	Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact	C/NC	Exceed Adj. Tier 1 RBTL?	Adjusted HI Ratio	Ingestion, Inhalation (Vapor Emissions and Particulates), and Dermal Contact	C/NC	Exceed Adj. Tier 1 RBTL?	Adj. ELCR Ratio	Value	Exceed Tier 1 RBTL?
PCB (Aroclor-1254)	3.3	1.11E-01	NC	Yes	29.7	1.90E+00	NC	Yes	1.7	7.29E-01	C	Yes	4.5	2.42E+00	Yes
			Total HI[b] =		3		**Total HI[b] =**		0.2		**Total ELCR[c] =**		5E-06		

		Adjusted Tier 1 Risk-Based Target Levels Soil Type 3 (Clayey) †											
		Residential Land Use				**Construction Worker**				**Industrial Worker**			
Chemical	Maximum Detected Conc.	Indoor Inhalation of Vapor Emissions	C/NC	Exceed Adj. Tier 1 RBTL?	Adjusted HI Ratio	Indoor Inhalation of Vapor Emissions	C/NC	Exceed Adj. Tier 1 RBTL?	Adjusted Ratio	Indoor Inhalation of Vapor Emissions	C/NC	Exceed Adj. Tier 1 RBTL?	Adj. ELCR Ratio
PCB (Aroclor-1254)	3.3	1.13E+02	NC	No	—	—	—	—	—	6.37E+02	C	No	—

Note:
[a] Based on ELCR = 1 x 10^{-6} and HQ = 0.1.
[b] Target HI for single chemical = 1.0.
[c] Target ELCR for single chemical = 1 x 10^{-5}.
Lab Method USGS-PCB.
CAS #11097-69-1.
Adj. HI ratio = (Maximum detected concentration) / (Adjusted Tier 1 RBTL)
Total HI = (Adjusted HI ratio) / 10.
Adj ELCR ratio = (Maximum detected concentration) / (Adjusted Tier 1 RBTL)
Total ELCR = (Adj. ELCR Ratio) x 10^{-6}

TABLE 3-4
Results of MRBCA Ecological Risk Assessment Level 1, Checklist A
FLW-035 Decision Document, Fort Leonard Wood, Missouri

Checklist Question	
Is the boundary of the contaminated area less than ½ mile to a surface waterbody (stream, river, pond, lake, etc.)?	No
Are wetlands (as defined by the 1987 Corps of Engineers' Delineation Manual) on or adjacent to the site?	No
Are contaminated soils uncovered or otherwise accessible to ecological receptors and the elements?	Yes
Are there karstic features (see Ecological Risk Assessment Figure #2 for definition) on or within ½ mile of the boundary of the contaminated area?	No
Are there federal or state rare, threatened, or endangered species on or within ½ mile of the contaminated area?	Potential
Are there one or more environmentally sensitive areas (see Ecological Risk Assessment Figure #1 for definition) at or within ½ mile of the contaminated area?	Yes
Are commercially or recreationally important species (fauna or flora) on or within ½ mile of the contaminated area?	Yes

TABLE 3-5

Results of MRBCA Ecological Risk Assessment Level 1, Checklist B

FLW-035 Decision Document, Fort Leonard Wood, Missouri

Checklist Questions	
Question 1: Could contaminants associated with the site reach ecological receptors through groundwater?	
1.a.) Can contaminants associated with the site leach, dissolve, or otherwise migrate to groundwater?	Yes
1.b.) Are contaminants associated with the site mobile in groundwater?	Yes
1.c.) Does groundwater from the site discharge to ecological receptor habitat?	Yes
Question 2: Could contaminants from the site reach ecological receptors through migration of NAPL?	No
2.a.) Is Non Aqueous Phase Liquid (NAPL) present at the site?	
2.b.) Is NAPL migrating?	
2.c.) Could NAPL discharge occur where ecological receptors are found?	
Question 3: Could contaminants reach ecological receptors through erosional transport of contaminated soils or through precipitation runoff?	
3.a.) Are contaminants present in surface soils?	Yes
3.b.) Can contaminants be leached from or be transported by erosion of surface soils?	Yes
Question 4: Could contaminants reach ecological receptors through direct contact?	
4.a.) Are contaminants present in surface soil or on the surface of the ground?	Yes
4.b.) Are potential ecological receptors on the site?	Yes
Question 5: Could contaminants reach ecological receptors through inhalation of volatilized contaminants or contaminants adhered to dust in ambient air or in subsurface burrows?	
5.a.) Are contaminants present on the site volatile?	Potential
5.b.) Could contaminants on the site be transported in air as dust or particulate matter?	Yes
Question 6: Could contaminants reach ecological receptors through direct ingestion of soil, plants, animals or contaminants?	
6.a.) Are contaminants present in surface and shallow subsurface soils or on the surface of the ground?	Yes
6.b.) Are contaminants found in soil on the site taken up by plants growing on the site?	Yes
6.c.) Do potential ecological receptors on or near the site feed on plants (e.g., grasses, shrubs, forbs, trees, etc.) found on the site?	Yes
6.d.) Do contaminants found on the site bioaccumulate?	Potential
Question 7: Could contaminants reach ecological receptors through transport through a karst system?	
7.a.) Are there karstic features (see Ecological Risk Assessment Figure #2 for definition) on or within ½ mile of the contaminated area?	Yes
7.b.) Is there a hydrogeological connection between the site and karstic features such as seeps, springs, streams or other surface water bodies?	Yes

