Final Feasibility Study
Revision 00

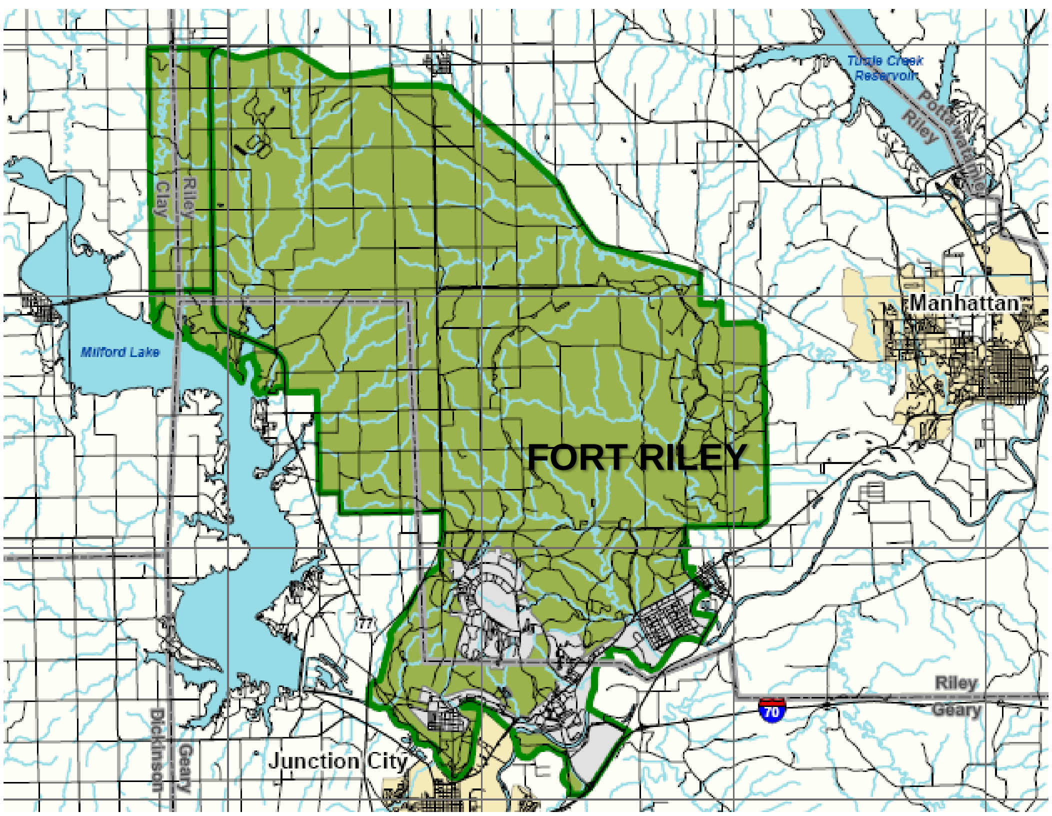
August 2018

Contract No.: W912DQ-17-D-3023
Delivery Order No.: W9128F-17-F-0233

Fort Riley

Military Munitions Response Program
Camp Forsyth Landfill Area 2 Munitions Response Site
Junction City, Kansas

U.S. Army Corps of Engineers
Omaha District



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FEASIBILITY STUDY
Revision 00

Prepared for

and

MILITARY MUNITIONS RESPONSE PROGRAM
FORT RILEY
CAMP FORSYTH LANDFILL AREA 2 MUNITIONS RESPONSE SITE
JUNCTION CITY, KANSAS

Prepared by

U.S. ARMY CORPS OF ENGINEERS
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August 2018

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
%	percent
°F	degrees Fahrenheit
AP	anti-personnel
ARAR	Applicable or Relevant and Appropriate Requirements
AT	anti-tank
Bay West	Bay West LLC
BER	Bureau of Environmental Remediation
bgs	below ground surface
BIP	blow-in-place
cal	caliber
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFLFA2	Camp Forsyth Landfill Area 2
CFR	code of federal regulations
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
DDESB	Department of Defense Explosives Safety Board
DERP	Defense Environmental Restoration Program
DGM	digital geophysical mapping
DMM	Discarded Military Munitions
DoD	Department of Defense
Eco-SSL	ecological soil screening level
EM	electromagnetic
EOD	Explosive Ordnance Disposal
ESL	ecological screening levels
EZ	exclusion zone
FS	feasibility study
ft	feet or foot
FTRI	Fort Riley, Kansas
GIS	geographic information system
GPS	Global Positioning System
GRA	General Response Action
HFD	hazardous fragmentation distance
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
HRR	historical records review
KDHE	Kansas Department of Health and Environment
LANL	Los Alamos National Laboratory
LOD	limit of detection
LUCIP	Land Use Control Implementation Plan
m	meter(s)
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MFD	maximum fragment distance
mg/kg	milligrams per kilogram
MMRP	Military Munitions Response Program
MPPEH	Material Potentially Presenting an Explosive Hazard
MRS	munitions response site
MURS	Magnetic UXO Recovery System
N/A	not applicable
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPL	National Priorities List
OB/OD	open burn/open demolition
OD	other debris
O&M	operations and maintenance
PAOC	potential area of environmental concern
RAB	Restoration Advisory Board
RAO	Remedial Action Objective

RCRA .... Resource Conservation and Recovery Act
RDX trinitro-1,3,5-triazine
RI .... remedial investigation
RRD .... range-related debris
RSL .... regional screening level
SAAD .... small arms ammunition debris
SAR .... species at risk
SARA .... Superfund Amendments and Reauthorization Act
SI .... site inspection
SINC .... species in need of conservation
SLERA .... screening level ecological risk assessment
TBC .... to be considered
TMV .... toxicity, mobility, volume
TNT .... trinitrotoluene
U.S. .... United States
USACE .... U.S. Army Corps of Engineers
USC .... United States Code
USEPA .... U.S. Environmental Protection Agency
UU/UE .... unlimited use/unrestricted exposure
UXO .... unexploded ordnance
Wenck .... Wenck Associates, Inc.

EXECUTIVE SUMMARY

This report presents the results of the Feasibility Study (FS) performed under the Military Munitions Response Program (MMRP) at the Camp Forsyth Landfill Area 2 (CFLFA2) Munitions Response Site (MRS; FTRI-003-R-01) located at Fort Riley, Kansas (FTRI). This work is being performed on behalf of the United States (U.S.) Army under U.S. Army Corps of Engineers (USACE) Contract W912DQ-17-D-3023, Delivery Order W9128F-17-F-0233.

The purpose of the FS is to identify, develop, and perform a detailed analysis of potential remedial alternatives that would meet the established remedial action objectives (RAOs) and thus afford the decision-makers adequate information to select the most appropriate remedial alternative(s) for the MRSs. Alternatives are selected based on their ability to mitigate, reduce, or eliminate unacceptable risks to human health and the environment from munitions and explosives of concern (MEC), taking into account the current and likely anticipated future uses of the property.

Based on the results from the previous investigations, an FS evaluation for MEC was recommended for CFLFA2 MRS. The Human Health Risk Assessment (HHRA) and Screening Level Ecological Risk Assessment (SLERA) demonstrated that there were no unacceptable risks to human health of the environment associated with munitions constituents (MC) in soil, sediment, surface water, or groundwater at the CFLFA2 MRS; therefore, an FS evaluation for MC was not recommended.

RAOs were developed based on criteria outlined in Section 300.430(e)(2)(i) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) and Section 121 of the Superfund Amendments and Reauthorization Act (SARA). RAOs specify the items/ contaminants of concern, media of concern, exposure routes and receptors and an acceptable contaminant level or range of levels for each exposure route.

The RAO for the MRS includes the following:

- Minimize FTRI residents, recreational users (including residents walking on the nature trail adjacent to the site), FTRI personnel, authorized contractors, and trespassers contact with MEC in the top two feet of the Republic River and Breakneck Creek and surrounding banks while maintaining the intended future land use which is primarily recreational use.

General response actions (GRAs) identified to meet the RAO include:

- No Action,
- Land use controls (LUCs),
- Monitoring of LUCs, and
- MEC clearance.

The GRAs and technologies/process options were preliminarily screened against the criteria for effectiveness, implementability, and cost. Technologies for LUCs included administrative, engineering, and educational controls.

Following the preliminary screening of GRAs and technologies/process options, alternatives were assembled and further screened against the criteria for effectiveness, implementability, and cost:

- **Alternative 1** – No Action. Perform no action and do not consider existing LUCs. Hazards remain at baseline conditions.
- **Alternative 2** – LUCs. The implementation of a LUC alternative based on public awareness and education components would provide a means for FTRI to coordinate efforts to prevent munitions handling by the property residents, FTRI personnel,

contractor/maintenance personnel, and recreational users/visitors through behavior modification.

- **Alternative 3** – MEC Clearance in Breakneck Creek and LUCs. MEC would be removed from Breakneck Creek using primarily land-based methods as Breakneck Creek is an intermittent stream and activities would be performed during the dry season. Areas with standing water would be cleared by a UXO technician wearing hip waders. LUCs would be implemented as described under Alternative 2 as MEC may remain in the substrate below 2 feet (ft) below ground surface (bgs).
- **Alternative 4** – MEC Clearance for Republican River and Breakneck Creek and LUCs. MEC would be removed from Breakneck Creek, as described under Alternative 3, and the shallow portions of the Republican River. In addition, UXO divers would clear MEC from the deeper areas in the Republican River. LUCs as described under Alternative 2 would continue to be required as MEC may remain in the substrate below 2 ft bgs.
- **Alternative 5** – MEC Clearance to Support UU/UE. The Republican River would be diverted and the sediments dried such that MEC could be located and removed using terrestrial methods. This will enable the location and removal of MEC to a deeper depth than water-based techniques.

Initial assessment of these alternatives found that Alternative 1 – No Action had no costs and no implementability issues, but the alternative would not be effective in the long-term as no safety controls for MEC would be implemented. However, No Action was retained as a baseline for evaluation. Alternative 2 – LUCs had no implementability issues, and would be effective over the long-term. Alternative 3 – MEC Clearance in Breakneck Creek and LUCs was slightly more expensive then Alternative 2, but provided an additional level of protection of human receptors in Breckneck Creek (where hiking occurs). It had slight implementability issues that could be overcome, and would be effective over the long-term. Alternative 4 – MEC Clearance for Republican River and Breakneck Creek and LUCs would be effective at removing MEC from the most accessible areas in the MRS. It would also minimize the potential for movement of MEC into areas previously cleared. However, as MEC may remain below 2 ft of sediment, the risk of encountering MEC subsequent to removal would be very low but not zero. As such, LUCs would still be required in order for the alternative to be protective. Under Alternative 5 – MEC Clearance to Support UU/UE the implementability was questionable as the Republican River would need to be relocated onto privately-owned commercial property. Further, the costs to divert the river and perform MEC clearance across the MRS is considered to be excessive. Therefore, because the costs associated with Alternative 5 are excessive compared to its overall effectiveness and implementability, Alternative 5 was not retained for detailed analysis.

Table ES-1 also presents a side-by-side comparison of the alternatives for the CFLFA2 MRS.