TABLE 3-6

Comparison of Aroclor-1254 Concentrations in Historical Soil Data at FLW-035 to Supplemental Ecological Screening Levels

FLW-035 Decision Document, Fort Leonard Wood, Missouri

Sample Location	Reported Concentration			Concentration used for Screening[a]	Ecological Screening Value	Exceedance Ratio
FLW-035-Soil 1	1	mg/kg	U	0.5	0.332	1.5
FLW-035-Soil 2	3.3	mg/kg		3.3	0.332	9.9
FLW-035-Soil 3	1	mg/kg	U	0.5	0.332	1.5
FLW-035-Soil 4	1.2	mg/kg		1.2	0.332	3.6
FLW-035-Soil 5	1	mg/kg	U	0.5	0.332	1.5
FLW-035-Soil 8	1.8	mg/kg		1.8	0.332	5.4
FLW-035-Soil 9	1.6	mg/kg		1.6	0.332	4.8
Average				1.3	0.332	4.0

[a] For screening one half the detection limit was used for nondeteced values.

U = Concentration was not measured above the reporting limit.

TABLE 3-7
Summary of Input Parameters for Food Web Exposure to PCBs
FLW-035 Decision Document, Fort Leonard Wood, Missouri

Input Parameters		White-footed Mouse
Food ingestion rate (kg/day dry weight) = FIR		0.0005[a]
Dietary composition (dry weight basis)	Soil invertebrates = PDF_i	47%[ab]
	Terrestrial plants = PDF_i	51%[ab]
	Soil = PDS	2%[c]
Water ingestion rate (L/day) = WIR		0.0062[a]
Body weight (kg wet weight) = BW		0.021[d]
Area foraging factor (Site Size/Home Range) = AFF		1

[a] Sample, B. E., and G. W. Suter II. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants.* Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-125.
[b] Martin, A. C., H. S. Zim, and A. L. Nelson. 1951. *American Wildlife and Plants: A Guide to Wildlife Food Habits.* Dover Publications, Inc. New York, NY. 500 pp.
[c] Beyer, W. N., E. E. Connor, and S. Gerould. 1994. "Estimates of Soil Ingestion by Wildlife." *Journal of Wildlife Management.* 58:375–82.
[d] Silva, M., and J. A. Downing. 1995. *CRC Handbook of Mammalian Body Masses.* CRC Press, Boca Raton, FL. 359 pp.

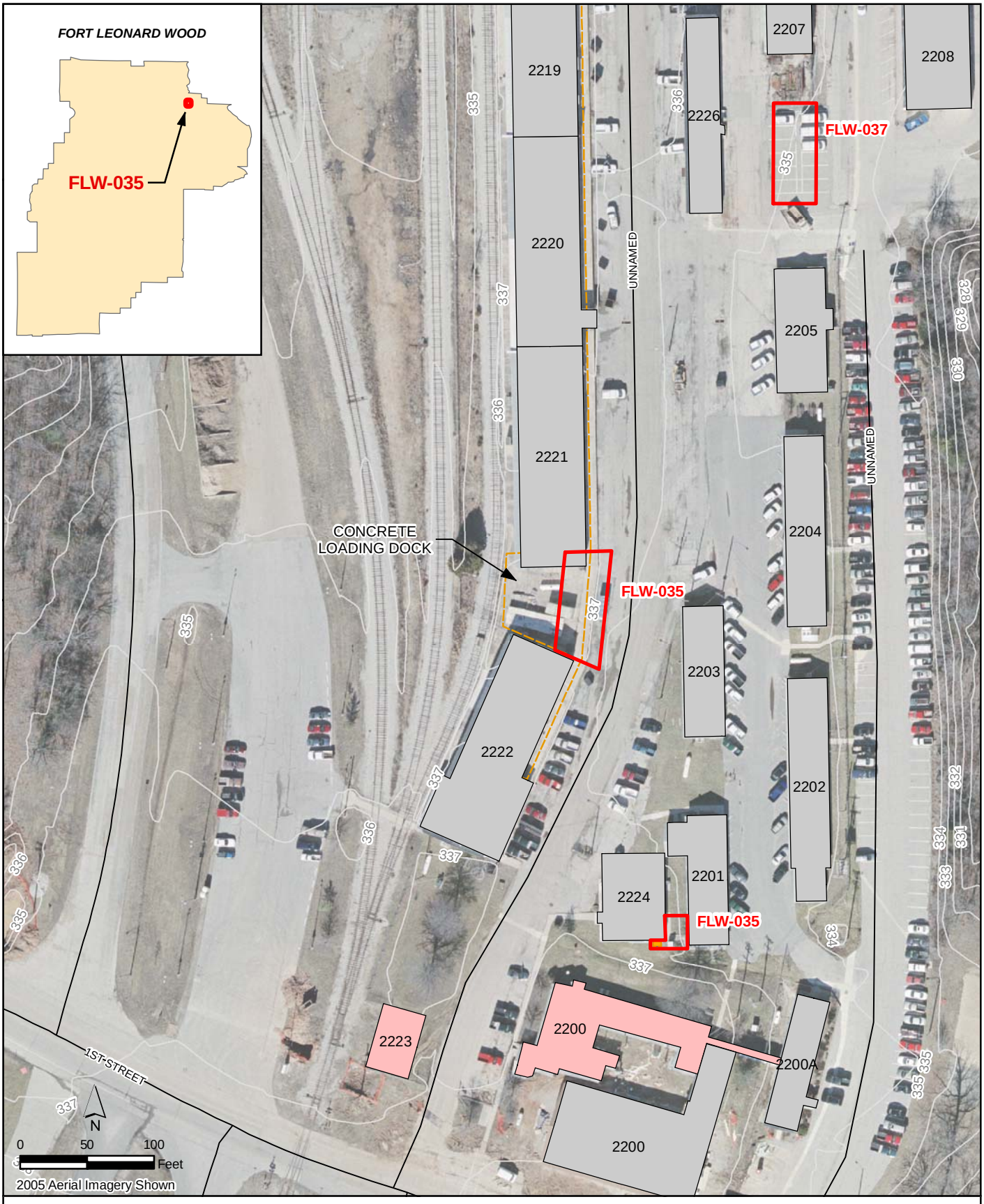
TABLE 3-8
Summary of Exposure Doses and Hazard Quotients
FLW-035 Decision Document, Fort Leonard Wood, Missouri

Receptor	White-footed Mouse
Soil Concentration (mg/kg, dry weight) - SC_x [a]	1.56
Soil- Invertebrate BAF[b]	4.27
Soil - Plant BCF[c]	0.0068
Food Concentrations (mg/kg dry weight) - FC_{xi}	
Soil Invertebrates	6.66
Terrestrial Plant	0.011
Surface Water Concentration (mg/L) - WC	0
Dietary Intake (mg/kg/d) - DI	0.076
Ingestion Screening Values (mg/kg/day)	
NOAEL[d]	0.077
LOAEL[d]	0.089
Hazard Quotient (HQ)	
NOAEL	0.99
LOAEL	0.85

[a] Mean soil concentration is based on using reporting limits for non-detect samples.
[b] Sample, B. E., J. J. Beauchamp, R. A. Efroymson, G. W. Suter II, and T. L. Ashwood. 1998. *Development and Validation of Bioaccumulation Models for Earthworms.* Environmental Restoration Division, ORNL Environmental Restoration Program. ES/ER/TM-220.
[c] Travis, C. C., and A. D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology.* 22:271–74.
[d] Hornshaw, T. C., R. J. Aulerich, and H. E. Johnson. 1983. "Feeding Great Lakes Fish to Mink: Effects on Mink and Accumulation and Elimination of PCBs by Mink." *Journal of Toxicology and Environmental Health.* 11: 933–46.