Table ES-1 Comparison of Alternatives for FTRI CFLFA2 MRS to NCP Criteria

MRS	Type	Screening Criterion	Alternative 1: No Action	Alternative 2: LUCs	Alternative 3: MEC Clearance in Breakneck Creek and LUCs	Alternative 4: MEC Clearance for Republican River and Breakneck Creek and LUCs
CFLFA2	Threshold	Overall Protection of Human Health and the Environment	No	Yes	Yes	Yes
		Compliance with ARARs	Yes	Yes	Yes	Yes
	Balancing	Long-Term Effectiveness	○	◊ (Effective Not Permanent)	◊ (Effective Not Permanent)	● (Effective Not Permanent)
		Reduction of Toxicity, Mobility and Volume through Treatment	○	◊	◊	●
		Short-Term Effectiveness	●	●	●	●
		Implementability	●	●	●	●
		-Technical Feasibility	●	●	●	●
		-Administrative Feasibility	●	●	●	●
		-Availability of Materials and Services	●	●	●	●
		Cost[1]	$0	$441,000	$958,000	$3,838,000
	Modifying[2]	Regulatory Agency Acceptance	TBD	TBD	TBD	TBD
		Community Acceptance	TBD	TBD	TBD	TBD

● *In comparison with other alternatives, complies well with criteria.*

◊ *In comparison with other alternatives, partially complies with criteria.*

○ *In comparison with other alternatives, does not comply well with criteria.*

[1] *30-Year present worth costs assuming a 0.7% escalation factor (OMB, 2016). Costs are detailed in* ***Appendix A****.*

[2] *The modifying criteria of regulatory agency and community acceptance are to be determined (TBD) following review and input from these parties and will be evaluated in the ROD.*

1 INTRODUCTION

This report presents the results of the Feasibility Study (FS) performed under the Military Munitions Response Program (MMRP) at the Camp Forsyth Landfill Area 2 (CFLFA2) Munitions Response Site (MRS; FTRI-003-R-01) located at Fort Riley, Kansas (FTRI) as shown in **Figure 1-1**. The FS was completed on behalf of the U.S. Army by Bay West LLC (Bay West) under the U.S. Army Corps of Engineers (USACE) Contract W912DQ-17-D-3023, Delivery Order W9128F-17-F-0233.

Per agreement between the Department of Defense (DoD) and the United States Environmental Protection Agency (USEPA), sites managed under the MMRP will follow a process consistent with that established under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The FS is the next step in this process that builds upon the CFCLA2 Remedial Investigation (RI) Report (Bay West, 2017).

This FS has been completed in accordance with the following documents:

- USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*, Interim Final, EPA-540/G-89-004, dated October 1988 (USEPA, 1988); and
- *Final Munitions Response Remedial Investigation/Feasibility Study Guidance*, (U.S. Army, 2009).

1.1 Purpose

The DoD established the MMRP to address DoD sites suspected of containing munitions and explosives of concern (MEC) or munitions constituents (MC). Under the MMRP, the Army is the lead agency conducting environmental response activities at FTRI. FTRI is on the National Priorities List (NPL) with EPA Site ID KS6214020756. Pursuant to the DoD Manual 4715.20, Defense Environmental Response Program (DERP) Management (DoD, 2012), the Army is conducting MEC response activities in accordance with the DERP statute (10 United States Code [USC] 2701 et seq.), CERCLA (42 USC §9620), Executive Orders 12580 and 13016, and the National Contingency Plan (NCP; 40 Code of Federal Regulations [CFR] Part 300.430). The DERP statute provides the DoD the authority to respond to releases of MEC/MC, and DoD policy states that such responses shall be conducted in accordance with CERCLA and the NCP.

The purpose of the FS is to identify, develop, and perform a detailed analysis of potential remedial alternatives that would meet the remedial action objectives (RAOs), and thus afford the decision-makers adequate information to select the most appropriate remedial alternative(s) for the MRSs. Alternatives are selected based on their ability to mitigate, reduce, or eliminate unacceptable risks to human health and the environment from MEC, taking into account the current and likely anticipated future uses of the property. This FS will:

- Develop RAOs and general response actions (GRAs) based on the conceptual site model (CSM) and applicable or relevant and appropriate requirements (ARARs);
- Screen the technologies and process options applicable to the GRAs and eliminate those that cannot be implemented at the MRS;
- Assemble the selected representative technologies into alternatives; and
- Evaluate the alternatives using criteria specified in the NCP 40 CFR Part 300.430(e)(9)(iii).

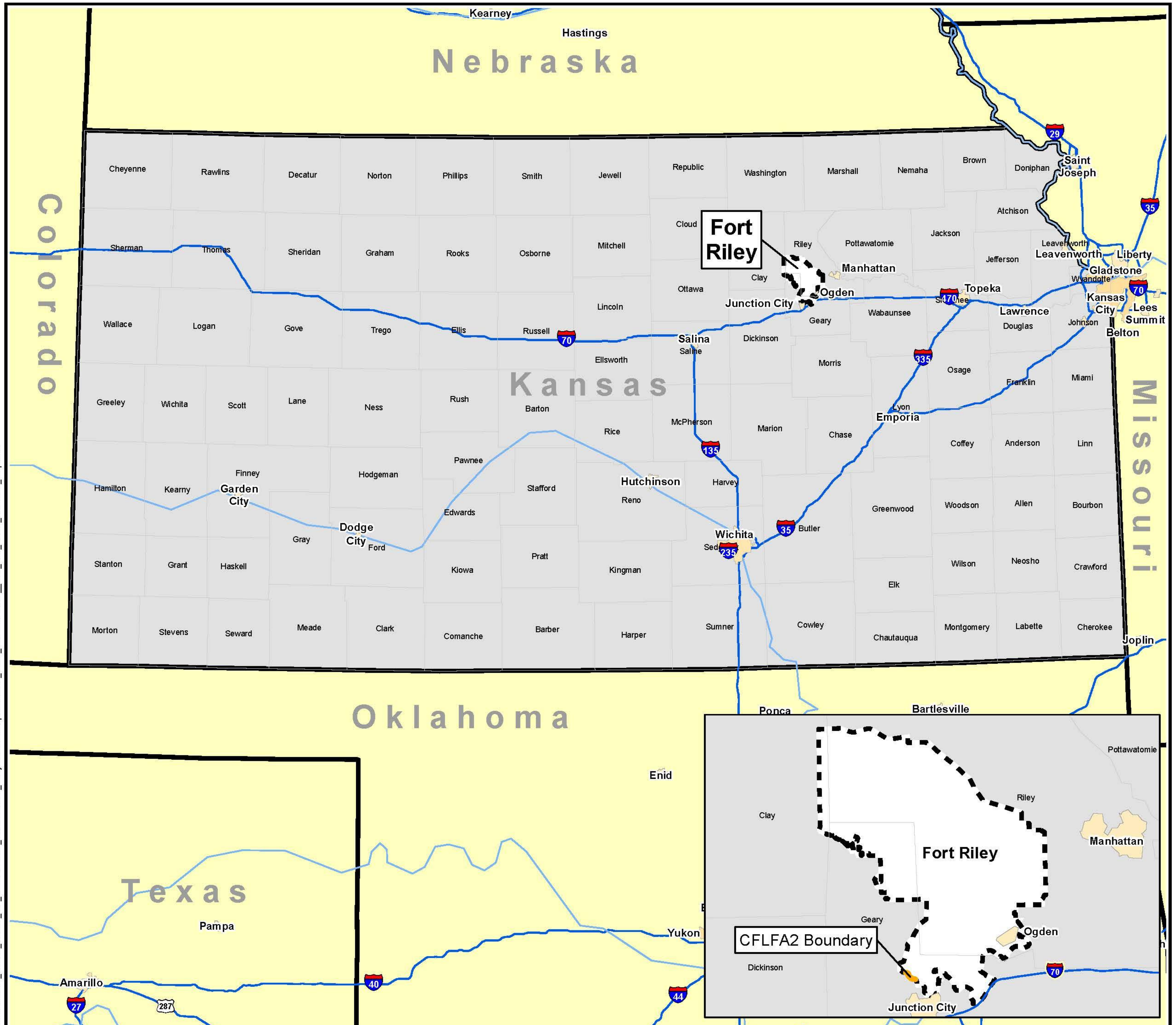

Figure 1-1
Site Location Map

MMRP Feasibility Study

Fort Riley, Kansas

Fort Riley
KANSAS

Fort Riley
CFLFA2 Boundary, 34.9 acres

0 20 40 Miles
0 50 100 Kilometers

Map Projection: NAD 83 Zone 14N Meters

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1.2 Installation Background

FTRI is a U.S. Army Post occupying approximately 101,733 acres in portions of Clay, Geary, and Riley Counties in northeast Kansas. Approximately 70,926 acres are used for maneuver training. FTRI is located directly north and east of Junction City, Kansas and lies 10 miles southwest of Manhattan, Kansas. FTRI is located at the confluence of the Smoky Hill and Republican Rivers, which combine to form the Kansas River. Portions of FTRI are bounded by the cities of Ogden, Riley, and Junction City, Kansas (**Figure 1-1**).

1.3 CFLFA2 MRS Site History

Historical activities near the CFLFA2 include the Camp Forsyth Landfill, historical maneuver and training areas (including a mock Vietnam Village), public parks, and dredging operations.

When the CFLFA2 MRS was originally developed during the Site Inspection (SI), the boundaries and investigations were geared towards determining if the Camp Forsyth Landfill is a source of MEC and MC that have been encountered in the Republican River. Due to operational boundary revisions performed by FTRI personnel subsequent to the submittal of the Draft SI Report, the actual landfill (i.e., the terrace above the river) is now within an active training area and the originally-designated MRS footprint is no longer eligible under the MMRP. The footprint of the MRS was modified after the Draft SI Report and was submitted to include the off-post sandbars and banks of the Republican River and to exclude the active training area. The reconfigured MRS footprint is 34.9 acres which is reflected on **Figure 1-2** (Bay West, 2014a). Historical activities near CFLFA2 are shown on **Figure 1-3**.

1.3.1 Camp Forsyth Landfill

The Camp Forsyth Landfill was identified as a landfill by the USEPA Environmental Monitoring Systems Laboratory in November 1983. Aerial photographs taken in 1950, 1956, and 1957 indicate trench-type land filling within the originally-designated Camp Forsyth Landfill boundary.

1.3.1.1 Camp Forsyth Landfill Activities

The Camp Forsyth Landfill appears to have been active in the area adjacent to the northeast of the CFLFA2 MRS from at least 1944 through 1957, as supported by evidence of activity on the aerial photos from this period. The former landfill is labeled "Sanitary Fill Area" in a 1957 topographic map. According to a FTRI Installation Assessment on-site records review performed in 1985, the Camp Forsyth Landfill operated from approximately 1943 to 1957 as both the debris and sanitary landfill for Camp Forsyth. The Camp Forsyth Landfill, which ceased operations around 1960, was closed by Kansas Department of Health and Environment (KDHE) under Resource Conservation and Recovery Act (RCRA) in a letter dated 7 August 2007.

An installation-wide assessment performed in 1993 identified limited information regarding the types of refuse placed at the former Camp Forsyth landfill; however, the former landfill is expected to consist of predominantly municipal-type waste (Louis Berger & Associates, Inc. [LBA], 1993). This waste-stream profile may include hazardous substances associated with materials like small amounts of paints, inks, and cleaners. In addition, the landfill may have potentially received hazardous wastes either from operations on FTRI or from Junction City sources. The Historical Records Review (HRR; Bay West, 2012b) described contaminants typically associated with municipal type wastes and mixed hazardous substances, which include metals and volatile organic compounds; further, the HRR indicated that there are no records or indications of incineration or hazardous waste disposal in the Camp Forsyth Landfill.