Dietary Intake (DI) Equation:

$$DI = \frac{[AFF[\sum_i (FIR)(FC_{xi})(PDF_i)]+[(FIR)(PDS)(SC_x)]+[(WIR)(WC)]]}{BW}$$



Legend

- Site Boundary
- Existing Building
- Demolished Building
- Concrete Pad
- Concrete Loading Dock
- Road
- Elevation Contour (1m interval)

Figure 3-1
Site Features Map
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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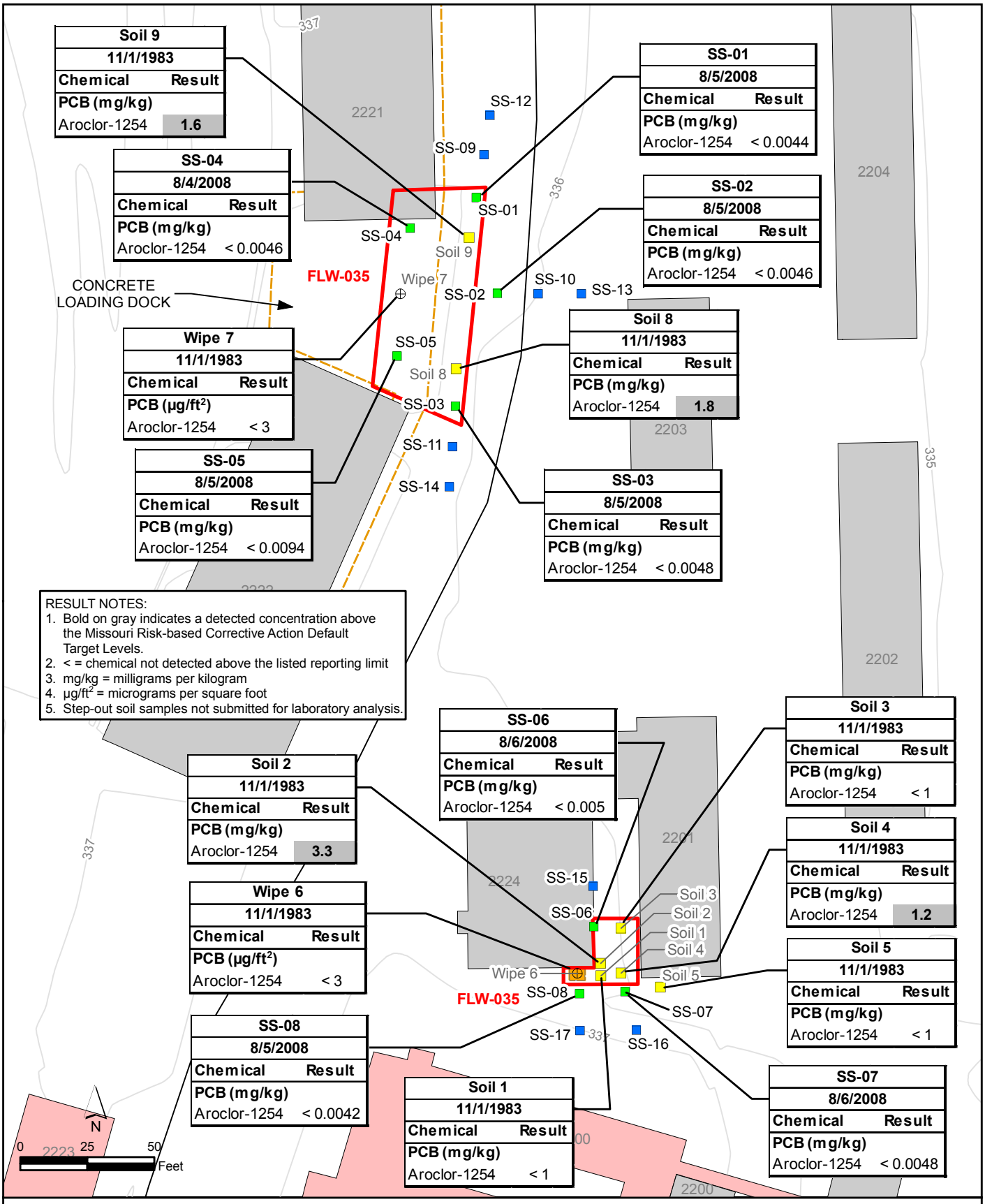

Legend

- Site Boundary
- Existing Building
- Demolished Building
- Concrete Pad
- Concrete Loading Dock
- Historic Soil Sample
- Historic Wipe Sample
- 2008 Soil Sample Location
- Step-Out Soil Sample Location
- Road
- Elevation Contour (1m interval)