No evidence of munitions disposal at the former landfill was identified in records reviewed for the HRR (Bay West, 2012b). Landfilling live munitions was not a common practice of disposal by the

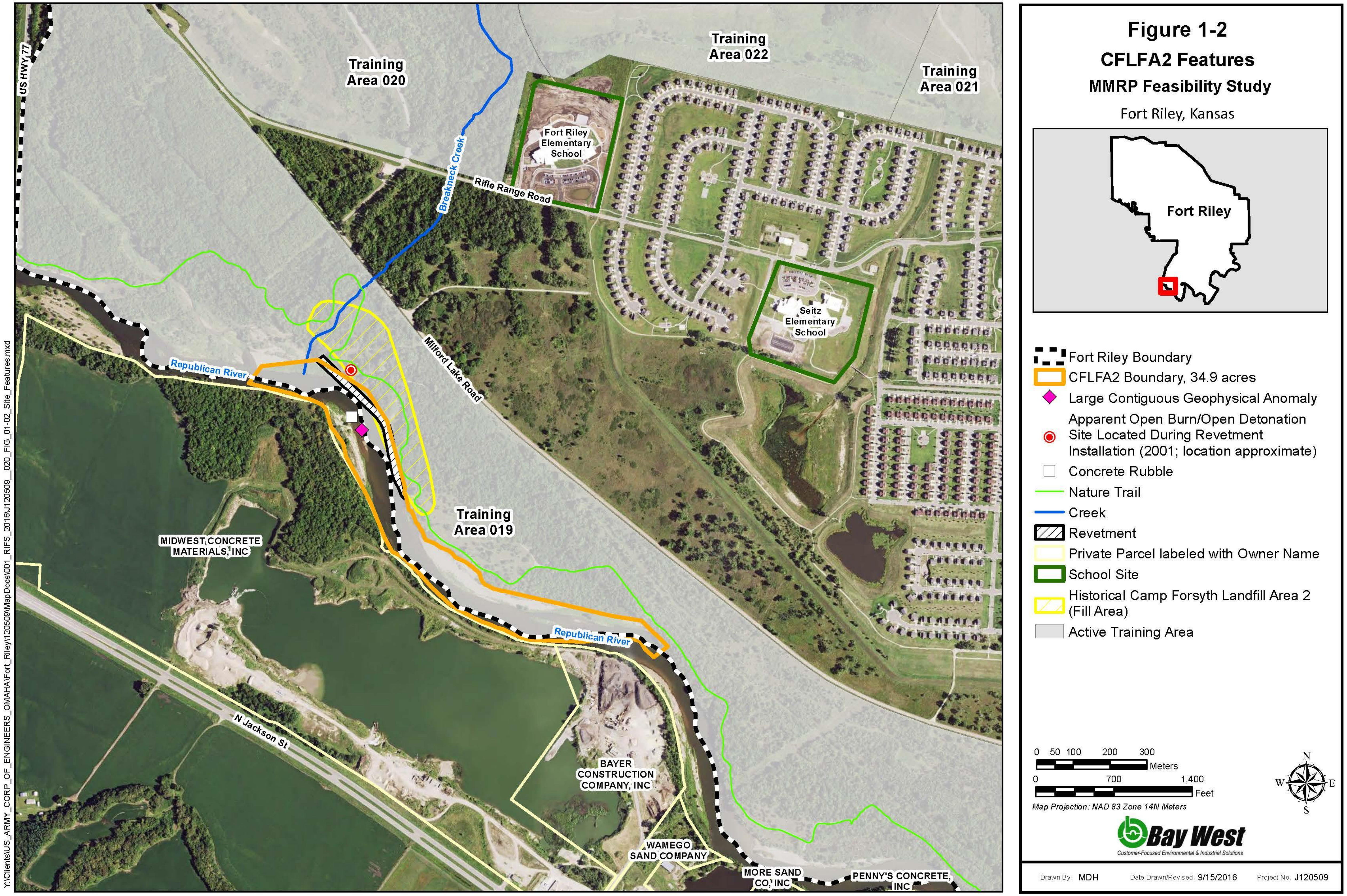
Figure 1-2
CFLFA2 Features
MMRP Feasibility Study
Fort Riley, Kansas
Fort Riley
Training Area 020
Training Area 022
Training Area 021
Training Area 019
US HWY 77
Breakneck Creek
Rifle Range Road
Fort Riley Elementary School
Seitz Elementary School
Milford Lake Road
Republican River
Republican River
N Jackson St
MIDWEST CONCRETE MATERIALS, INC
BAYER CONSTRUCTION COMPANY, INC
WAMEGO SAND COMPANY
MORE SAND CO, INC
PENNY'S CONCRETE, INC
Fort Riley Boundary
CFLFA2 Boundary, 34.9 acres
Large Contiguous Geophysical Anomaly
Apparent Open Burn/Open Detonation Site Located During Revetment Installation (2001; location approximate)
Concrete Rubble
Nature Trail
Creek
Revetment
Private Parcel labeled with Owner Name
School Site
Historical Camp Forsyth Landfill Area 2 (Fill Area)
Active Training Area
0 50 100 200 300 Meters
0 700 1,400 Feet
Map Projection: NAD 83 Zone 14N Meters
N S E W
Bay West
Customer-Focused Environmental & Industrial Solutions
Drawn By: MDH
Date Drawn/Revised: 9/15/2016
Project No. J120509
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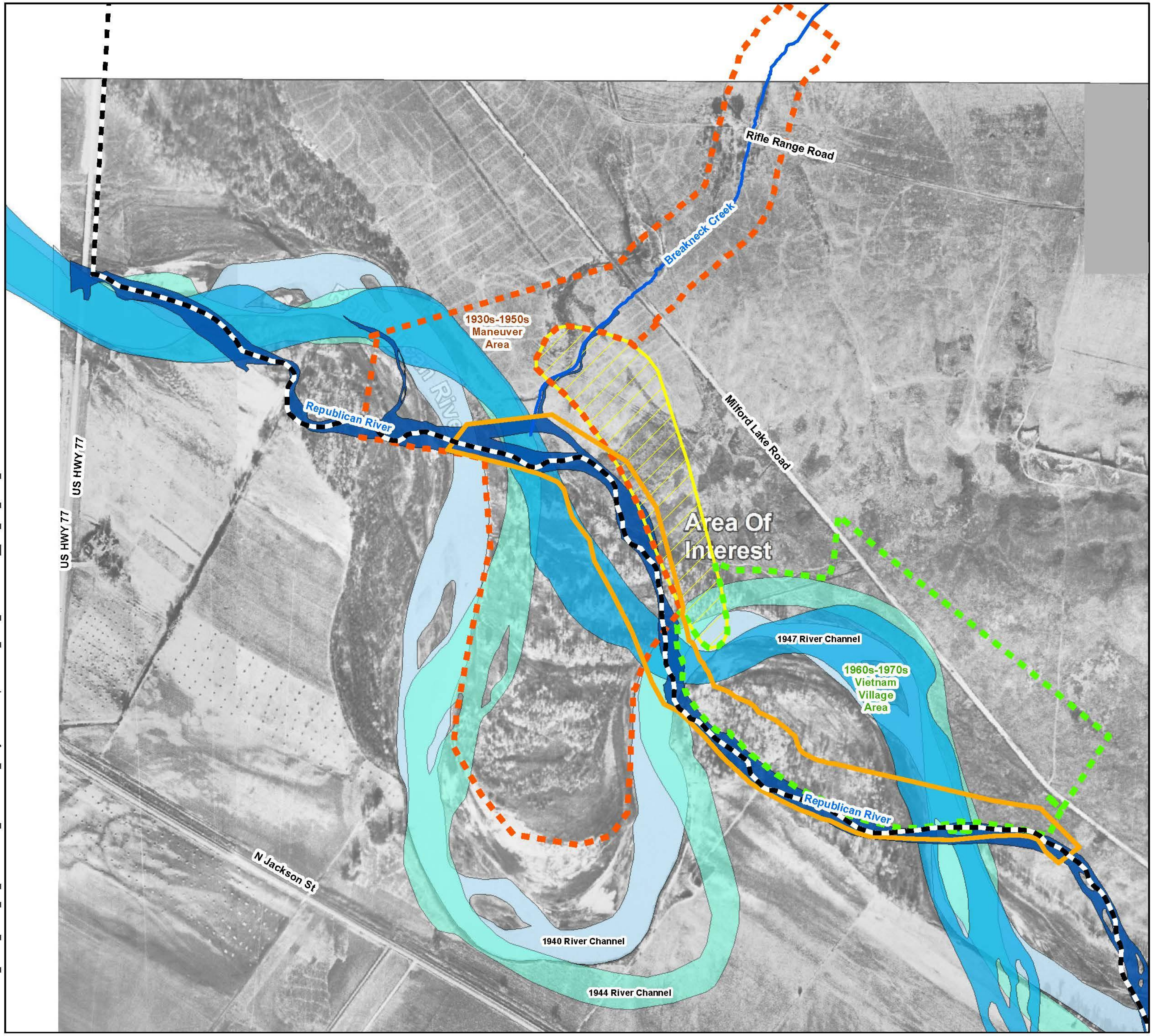
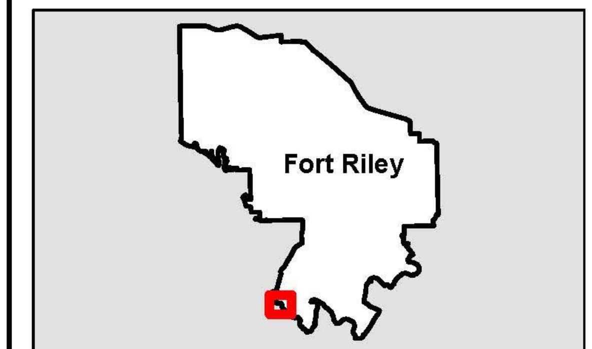


Figure 1-3
Summary of Historical Activities and Features
MMRP Feasibility Study
Fort Riley, Kansas



Fort Riley Boundary
CFLFA2 Boundary, 34.9 acres
1930s-1950s Maneuver Area
1960s-1970s Vietnam Village Area
Creek
Historical Camp Forsyth Landfill Area 2 (Fill Area)
Current River Channel
1947 River Channel
1944 River Channel
1940 River Channel
Photo Background from 1940 (Bay West, 2012b)

0 50 100 200 300 Meters
0 700 Feet
Map Projection: NAD 83 Zone 14N Meters

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U.S. Army, as this practice would be a highly dangerous activity. Live and suspected-live munitions were routinely disposed by detonation at Open Burn/Open Detonation (OB/OD) or firing ranges. The U.S. Army published technical guidance prohibiting disposal of explosives and ammunition in waste places, pits, wells, marshes, shallow streams, and inland waterways since at least the 1920s (U.S. Army, 1928; U.S. War Dept., 1945).

1.3.1.2 Landfill Erosion and Control

Evidence of erosion and solid waste debris was discovered along the bank of the Republican River following regional flooding during 1993. The Republican River overflowed its banks for approximately 30 days during the 1993 flood. A sandbar in the Republican River, approximately 700 feet downstream from the original Camp Forsyth Landfill footprint, was found to contain MEC in the spring of 1994. Approximately 200 3.5- and 2.36-inch rockets, M1 mines and a variety of small arms ammunition were discovered. The FTRI 774th Explosive Ordnance Disposal (EOD) Detachment detonated the rockets and mines in-place during the summer of 1994 and the remaining ordnance was relocated to the FTRI EOD Range and properly destroyed.

Aerial photographs and land surveys show that over time, the Republican River eroded an approximate 800- by 100-foot area along the riverbank of the original Camp Forsyth Landfill footprint. In 1998, a design was developed to stabilize the erosion. Construction of a revetment and baffles for riverbank stabilization was completed in two phases. The first 500 feet of the revetment were completed in the summer of 2000 and the remaining 1,000 feet of the revetment were constructed in the spring of 2001.

1.3.2 <u>Historical Maneuver and Training Areas</u>

Training activities appear to have been conducted on and around the CFLFA2 from at least the 1930s through the 1970s. The specific nature of the training activities is unknown; however, the activities potentially involved munitions firing activity and disposal. There is evidence of tracks crossing the north portion of the CFLFA2 as early as 1934; and various tracks, roads, and disturbed areas are observed throughout the CFLFA2 and adjacent areas in aerial photos until at least 1977. There also appear to be tracks and roads leading to the Republican River in the area of the CFLFA2, sometimes with disturbed areas along the riverbank, in the aerial photos and base maps from at least 1934 through 1977. Anecdotal evidence indicates that the tracks, roads, and disturbed areas visible on the aerial photographs may be from both civilian and military uses.

In a 1994 memo regarding the discovery of MEC on Republican River sandbars in the area of the CFLFA2 (following the 1993 flood), First Lieutenant Leland A. Browning, Jr., Commanding Officer, Fort Riley Ordnance Division, estimated that ordnance was dumped at or very near this area sometime between 1950 and 1965 (prior to the avulsion of the river); and he suspected that all ordnance encountered on the sandbars was training ammunition (i.e., practice ammunition generally void of high explosives but sometimes containing a spotting charge). The tracks and disturbed areas observed along the Republican River in the aerial photos from 1940 through 1977 corroborate the possible MEC disposal activities at or near the Republican River as stated in the memo. However, the U.S. Army published technical guidance prohibiting disposal of explosives and ammunition in waste places, pits, wells, marshes, shallow streams, and inland waterways since at least the 1920s (U.S. Army, 1928; U.S. War Dept., 1945). Disposal practices used at the time are described in documents that are not available to the public; they are restricted to active-duty EOD personnel. However, general procedures included a determination on whether MEC are safe to move and then destroyed by either burning or controlled explosion. It is probable that material was deposited prior to 1950, before the oxbow avulsed.

Munitions types discovered on the Republican River sandbars in 1994 and during subsequent investigation activities performed at the CFLFA2 MRS since 2000 correspond to the munitions types identified in 1930s and 1940s training records reviewed for the HRR, such as rockets, mortars, rifle grenades, hand grenades, and small arms ammunition. This is an indication that munitions-related training activities may have been conducted at or near the CFLFA2 in the 1930s through 1940s and munitions from this era may have been fired or disposed of at the CFLFA2.

Tank training appears to have been conducted in the immediate vicinity of the CFLFA2 MRS since at least 1944, as supported by evidence of tank maneuvering activities observed in the aerial photos. A tank crew proficiency course is indicated adjacent to the north of the Camp Forsyth Landfill in a 1969 base map. A tank trail is indicated adjacent to the northeast of the former landfill in the base maps from at least 1977 through 2010. A report of excess real property indicated that maneuver training was conducted on the 68-acre portion of oxbow land formerly within FTRI and adjacent to the south of the CFLFA2 prior to 1945. The oxbow land was severed from FTRI and became inaccessible when the Republican River avulsed in 1945.

The majority of munitions debris (MD) identified during initial RI field work in 2011 was clustered on the sandbar along the south side of the Republican River, in the immediate vicinity of concrete rubble. A large continuous geophysical anomaly was identified on a sandbar within the river channel approximately 100 feet southeast of the concrete structure (adjacent to the revetment) during the 2011 geophysical survey (Section 1.5.7). This anomaly was suspected to represent a high concentration of MD and MEC buried in the sandbar. Significant amounts of MEC and MD have also been identified downstream of the concrete rubble. However, very few MEC and MD items had been encountered upstream of the concrete rubble, and these few items were located immediately upstream of the concrete rubble (Bay West, 2012a).

1.4 Environmental Setting

1.4.1 Climate

FTRI has a temperate continental climate characterized by hot summers, cold dry winters, moderate winds, low humidity, and a pronounced peak in rainfall late in the spring and in the first half of summer. Prevailing winds are from the south to southwest during most of the year, except during February and March when the prevailing winds are from the north.

Temperatures in the FTRI area vary widely and often fluctuate abruptly throughout the year. July and August are the hottest months, averaging 80 degrees Fahrenheit (°F). January is the coldest month, averaging 26°F. The average date of the last killing frost in spring is 22 April and the average date of the first killing frost of the fall is 17 October. The area has an average of 180 frost-free days per year.

Average yearly precipitation is 31.64 inches and 75 percent (%) of the precipitation falls within the 6-month period from April through September, with the three highest rainfall averaging more than 4 inches per month in May, June, and July. Much of this precipitation occurs during severe thunderstorms, when 2 inches or more of rain may fall in one storm. The driest months are December, January, and February, with each averaging less than 1.56 inches of liquid equivalent precipitation. An average of 22 inches of snowfall occurs annually.

Insufficient precipitation is the major limiting factor to plant growth at FTRI. Spring rains are sufficient to recharge soil moisture before the summer months when evapotranspiration rates typically exceed precipitation rates, especially in the latter half of the summer. In years of below average rainfall, soil moisture in the upper soil levels is depleted, which stresses shallow rooted plants (Bay West, 2014a).

1.4.2 Topography

Three types of geological-physiographic areas comprise FTRI: high upland tall grass prairies; alluvial bottomland floodplains; and broken and hilly transition zones. Alternating layers of

Permian-aged limestone and shale dominate the uplands. Softer shale units are weathered and eroded at a significantly faster rate than the more resistant limestone escarpments, which form the broken and hilly transition areas of the central and east portions of FTRI. The cutting action of the streams on the thick shale units has sculpted much of the area into a rolling plateau. FTRI is comprised of two types of alluvial bottomlands: wide meandering floodplains of major rivers with associated terraces, and areas created by smaller creeks and streams that cut the uplands (Bay West, 2014a).

1.4.3 Hydrology

Surface waters on FTRI are within the Lower Republican-Upper Kansas River drainage basin. Intermittent and perennial creeks, ponds, lakes, and rivers are represented at FTRI. With 15,600 surface acres of water and 163 miles of shoreline, Milford Lake is a reservoir on the western edge of FTRI that impounds the Republican River; it is located approximately 2.25 miles upstream of CFLFA2. FTRI has an additional 174 lakes and ponds ranging in size from 0.1 to 40 acres. With the exception of three oxbow lakes, the lakes and ponds on FTRI are man-made. Approximately 50% of these impoundments have little water. FTRI manages 29 lakes and ponds to provide fishing opportunities for civilian and military personnel.

FTRI is drained by the following: Republican River, Kansas River, Threemile Creek, Sevenmile Creek, Honey Creek, Wildcat Creek, and numerous smaller tributaries. The Kansas and Republican Rivers are along the southern boundary of FTRI. FTRI has 14 named creeks, 10 of which have perennial flow. Numerous unnamed intermittent flow creeks are also present at FTRI. The CFLFA2 straddles the Republican River and some of its tributaries (Bay West, 2014a).

1.4.4 Geology

FTRI is underlain by consolidated bedrock of Permian age. The bedrock is comprised of the Chase Group formation from the Upper Permian system which is exposed at the ground surface in many areas or covered by a thin mantle of loess (wind-blown silts). Older Permian rocks of the Council Grove Group are limited to the southeastern portion of the FTRI.

The Permian bedrock units consist of alternating layers of shale and limestone. The Barneston and Winfield Formations underlie most of FTRI; both units contain limestone and shale members. Many of the more prominent bedrock outcrops at FTRI are composed of the Fort Riley Limestone Member of the Barneston Limestone, which due to its 30-foot thickness and its massive, chert-free character, is resistant to erosion. The Barneston Limestone Formation is visible in many stream banks as white, wall-like exposures. The Fort Riley Limestone is prominent as a 'rim rock' outcrop that has a 'wall-like' appearance near the top of bluff lines.

The overall thickness of the Fort Riley Limestone Member is 30- to 45-feet and is a massive to thin-bedded limestone with minor shale. The basal part is the massive 'rim rock.' Quaternary-aged alluvial sand and gravel deposits are present within the river floodplains. The alluvial deposits of the Republican River consist of clay, silt, and sand near the surface and coarser sands and gravel at depth. The alluvial deposits are underlain by area limestones and shales (Bay West, 2014a).

1.4.5 Hydrogeology

Alluvial sand and gravel deposits in the FTRI area serve as excellent aquifers. Water table maps indicate the general direction of groundwater flow in the alluvial aquifer is down the valley, but flow can be variable near the Kansas and Republican Rivers in the FTRI vicinity. Groundwater levels in the alluvial aquifer are affected primarily by the stage of the Kansas River and to a lesser extent by the stage of tributaries, ponds, and lakes and by infiltration from precipitation. The correlation between Kansas River stage and groundwater levels in the alluvial aquifer is strongest near the river and weakens farther from the river.

FTRI and the surrounding communities of Junction City, Ogden and Manhattan rely on groundwater withdrawn from alluvial materials. FTRI has eight active water supply wells. In the upland areas, the limestone formations are identified as groundwater sources. Lateral inflow of groundwater from adjacent bedrock likely contributes a small but important component of groundwater to the alluvial aquifer in the valley. The town of Riley and many of the rural residences surrounding FTRI are located in the uplands area and their wells tap bedrock formations. For example, the town of Riley uses seven wells ranging in depths from 90- to 100-feet and the wells draw water from the limestone formations. In general, the limestone formations are sufficiently transmissive to yield reliable groundwater supplies. Groundwater in the uplands area is generally present within 100 feet of the ground surface (Bay West, 2014a). During the SI field work, groundwater was encountered at depths of 14 to 24 feet bgs (Engineering-Environmental Management, Inc. [e^{2}M], 2006).

1.4.6 Vegetation Types

The vegetation in the MRS includes four main vegetation communities (Bay West, 2014a):

- **Riverine Sand Flats/Bars** – occurs on alluvial sands in the beds of rivers and streams. Vegetation usually is highly ephemeral due to hydraulic action of the Republican River. Plant types include purslane, amberique bean, curly top knotweed, bearded sprangletop and various sedges.
- **Green Ash-Elm-Hackberry Forest** – occurs in the upper floodplain terraces of the Republican River. It has an open to closed canopy. Trees are mainly American elm, ash, and hackberry with a lesser occurrence of walnut, maple, and cottonwood. The subcanopy may include slippery elm. The shrub layer is very diverse and includes poison ivy, Missouri gooseberry, coral berry, and common prickly ash. Herbaceous undergrowth includes fescue, Virginia wild rye, and catchweed bed straw.
- **Eastern Cottonwood-Black Willow Forest** – occurs on the floodplain terraces along the Republican River. It has closed or nearly closed tree canopies and consists chiefly of cottonwood and black willow trees with a smaller amount of maple, poplar, willow, and sycamore trees. The undergrowth often lacks shrubs and herbaceous types are lush but patchy consisting of such types such as purslane and rice cutgrass.
- **Oak Ravine Woodland –** occurs on moderate to steep south and west facing slopes along the Republican River. It is an open-canopy, upland community dominated by chinquapin oak and bur oak. Elm and eastern redbud are found in moister areas. Common shrubs are dogwood and coral berry. Herbaceous species include little bluestem and switchgrass.