Figure 3-2
1983 and 2008 Investigation Sample Locations and Chemical Concentrations Exceeding DTLs
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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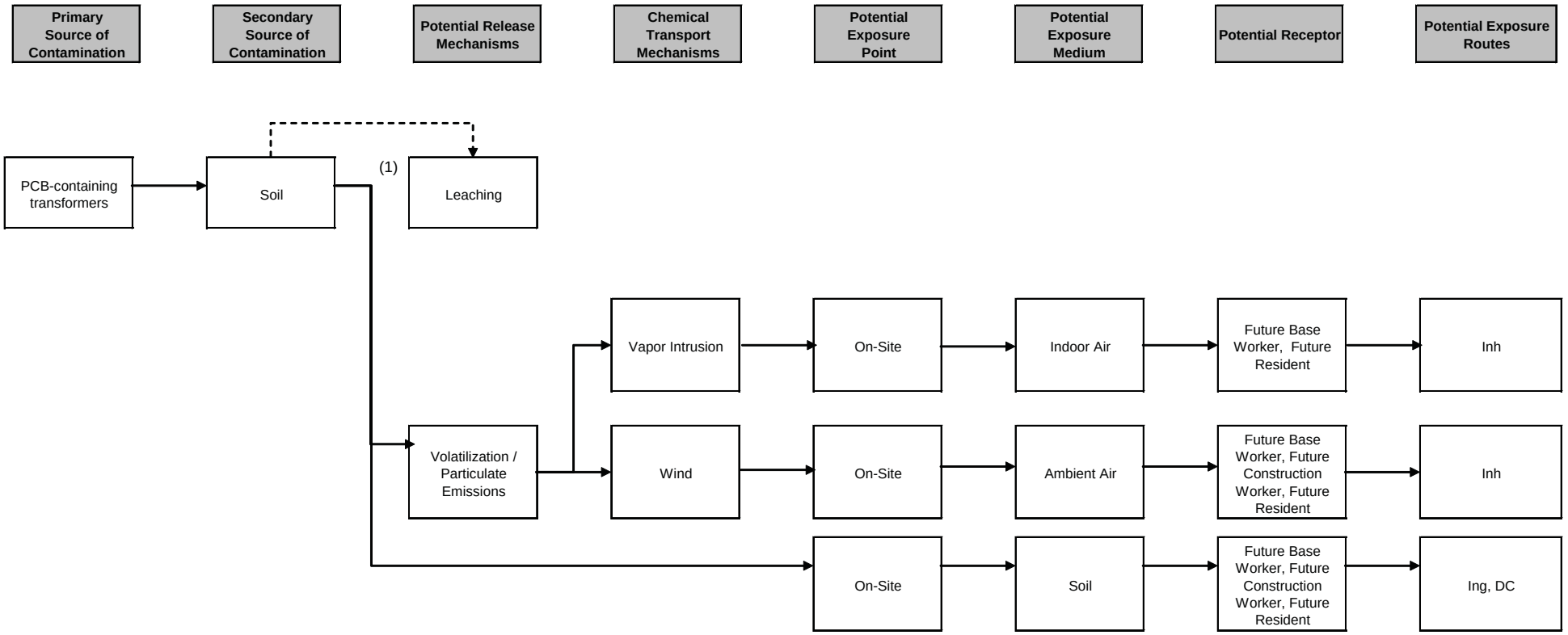


Notes: (1) = If present

(2) = Insignificant due to the low concentrations in site soil.