1.4.7 Wildlife and Fish

There is no federally-listed critical habitat on FTRI. The Kansas Department of Wildlife and Parks has rated the Republican River as a high priority fishery resource. Primary habitat types identified by the Kansas Biological Survey in proximity of the CFLFA2 include sand prairie and floodplain forest. Sand prairie is restricted to the floodplain of the Republican River, usually immediately adjacent to the river (Integrated Natural Resources Management Plan [INRMP], 2010).

The three federally-listed species have been documented on FTRI as follows: the least tern and Topeka shiner, with are both endangered, and the piping plover which is threatened. The bald eagle, delisted in 2007, is a year-round resident. The Kansas-listed species documented on FTRI are the least tern which is endangered, and the plains minnow, piping plover, snowy plover, sturgeon chub and Topeka shiner which are all threatened. Two of the listed species on the installation are birds that use riverine habitat along the Republican River. Of these listed species, the least tern and piping plover are uncommon, primarily transient migrants, but are also potential breeders along the Republican and Kansas River sandbars. The piping plover has been observed along the Republican River sandbars. Bald eagles are frequently observed perched along the Republican River and flying over FTRI, particularly during winter months (INRMP, 2010).

The U.S. Army created a Species at Risk (SAR) list to identify imperiled species that would have a significant impact on military missions if federally-listed as threatened or endangered. The objective of creating the SAR list is to proactively conserve these species now and thereby preclude the need for a future listing. U.S. Army-designated SARs that occur on FTRI are the Henslow's sparrow, regal fritillary, rusty blackbird, and Texas horned lizard (INRMP, 2010).

Species in Need of Conservation (SINC) is a Kansas designation given to any nongame species in the state deemed to require conservation measures in an attempt to keep the species from becoming a threatened or endangered species. SINC species do not have the level of statutory protection as those species listed as threatened or endangered in Kansas. Species on the SINC list that have been documented on FTRI are the prairie mole cricket, blue sucker, common shiner, Johnny darter, southern redbelly dace, western hognose snake, black rail, black tern, bobolink, ferruginous hawk, golden eagle, Henslow's sparrow, short-eared owl, whip-poor-will, and southern bog lemming (INRMP, 2010).

1.5 Current and Anticipated Future Land Use

The CFLFA2 footprint consists of a river shoreline with sandbars along the Republican River and small, heavily wooded portions at the fringes. The FTRI property boundary extends into the Republican River (**Figure 1-2**).

In 1997, the U.S. Army entered into a licensing agreement with Junction City, Kansas to allow construction of a pedestrian trail and recreational access along the Republican River adjacent to the original Camp Forsyth Landfill footprint. The river shoreline, a relatively flat area, is used for a nature trail maintained by the City of Junction City through an easement with FTRI and is currently open to the public. FTRI posted (May 2002) a series of unexploded ordnance (UXO) warning signs stating the following: "Caution Potential Unexploded Ordnance May Be Present in the Area, Avoid Entry" between the riverbank stabilization area and the nature trail. The purpose of the signs is to notify the public of the site conditions. There are currently no known plans to change the land use at the CFLFA2 MRS (Bay West, 2014a).

1.6 Nature and Extent of MEC and MC

The term MEC distinguishes specific categories of military munitions that may pose unique explosive safety risks, including the following:

- **Unexploded ordnance (UXO)**—Military munitions that fulfill the following criteria:
  - Have been primed, fused, armed, or otherwise prepared for action;
  - Have been fired, dropped, launched, projected, or placed in a manner as to constitute a hazard to operations, installations, personnel, or material; and
  - Remain unexploded either by malfunction, design, or any other cause (DoD, 2008).
- **Discarded military munitions (DMM)**—Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include UXO, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations. (DoD, 2008).

The definition of MEC also includes MC, such as trinitrotoluene (TNT) and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), present in soil, facilities, equipment, or other materials in high enough concentrations so as to pose an explosive hazard (DoD, 2008).

MC is defined as follows:

- Any materials originating from MEC, DMM, or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such munitions (DoD, 2008).

A summary of the nature and extent of MEC and MC is discussed in the following subsections.

1.6.1 MEC

In February 1993, an installation-wide assessment for FTRI was completed that identified the Camp Forsyth Landfill as a potential area of environmental concern (PAOC). The Installation-Wide Site Assessment stated that "The landfills are expected to consist of predominately municipal type waste. This waste often includes hazardous substances associated with small amounts of paints, inks, cleaners, etc." Contaminants typically associated with municipal type wastes and mixed wastes include metals and volatile organic compounds; however, there are no records or indications of hazardous waste disposal in the Camp Forsyth Landfill (Bay West, 2012b). No mention was made of munitions disposal in the landfill. In addition, operations at the landfill started during WWII. Since the designated site for treating MEC was Range 16, there is no reason to expect MEC were landfilled at the Camp Forsyth Landfill (Bay West, 2014a).

In December 2001, Wenck Associates, Inc. (Wenck) completed what was termed a removal action consisting of constructing a bank stabilization revetment to halt the erosion of the Republican River bank into the former Camp Forsyth Landfill and its exposed landfill trenches. In August 2000, prior to starting the first phase of construction activities, the UXO subcontractor (ISSI UXO, Inc.) conducted an initial UXO survey of the access road, stockpile, and trailer areas to identify any UXO that might be present. The UXO subcontractor then performed an initial UXO survey of the riverbank and river bottom. The following UXO items were encountered during construction: blank small arms cartridges, 30 caliber (cal) magazine containing live cartridges, 2.36-inch rocket heads, 2.36-inch anti-tank (AT) rocket, 2.36-inch rocket motor, 3.5-inch AT rocket, 4.2" mortar primers/igniters, dynamite (3 ounces), and miscellaneous AT round components. An apparent OB/OD site was discovered approximately 100 feet outside of the active construction area (southwest of Baffle 5) on and around a sandbar in the middle of the Republican River. The OB/OD site is likely associated with the MEC disposal activities conducted in 1994 in response to the 1993 flood. Numerous 2.36-inch and 3.5-inch AT rockets, two rifle grenades (smoke), and other blank small arms cartridges were found at the OB/OD site. The FTRI 774th EOD inspected the area, fenced it off, and detonated the items in-place after Wenck's demobilization from the site.

FTRI personnel began conducting annual inspections of the Republican River sandbars and riverbed in approximately 2002. While suspect munitions were encountered, the subsequent blow-in-place (BIP) operations by FTRI's EOD did not yield sympathetic detonations. This indicates that the suspect munitions were inert MD, not MEC. (Fort Riley 774th Explosive Ordnance Disposal Detachment, 2003 and e2M, 2006).

An SI was then completed to evaluate the potential for MEC, MC, or MD at FTRI. The SI Report included the findings of an investigation completed in July 2005 at CFLFA2. During the visual/magnetometer survey of the originally-designated MRS, a number of suspected MD and MEC items were observed on a sandbar in the Republican River, including 7.62-millimeter (mm) cartridges, .50-cal cartridges, expended 2.36-inch rocket bodies, 2.36-inch rocket nose cones, smoke grenades and rifle grenades. Analytical results of surface soil samples did not indicate the presence of explosives at concentrations greater than the limits of detection (LODs), nor metals at concentrations greater than the KDHE Bureau of Environmental Remediation Tier 2 Standards. Based on results of the SI, the CFLFA2 was recommended for further characterization. Subsequent to the SI, the MRS footprint was modified to include the off-post sandbars and banks of the Republican River and to exclude the active training area (e^{2}M, 2006).

During the SI field work, as documented in the May 2006 SI Report, no MEC that required detonation was found. This includes both the landfill (which is now within the active training area) and the sandbars within the CFLFA2; nor did any soil samples indicate the presence of MC (Bay West, 2014a).

In 2011, Bay West performed the initial RI field effort at CFLFA2 (i.e., Mobilization 1), which was summarized in the 2011 Technical Memorandum (Bay West, 2011b). The RI field work did not identify a definitive source of the encountered MEC and MD. A large amount of MD was recovered in an area that is not downstream of the CFLFA2 landfill. No rocket targets were encountered; however, three dud M6 rockets were encountered. MD such as fins, nose cones and expended motors related to M6 and M7 rockets were encountered. Trip flares and landmines were encountered in the bank of the river within the central region of the MRS which included practice AT landmines and one live AT landmine.

Based on these findings, a follow-on RI effort was completed from 2014-2015. The effort was completed over three mobilizations (Mobilization 1, Mobilization 2, and Mobilization 3). The follow-on RI included an expanded RI area, including underwater areas and a portion of Breakneck Creek. The goal of the RI was to delineate the nature and extent of MEC at the CFLFA2 MRS. A total of 14 MEC items were recovered. The average MEC density for the area investigated (48.7 acres) was 0.29 MEC/acre. In general, the MEC encountered were located adjacent to or in the Republican River at depths up to 2 feet. Concentrated areas of MD were encountered in sediments and sandbars within the Republican River and were located primarily within the northern portions of the MRS. Pits of debris were excavated to depths up to 9 feet bgs.