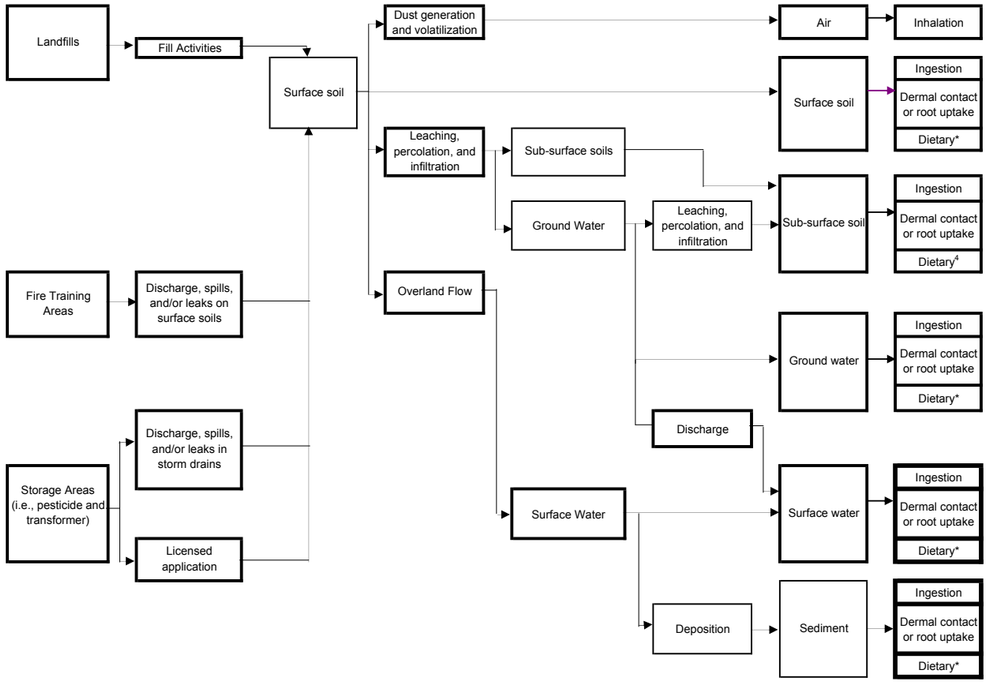
Ing = Ingestion, DC = Dermal Contact, Inh = Inhalation

Potentially complete pathway

Insignificant pathway

Incomplete pathway

Figure 3-3
Preliminary Human Health Conceptual Exposure Model
FLW-035 Decision Document
Fort Leonard Wood, Missouri