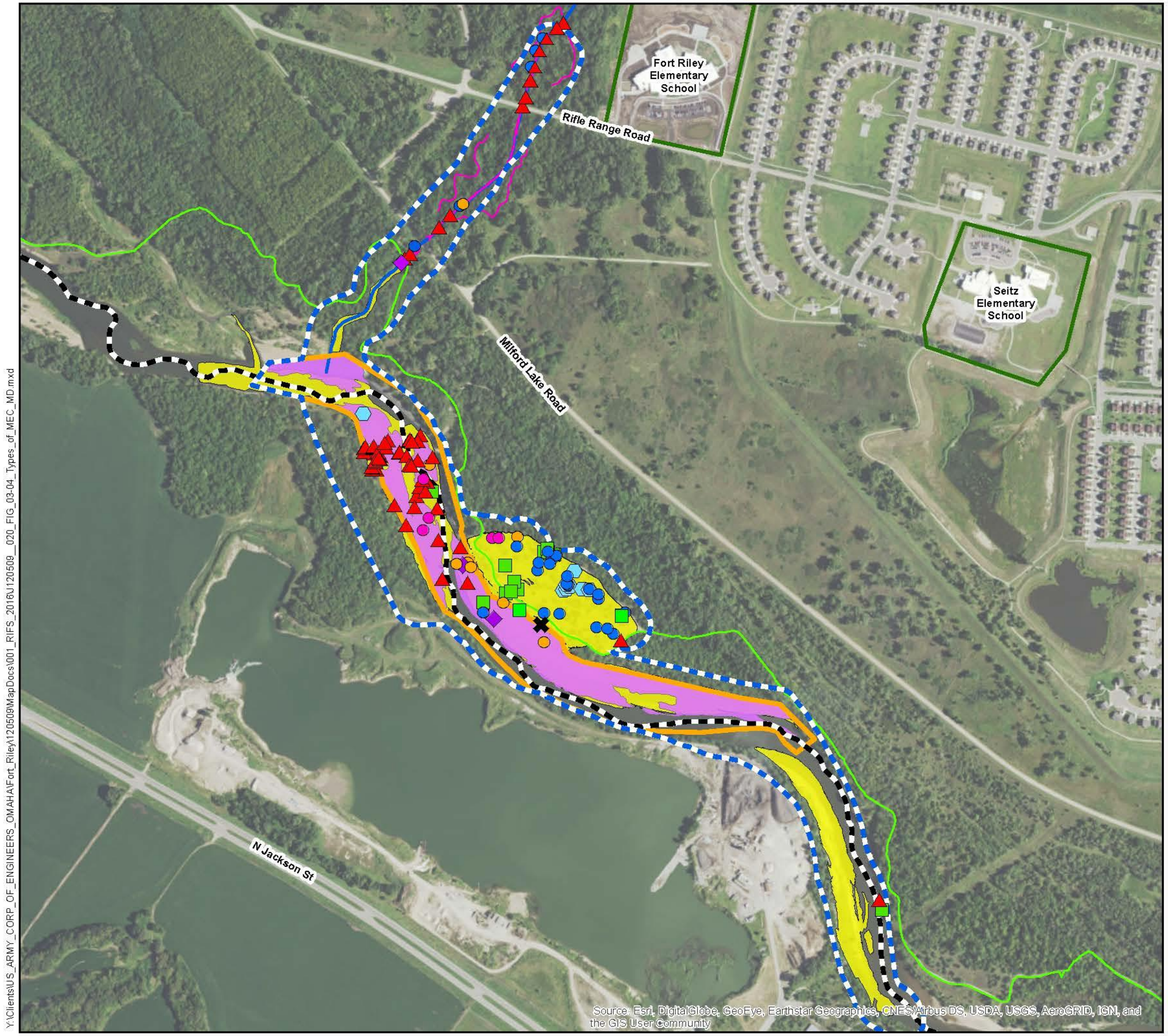
A trash pit was encountered during the follow-on RI effort. The pit was dense with household waste and MD. The pit was characterized using earth moving machinery. Although the pit was determined to be a potential source of MEC and MD in the Republican River, it was concluded that it did not appear to be the only source. Although not intrusively investigated, the follow-on digital geophysical mapping (DGM) that was performed as well as surveys completed to the north of the pit indicate additional anomalies are present that may represent MEC upstream of the pit. These anomalies were not investigated due to a decision made by the project team for the underwater area to excavate as many anomalies as funding permitted within the field season because, due to the annual flooding events, an anomaly is only valid for the current dig season. This decision did not impact meeting RI objectives as the total number of anomalies that were investigated exceeded the statistical requirement for characterization (i.e., to determine with 95% confidence and ± 2.5% sampling error the proportion of MEC to non-MEC magnetic anomalies within the total population).

In addition, the MEC and MD encountered in Breakneck Creek indicate that munitions extend beyond the Republican River.

A summary of the types of identifiable MD encountered during the follow-on RI is presented in **Figure 1-4**. The trends evidenced by these data include:

- **Rockets**: rocket debris was clustered along Breakneck Creek and in the northern portions of the CFLFA2. This supports historical records which indicate that there was a rocket range near the current location of the Fort Riley Elementary School.

- **Grenades**: grenade debris was found primarily along Breakneck Creek and near the historical Vietnam village.
- **Mines**: anti-personnel (AP) and AT landmine debris was found near the historical Vietnam village.
- **Trip Flares**: in general, trip flare debris was encountered near the historical Vietnam village. Additional trip flare debris was encountered upstream of the village.


Fort Riley Elementary School
Rifle Range Road
Seitz Elementary School
Milford Lake Road
N Jackson St
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
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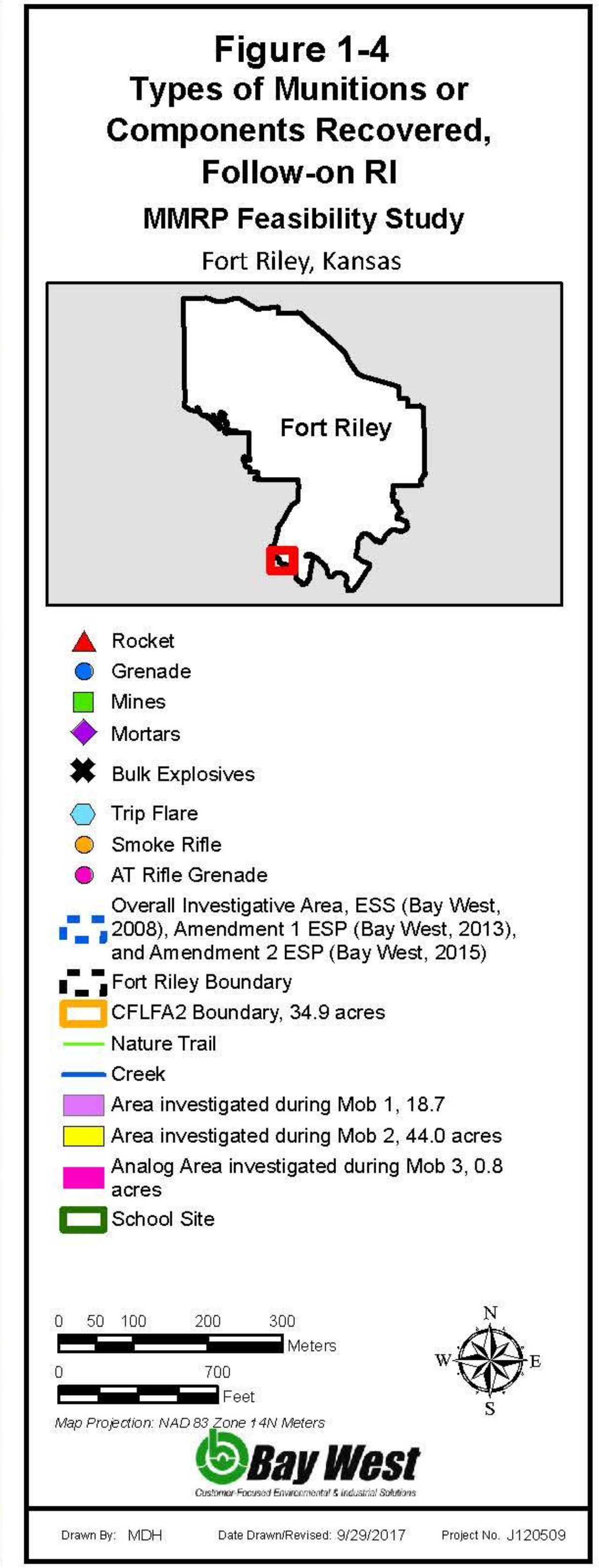
Figure 1-4
Types of Munitions or Components Recovered, Follow-on RI
MMRP Feasibility Study
Fort Riley, Kansas
Fort Riley
Rocket
Grenade
Mines
Mortars
Bulk Explosives
Trip Flare
Smoke Rifle
AT Rifle Grenade
Overall Investigative Area, ESS (Bay West, 2008), Amendment 1 ESP (Bay West, 2013), and Amendment 2 ESP (Bay West, 2015)
Fort Riley Boundary
CFLFA2 Boundary, 34.9 acres
Nature Trail
Creek
Area investigated during Mob 1, 18.7
Area investigated during Mob 2, 44.0 acres
Analog Area investigated during Mob 3, 0.8 acres
School Site
0 50 100 200 300 Meters
0 700 Feet
Map Projection: NAD 83 Zone 14N Meters
Bay West
Drawn By: MDH
Date Drawn/Revised: 9/29/2017
Project No. J120509

- **Rifle Grenade (smoke and AT)**: rifle grenade debris was encountered in the banks and the river near the historical Vietnam village.

In addition, range-related debris (RRD), small arms ammunition debris (SAAD), and other debris (OD) was recovered during the follow-on RI as described below:

- **RRD and SAAD**: RRD and SAAD were encountered in the Republican River, Breakneck Creek, and the banks of the Republican River. The highest densities of RRD and SAAD were located in the vicinity of the Vietnam village and where Breakneck Creek meets the Republican River. In general, RRD and SAAD were not recovered downstream of the historical Vietnam village.
- **OD**: OD was the most common material recovered during the RI. It was most dense from the south portion of Breakneck Creek to just downstream of the Vietnam Village. Although the density of OD recovered does not assist with the definition of the nature and extent of MEC and MD at the site, it provides context for the level of effort for any future investigation or remedial activities in the area.

Although a specific source area has not been identified, the findings of the three mobilizations support the findings of the HRR (discussed in **Section 1.3.1.1**) which indicate that the landfill itself is not the specific source. MEC that are present in site media may be associated with the historical maneuver areas or active training areas. **Figure 1-5** indicates areas associated with the historical maneuver areas and active training areas that that may have MEC present. In addition, areas downstream from the historical maneuver areas—whether that be downstream from the current location of the Republican River or the historical alignment of the river—may have MEC present.

Based on the findings from the RIs, a FS for MEC was recommended for the portions of the areas investigated that are not part of the active training areas or landfill (i.e., the areas hatched in red within the orange circles on **Figure 1-5**). These are considered to be the primary source areas for MEC. Secondary areas that may also be impacted include areas within the historical maneuver areas and areas downstream of the historical maneuver areas (i.e., areas hatched in red outside of the orange circles on **Figure 1-5**). The areas located within the active training areas or landfill were recommended for management for MEC and MC under their respective programs so are not included in this FS.

1.6.2 <u>MC</u>

Environmental sampling of soil, surface water, sediment, and groundwater for MC was completed for the RI field efforts. The MC sample results are presented in **Tables 1-1 through 1-4** where they are compared to their most conservative media-specific human health and ecological soil screening levels (Eco-SSLs).

Nine metals and one explosive compound were detected in soil where onsite demolition activities were performed for Material Potentially Posing an Explosive Hazard (MPPEH) found during the RI. A discussion of these results is provided following the tables at the end of this section, including evaluation of the potential impact to human health and ecological receptors due to RI demolition activities at the site.

Seven metals and one explosive compound were detected in site characterization samples. The risk posed by the constituents identified in the MC evaluation samples were evaluated in a human health risk assessment (HHRA) and screening level ecological risk assessment (SLERA). The results from the HHRA and SLERA is presented in **Section 1.7.2**.