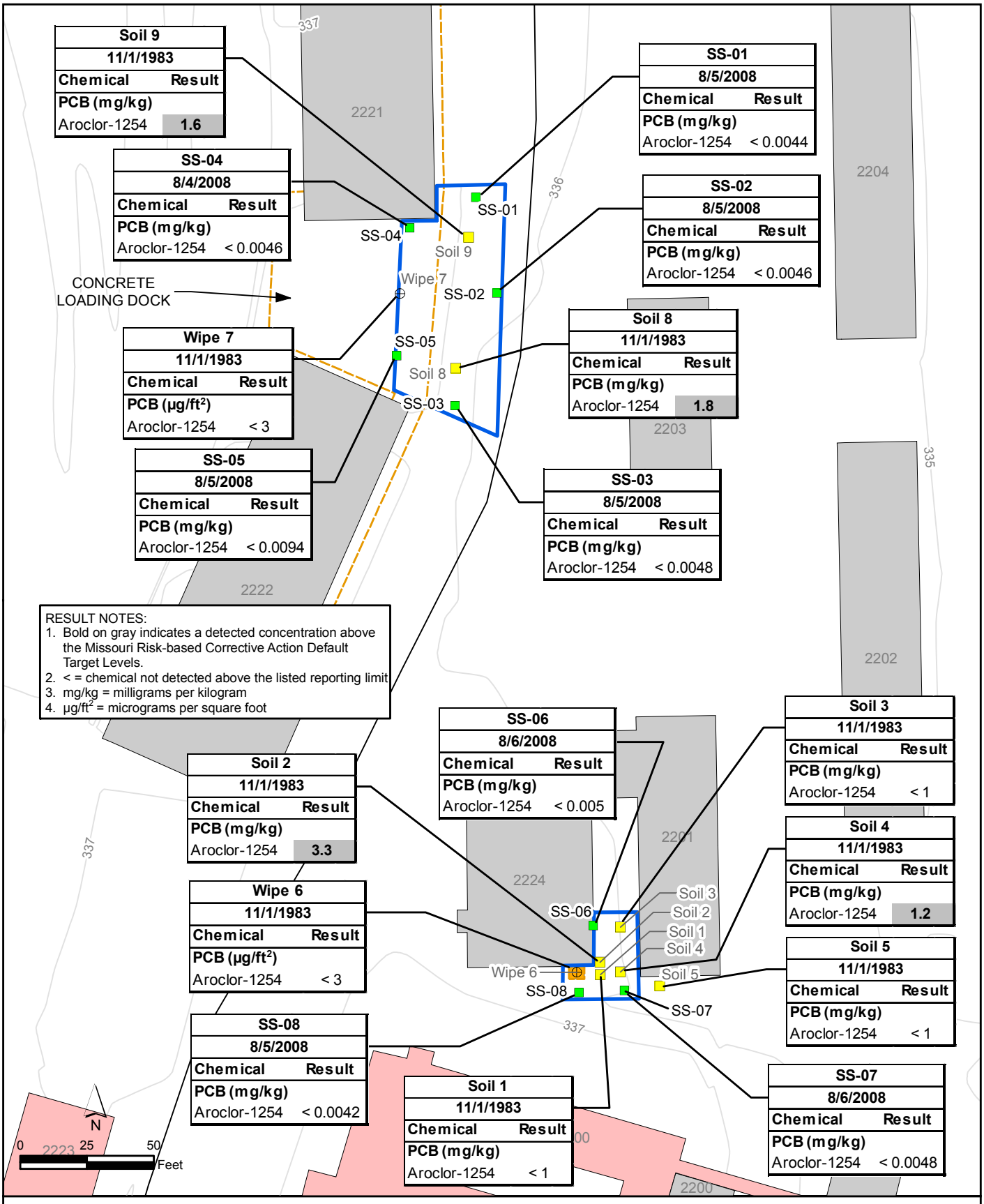


Primary Source	Primary Release Mechanism	Secondary Source	Secondary Release Mechanism	Tertiary Source	Tertiary Release Mechanism	Exposure Medium	Exposure Route	Ecological Receptors																		
								Plants		Invertebrates		Fish	Amphibians/Reptiles		Birds				Mammals							
								Terrestrial Plants	Aquatic Plants	Soil	Aquatic		Amphibians	Reptiles	Predator	Wading Piscivore	Omnivore	Herbivore	Insect eater/Burrower	Herbivore	Seed eater	Predator	Semi-aquatic omnivore			
															Bald Eagle	Great Blue Heron	Wild Turkey	Rufous-side	Short-tailed shrew	Whitetail deer	White-footed mouse	Coyote	Racoon			
Landfills	Fill Activities	Surface soil	Dust generation and volatilization			Air	Inhalation	x	x	x	x	x	x	x	i	i	i	i	i	i	i	i	i			
						Surface soil	Ingestion	x	x	●	x	x	i	i	i	i	i	i	○	i	i	i	i			
							Dermal contact or root uptake	●	x	i	x	x	i	i	i	i	i	i	○	i	i	i	i			
							Dietary*	x	x	○	x	x	x	x	●	●	●	●	●	●	●	●	●			
			Leaching, percolation, and infiltration	Sub-surface soils		Sub-surface soil	Ingestion	x	x	●	x	x	x	x	x	x	x	x	i	x	x	x	x			
							Dermal contact or root uptake	●	x	i	x	x	x	x	x	x	x	x	i	x	x	x	x			
							Dietary[4]	x	x	x	x	x	x	x	○	○	○	○	○	○	○	○				
				Ground Water	Leaching, percolation, and infiltration	Ground water	Ingestion	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
							Dermal contact or root uptake	○	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
							Dietary*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
Fire Training Areas	Discharge, spills, and/or leaks on surface soils		Overland Flow																							
Storage Areas (i.e., pesticide and transformer)	Discharge, spills, and/or leaks in storm drains				Discharge	Surface water	Ingestion	x	x	x	x	x	i	i	i	i	i	i	i	i	i	i	i			
				Surface Water			Dermal contact or root uptake	x	●	x	●	●	○	○	i	i	i	i	i	i	i	i	i			
							Dietary*	x	x	x	●	●	●	●	●	●	x	x	x	x	x	●	●			
	Licensed application				Deposition	Sediment	Ingestion	x	x	x	x	i	i	i	i	i	i	i	i	i	i	i	i			
							Dermal contact or root uptake	x	●	x	●	x	○	○	i	i	i	i	i	i	i	i	i			
							Dietary*	x	x	x	i	●	●	●	●	●	x	x	x	x	x	●	●			

Notes
- ● = Complete and significant pathway - A Complete and significant pathway means there is a potential for a contaminant to reach a receptor via the proposed route and there is a high potential that the receptor will receive a significant proportion of the contamination via this exposure route.
- ○ = Complete and significance unknown - A Complete and significant pathway means there is a potential for a contaminant to reach a receptor via the proposed route and that it is unknown if the receptor will receive a significant proportion of the contamination via this exposure route alone.
- i = Complete and insignificant pathway - A Complete and insignificant pathway means there is a potential for a contaminant to reach a receptor via the proposed route and there is a low potential that the receptor will receive a significant proportion of the contamination via this exposure route.
- x = Incomplete pathway - An Incomplete pathway means there is no potential for a contaminant to reach a receptor via the proposed route.

*Dietary = Uptake from food items and trophic transfer.

Figure 3-4
Generalized Ecological Conceptual Site Model for Fort Leonard Wood Sites
FLW-035 Decision Document
Fort Leonard Wood, Missouri



Legend

- Land Use Control Boundary
- Existing Building
- Demolished Building
- Concrete Pad
- Concrete Loading Dock
- Historic Soil Sample
- Historic Wipe Sample
- 2008 Soil Sample Location
- Road
- Elevation Contour (1m interval)

Figure 3-5
Land Use Control Boundaries
FLW-035 Decision Document
Fort Leonard Wood, Missouri

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4. References

Black & Veatch. 1992. *Final RCRA Facility Assessment Report.* Fort Leonard Wood, Missouri.

Burns and McDonnell. 1995. Baseline Contaminant Study for Fort Leonard Wood, Missouri.

CDM. 2005. *Final Remedial Investigation Report for the FLW-056 Site*. Fort Leonard Wood, Missouri.

CH2M HILL. 2007. *Final Remedial Investigation Work Plan, Fort Leonard Wood, Missouri*. December.

CH2M HILL. 2008a. *Final Supplemental Investigation at FLW-035, Former Transformer Storage Area, Fort Leonard Wood, Missouri.* September 14, 2008.

CH2M HILL. 2008b. *Final Community Involvement Plan, Fort Leonard Wood, Missouri. April*.

Chapman, S. S., J. M. Omernik, G. E. Griffith, W. A. Schroeder, T. A. Nigh, and T. F. Wilton. 2002. Ecoregions of Iowa and Missouri (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,800,000).

Department of the Army. 2004. *Army Defense Environmental Restoration Program Management Guidance for Active Installations.*

Efroymson, R. A., M. E. Will, and G. W. Suter II. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process*. 1997 revision. Environmental Restoration Division, ORNL.

Fort Leonard Wood. 2006. *Draft Integrated Natural Resources Management Plan and Environmental Assessment.* Prepared by Gene Stout and Associates and Blythe & Trousil, Inc., for the U.S. Army Maneuver Support Center and Fort Leonard Wood.

Hornshaw, T. C., R. J. Aulerich, and H. E. Johnson. 1983. "Feeding Great Lakes Fish to Mink: Effects on Mink and Accumulation and Elimination of PCBs by Mink." *Journal of Toxicology and Environmental Health.* 11: 933–46.

Hu, Q., G. D. Wilson, X. Chen, and A. Akyuz. 2005. "Effects of Climate and Landcover Change on Stream Discharge in the Ozark Highlands, USA." *Environmental Modeling and Assessment.* Vol. 10, No. 1, March.

Midwestern Regional Climate Center. 2006. Historical Climate Data for Station 238777, Waynesville 2 W, Missouri—Period of Record: 1949–2001.

Office of the Under Secretary of Defense. September 2001. Management Guidance for the Defense Environmental Restoration Program.

Parmelle, R. W., C. T. Philips, R. T. Checkai, and P. J. Bohlen. 1997. "Determining the Effects of Pollutants on Soil Faunal Communities and Trophic Structure Using Refined Microcosm System." *Environmental Toxicology and Chemistry.* 16(6):1212–17.

Travis, C. C., and A .D. Arms. 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." *Environmental Science and Technology.* 22:271–74.

U.S. Census Bureau. 2006. http://www.census.gov, American Fact Finder.

U.S. Army Environmental Hygiene Agency, U.S. Department of the Army. 1988. *Interim Final Report Hazardous Waste Consultation No. 37-26-1646-88, Evaluation of Solid Waste Management Units 1–4 June 1987 and 27 June–1 July 1988*. Fort Leonard Wood, Missouri.

U.S. Environmental Protection Agency (USEPA). 1993. *Wildlife Exposure Factors Handbook. Volume I of II.* EPA/600/R-93/187a.

U.S. Environmental Protection Agency (USEPA). 2003. *RCRA Ecological Screening Levels*. USEPA Region 5, Chicago.

U. S. Geological Survey (USGS). 1996. John G. Schumacher and Jeffrey L. Imes. Geohydrologic and Water-Quality Assessment of the Fort Leonard Wood Military Reservation, Missouri, 1994–95.

U. S. Geological Survey (USGS). 2000. John G. Schumacher and Jeffrey L. Imes. Geohydrology and Water Quality at Shanghai Spring and Solid Waste Management Units at the Fort Leonard Wood Military Reservation, Missouri, 1995–98.

U. S. Geological Survey (USGS). 2003. Douglas N. Mugel and Jeffrey L. Imes. Geohydrologic Framework, Ground-Water Hydrology, and Water Use in the Gasconade River Basin Upstream from Jerome, Missouri, including the Fort Leonard Wood Military Reservation.