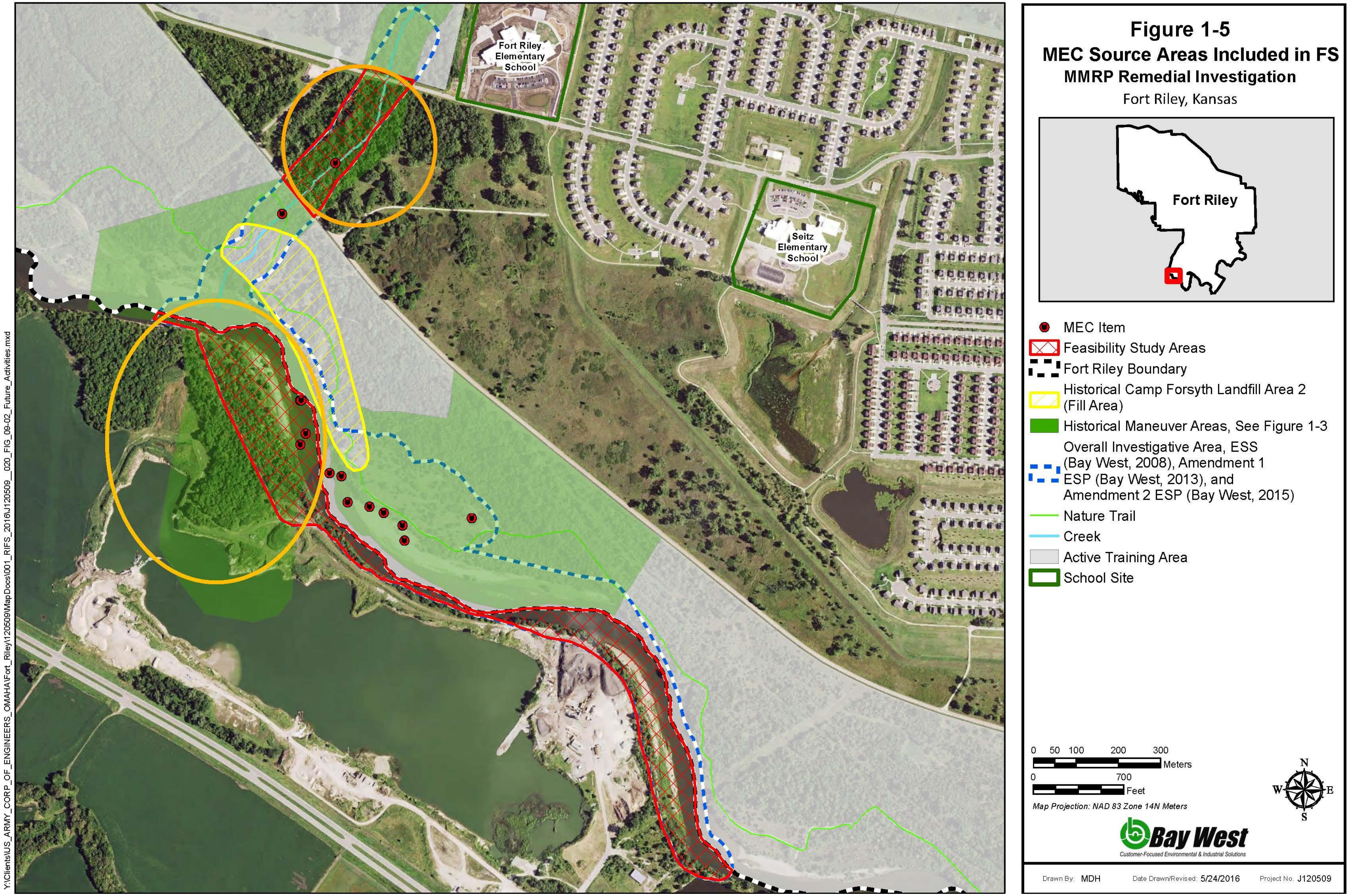
Figure 1-5
MEC Source Areas Included in FS
MMRP Remedial Investigation
Fort Riley, Kansas
Fort Riley
Fort Riley Elementary School
Seitz Elementary School
MEC Item
Feasibility Study Areas
Fort Riley Boundary
Historical Camp Forsyth Landfill Area 2 (Fill Area)
Historical Maneuver Areas, See Figure 1-3
Overall Investigative Area, ESS (Bay West, 2008), Amendment 1 ESP (Bay West, 2013), and Amendment 2 ESP (Bay West, 2015)
Nature Trail
Creek
Active Training Area
School Site
0 50 100 200 300 Meters
0 700 Feet
Map Projection: NAD 83 Zone 14N Meters
Bay West
Drawn By: MDH
Date Drawn/Revised: 5/24/2016
Project No. J120509
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Table 1-1 MC Analytical Data, Soil

Analyte	Background Levels (mg/kg) [5]	Human Health Screening Criteria* (mg/kg)	Ecological Screening Criteria† (mg/kg)	4/12/2011 CFLFA2-11-04-S-003-PS	4/12/2011 CFLFA2-11-04-S-004-PS	4/12/2011 CFLFA2-11-04-S-005-PS	4/12/2011 CFLFA2-11-04-S-006-PS	4/12/2011 CFLFA2-11-04-S-007-PS	4/12/2011 CFLFA2-11-04-S-008-TS [1]	4/13/2011 CFLFA2-11-04-S-009-PS	4/14/2011 CFLFA2-11-04-S-010-PS	4/14/2011 CFLFA2-11-04-S-011-PS	4/14/2011 CFLFA2-11-04-S-013-PS	4/14/2011 CFLFA2-11-04-S-014-PS	4/14/2011 CFLFA2-11-04-S-015-TS [3]	4/14/2011 CFLFA2-11-04-S-017-PS	4/18/2011 CFLFA2-11-04-S-018-PS	4/18/2011 CFLFA2-11-04-S-019-PS	6/19/2014 CFLA2-14-06-S-002-PS	6/19/2014 CFLA2-14-06-S-003-PS	6/19/2014 CFLA2-14-06-S-004-PS	6/19/2014 CFLA2-14-06-S-005-PS	6/19/2014 CFLA2-14-06-S-006-PS	2/16/2011 CFLFA2-11-02-S-001-PS	4/5/2011 CFLFA2-11-04-S-002-PS	4/14/2011 CFLFA2-11-04-S-012-PS [2]	4/14/2011 CFLFA2-11-04-S-016-PS [4]	10/28/2015 CFLA2-15-10-S-013-PS	11/4/2015 CFLA2-15-11-S-014-PS	11/4/2015 CFLA2-15-11-S-015-FS
			Sample Type	Investigative Area Soil																				Demolition Area Soil						
Inorganics (mg/kg)																														
Antimony	6	31	0.27	0.58 U	0.59 U	0.57 U	0.59 U	0.55 U	0.58 U	0.55 U	0.57 U	0.59 U	0.58 U	0.57 U	0.58 U	0.55 U	0.60 U	0.55 U	0.63 U	0.65 U	0.63 U	0.62 U	0.65 U	0.59 U	0.58 UJ	0.56 U	0.56 U	**0.44 J**	0.48 U	0.49 U
Arsenic	5	0.68	18	**2.1 J**	**1.1 J**	**1.5 J**	**1.5 J**	**1.4 J**	**1.9 J**	**1.2 J**	**1.0 J**	**1.1 J**	**1.1 J**	**1.3 J**	**1.2 J**	**1.3 J**	**1.4 J**	**0.76 J**	**1.4 J**	**3.8**	**2**	**2**	**1.7**	**1.0 J**	**0.88 J**	**1.3 J**	**1.4 J**	**5**	**2.5**	**2.4**
Barium	–	15,000	330	**31**	**22**	**33**	**28**	**36**	**31**	**23**	**22**	**16**	**21**	**22**	**29**	**29**	**38**	**21**	**38 J**	**52**	**40**	**35**	**33**	**25**	**18**	**29**	**38**	**130 J**	**46**	**41**
Cadmium	1	71	0.36	**0.048 J**	0.098 U	**0.041 J**	0.099 U	**0.049 J**	**0.046 J**	0.091 UJ	0.096 U	0.098 U	0.097 U	0.095 U	0.096 U	0.091 U	**0.047 J**	0.092 U	**0.069 J**	**0.10 J**	**0.11 J**	**0.049 J**	**0.15 J**	0.099 U	0.097 U	0.093 U	0.094 U	**0.53**	**0.10 J**	**0.078 J**
Chromium	24.06	0.3	26	**2.1 J**	**0.88 J**	**2.0 J**	**1.6 J**	**2.6 J**	**2.1 J**	**1.1 J**	**0.87 J**	**0.69 J**	**0.97 J**	**1.4 J**	**1.0 J**	**2.4 J**	**2.7 J**	**1.1 J**	**1.0 J**	**3.1**	**1.9 J**	**1.3 J**	**1.5 J**	**0.75 J**	**0.85 J**	**0.83 J**	**0.87 J**	**12 J**	**3.4**	**3.4**
Copper	17.68	3,100	28	**1.8 J**	**0.57 J**	**1.5 J**	**1.6 J**	**2.7 J**	**1.7 J**	**0.71 J**	**0.47 J**	**0.38 J**	**0.68 J**	**0.64 J**	**0.72 J**	**1.3 J**	**1.6 J**	**0.54 J**	**1.2 J**	**3.3**	**3.2**	**2.9**	**3.8**	**0.38 J**	**0.53 J**	**1.3 J**	**1.4 J**	**2700**	**4.9**	**3.7**
Lead	32.31	400	11	**2.9**	**1.3**	**3.9**	**2.6**	**2.2**	**2.7**	**1.7 J**	**1.5**	**1.4**	**6.5 J**	**2**	**1.9 J**	**2.5**	**2.9**	**1.7**	**2.2**	**3.2**	**4.7**	**3**	**1.8**	**1.2**	**1.4**	**2**	**2.3**	**770 J**	**4.1**	**3.8**
Selenium	0.6	390	0.52	1.2 U	1.2 U	1.1 U	1.2 U	1.1 U	1.2 U	1.1 U	1.1 U	1.2 U	1.2 U	1.1 U	1.2 U	1.1 U	1.2 U	1.1 U	1.3 U	1.3 U	1.3 U	1.2 U	1.3 U	1.2 U	1.2 U	1.1 U	1.1 U	**1.4 J**	**0.83 J**	0.97 U
Zinc	72.86	23,000	46	**11**	**4.2**	**6.8**	**8.9**	**8.7**	**7.9**	**4.2 J**	**2.8 J**	**2.4 J**	**5.5**	**4.6**	**4.1**	**8.6**	**8**	**3.2**	**50 J**	**11**	**16**	**10**	**5.9**	**2.5 J**	**2.6 J**	**3.5**	**4.2**	**130 J**	**11**	**11**
Explosives (mg/kg)																														
2,4,6-TNT	–	21	7.6	0.039 U	0.038 U	0.038 U	0.038 U	0.040 U	0.038 U	0.040 U	0.037 U	0.038 U	0.040 U	0.040 U	0.039 U	**0.96**	0.037 U	0.038 U	0.040 U	0.039 U	0.039 U	0.039 U	0.038 U	0.039 U	0.038 U	0.040 U	0.039 U	0.097 U	0.095 U	0.096 U
Tetryl	–	160	1.5	0.078 U	0.075 U	0.076 U	0.077 U	0.080 U	0.077 U	0.079 U	0.074 U	0.076 U	0.080 U	0.079 U	0.077 U	0.076 U	0.075 U	0.077 U	0.079 U	0.079 U	0.078 U	0.078 U	0.076 U	0.077 U	0.075 U	**0.047 J**	0.078 U	**0.11 J**	0.095 U	0.096 U

Notes:

Shaded indicates the result exceeds one or more screening criterion

Bold = Result above LOD

** Screening criteria is the most conservative of KDHE risk-based residential scenario values for soil (soil pathway and soil to groundwater pathway) (RSK Manual, 5th Version, September 2015) and the EPA Regional Screening Level (RSL) for residential soil (USEPA RSL Table, November 2017).*
RSLs are based on a 1E-06 excess cancer risk and a non-cancaer target hazard quotient of 1.0.

† Screening criteria is the most conservative of the EPA Eco-SSLs. If an Eco-SSL is not available, the most conservative Los Alamos National Laboratory (LANL) EcoRisk Database Ecological Screening Levels (ESLs) (Release 3.2, October 2014) was used.

– Not established or insufficient data to calculate value

(1) Replicate sample of S-003

(2) Post-explosive demil sample (pre explosive sample = S-001)

(3) Replicate sample of S-013

(4) Post-explosive demil sample (pre explosive sample = S-002)

(5) Burns and McDonnell, 2001

J = estimated quantity

mg/kg = milligrams per kilogram

U = non-detection as <LOD

LOD = limit of detection

Table 1-2 MC Analytical Data, Sediment

Analyte	Human Health Screening Criteria* (mg/kg)	Ecological Screening Criteria† (mg/kg)	04/14/11 CFLFA2-11-04-SD-001-PS	04/14/11 CFLFA2-11-04-SD-002-PS	04/14/11 CFLFA2-11-04-SD-003-PS	04/14/11 CFLFA2-11-04-SD-004-FS (1)	08/27/14 CFLA2-14-08-SD-010-PS	08/27/14 CFLA2-14-08-SD-011-PS	08/27/14 CFLA2-14-08-SD-012-PS
Inorganics (mg/kg)									
Arsenic	0.68	9.79	**2.0**	**1.4 J**	**2.2**	**1.0 J**	**1.5**	**0.78 J**	**1.1 J**
Barium	15,300	48	**34**	**27**	**27**	**19**	**39**	**24**	**25**
Cadmium	71	0.99	0.10 U	0.11 U	**0.078 J**	0.11 U	0.098 U	0.088 U	0.11 U
Chromium	0.3	43.4	**1.1 J**	**0.61 J**	**0.80 J**	**0.61 J**	**1.0 J**	**0.74 J**	**1.1 J**
Copper	3,100	31.6	**0.98 J**	**0.72 J**	**0.83 J**	**0.66 J**	**0.88 J**	**0.53 J**	**0.53 J**
Lead	400	35.8	**2.0**	**1.5**	**2.7**	**1.2**	**2.0**	**1.2**	**1.2**
Zinc	23,000	121	**3.6**	**3.0**	**3.2**	**2.2 J**	**4.9**	**3.3**	**4.0**

Shaded indicates the result exceeds one or more screening criterion
Bold = Result above LOD
LOD = limit of detection
** Screening criteria is the most conservative of KDHE risk-based residential scenario values for soil (soil pathway and soil to groundwater pathway) (RSK Manual, 5th Version, September 2015) and the EPA Regional Screening Level (RSL) for residential soil (USEPA RSL Table, November 2017) was used. RSLs are based on a 1E-06 excess cancer risk and a non-cancer target hazard quotient of 1.0*

† Screening criteria is the consensus-based Threshold Effect Concentration (TEC) (MacDonald et al., 2000). If a TEC is not available, the LANL ESL (Release 3.2, October 2014) was used.

(1) Duplicate sample of SD-003

ESL = ecological screening level

LANL = Los Alamos National Laboratory

Table 1-3 MC Analytical Data, Surface Water

Analyte	Human Health Screening Criteria* (µg/L)	Ecological Screening Criteria† (µg/L)	04/14/11 CFLFA2-11-04-SW-001-PS	04/14/11 CFLFA2-11-04-SW-002-PS	04/14/11 CFLFA2-11-04-SW-003-PS	04/14/11 CFLFA2-11-04-SW-004-FS (1)	08/27/14 CFLA2-14-08-SW-007-PS	08/27/14 CFLA2-14-08-SW-008-PS	08/27/14 CFLA2-14-08-SW-009-PS
Inorganics (µg/L)									
Arsenic	0.052	150	**9.4 J**	**6.5 J**	**6.2 J**	**8.4 J**	**11 J**	**11 J**	**9.1 J**
Barium	2,000	--	**230**	**220**	**220**	**220**	**210**	**190**	**190**
Chromium	0.035	40	1.5 U	1.5 U	1.5 U	1.5 U	**1.3 J**	1.5 U	1.5 U
Copper	800	9.3 a,b	**3.1 J**	**3.7 J**	**3.2 J**	**3.1 J**	**3.6 J**	3.5 U	3.5 U
Selenium	50	5	**9.1 J**	12 U	12 U	12 U	12 U	**4.9 J**	12 U
Zinc	5000	120 a	13 U	13 U	13 U	13 U	**7.5 J**	13 U	13 U

Shaded indicates the result exceeds one or more screening criterion
Bold = Result above LOD
LOD = limit of detection
** Screening criteria is the more conservative of public health domestic water supply values from KDHE Kansas Surface Water Quality Standards (March 2015), USEPA maximum contaminant levels (MCLs) and USEPA tap water RSL (USEPA RSL Table, November 2017). RSLs are based on a 1E-06 excess cancer risk and a non-cancer target hazard quotient of 1.0*
† Screening criteria is aquatic life chronic values from KDHE Kansas Surface Water Quality Standards, March 2015.
-- Not established or insufficient data to calculate value
(1) Duplicate sample of SW-003

[a] Hardness-dependent aquatic life support criteria. Value shown assumes a hardness of 100 mg/L. http://www.kdheks.gov/water/download/swqs_numeric_criteria.pdf

[b] KDHE Bureau of Water. Kansas Surface Water Standards. 1 October 2012. (http://www.kdheks.gov/water/download/swqs_numeric_criteria.pdf)

µg/L = micrograms per liter

J = estimated quantity

LOD = limit of detection

mg/L = milligrams per liter

RSL = regional screening level

U = non-detection as <LOD

Table 1-4 MC Analytical Data, Groundwater

Analyte	Background Levels[c]	Human Health Screening Criteria* (µg/L)	Ecological Screening Criteria† (µg/L)	04/13/11 CFLFA2-11-04-GW-001-PS	04/13/11 CFLFA2-11-04-GW-002-PS	04/13/11 CFLFA2-11-04-GW-003-PS	04/13/11 CFLFA2-11-04-GW-004-PS	04/13/11 CFLFA2-11-04-GW-005-PS	04/13/11 CFLFA2-11-04-GW-006-PS	04/13/11 CFLFA2-11-04-GW-007-FS [(1)]	04/13/11 CFLFA2-11-04-GW-008-PS	04/13/11 CFLFA2-11-04-GW-009-PS
Inorganics (µg/L)												
Arsenic	20	0.052	150	12 U	**4.6 J**	12 U	**11 J**	**5.2 J**	12 U	12 U	12 U	12 U
Barium	--	2,000	--	**150**	**220**	**260**	**430**	**370**	**240**	**220**	**420**	**360**
Chromium	6.5	0.035	40	1.5 U	1.5 U	1.5 U	**8.4 J**	1.5 U	1.5 U	1.5 U	**1.4 J**	**1.2 J**
Copper	52	800	9.3 a,b	**4.0 J**	**4.2 J**	**3.5 J**	**12 J**	**5.0 J**	**2.4 J**	**4.0 J**	**4.0 J**	**4.2 J**
Lead	12	15	2.5 a	5.0 U	5.0 U	5.0 U	**7.8 J**	5.0 U	5.0 U	5.0 U	5.0 U	5.0 U
Selenium	5	50	5	**26**	12 U	**7.8 J**	12 U	12 U	12 U	12 U	**7.0 J**	**6.5 J**
Zinc	388	4,670	120 a	13 U	13 U	13 U	**31 J**	**4.8 J**	13 U	13 U	**5.3 J**	**8.4 J**

Shaded indicates the result exceeds one or more screening criterion
Bold = Result above LOD
LOD = limit of detection
** Screening criteria is the more conservative of the KDHE risk-based residential scenario values for groundwater pathway from RSK Manual 5th Version, September 2015, USEPA maximum contaminant levels (MCLs) and USEPA tap water RSL (USEPA RSL Table, November 2017). RSLs are based on a 1E-06 excess cancer risk and a non-cancer target hazard quotient of 1.0*
† Screening criteria is aquatic life chronic values from KDHE Kansas Surface Water Quality Standards, March 2015.
-- Not established or insufficient data to calculate value
[(1)] Duplicate sample of GW-002
[a] Hardness-dependent aquatic life support criteria. Value shown assumes a hardness of 100 mg/L. http://www.kdheks.gov/water/download/swqs_numeric_criteria.pdf
[b] KDHE Bureau of Water. Kansas Surface Water Standards. 1 October 2012. http://www.kdheks.gov/water/download/swqs_numeric_criteria.pdf
[c.] Burns and McDonnell, 2001

A total of seven Demolition Area soil samples were collected from four demolition locations associated with the 2011 and 2015 field efforts. Explosives were not detected in demolition area soil in concentrations above their respective human health and Eco-SSLs.

The following metals were detected in demolition area soil in concentrations exceeding their respective human health-based screening levels:

- Lead
- Arsenic
- Chromium

The following metals were detected in demolition area soil in concentrations exceeding their respective Eco-SSLs:

- Antimony
- Cadmium
- Copper
- Lead
- Selenium
- Zinc

Of these metals, copper, lead, selenium, and zinc were detected in concentrations exceeding their respective background concentrations (Burns and McDonnell, 2001).

- **Copper, lead, and zinc:** These exceedances were limited to sample location CFLA2-15-10-S-013-PS. This sample location was associated with the Breakneck Creek work and was collected within the historical maneuver areas approximately 1600 feet north of the nearest RI soil sample location. Given the location of this sample and that explosives were not associated with this sample location, these metals in soil are likely not associated with demolition activities and instead, likely indicate an impact from the historical small arms ranges located to the east of the MRS.
- **Selenium:** was detected at two locations (CFLA2-15-10-S-013-PS and CFLA2-15-10-S-014-PS); both detections exceeded the most conservative Eco-SSL. A 1998 USGS study of sediments in Milford Lake as well as other lakes in its drainage basin noted an increase in selenium concentrations due to irrigation of areas within the watershed (Juracek and Ziegler, 1998). The sediment concentration associated with Milford Lake during this study (0.8 mg/kg) is greater than the soil background concentration for selenium at FTRI (0.6 mg/kg). Irrigation water may be contributing to the selenium detected in soil at CFLFA2.

The demolition area shot holes were backfilled, limiting the potential for exposure to residual contaminants.

1.7 Summary of the Risk

1.7.1 MEC Risk Assessment

The CERCLA process for responding to releases or potential releases of hazardous substances includes the development of site-specific risk assessments. The results of the risk assessments are used to help site managers decide whether a response action is required, and to support the risk management decisions that are made through the remedy evaluation, selection, and implementation process. The CERCLA methodology for human health chemical risk assessment was not designed to address explosive safety hazards at MEC sites.

The MEC risk assessment was used to evaluate explosives hazards to human receptors under existing conditions (baseline hazard assessment). The information obtained during the RI field activities was used as the input to the MEC risk assessment. A MEC risk assessment is performed as part of an RI to assess baseline explosive hazards. The potential receptors considered during MEC hazard assessment at this MRS included FTRI residents, recreational users (including residents walking on the nature trail adjacent to the site), FTRI personnel, authorized contractors and trespassers. The potential for expanded use in the future is limited due to location within a flood plain.

By nature, MEC explosive hazards are acute and are therefore evaluated as present or not present. The following three components are used to evaluate the potential for explosive hazard incidents:

- **Severity**: the potential consequences of the effect on human receptors (i.e., initiating and secondary human receptors) should a MEC item detonate;
- **Accessibility**: the likelihood that a human receptor will be able to come in contact with a MEC item; and
- **Sensitivity**: the likelihood that a human receptor will be able to interact with a MEC item such that it will detonate.

Using the findings of the previous investigations and the RI field efforts, CFLFA2 risks are characterized as the following:

- **Severity**: The potential consequences for primary and secondary human receptors include loss of life, limb, and/or livelihood.
- **Accessibility**: MEC and MD have been encountered within and along the banks of the Republican River and Breakneck Creek, and have been reported at the sand dredging operations. A public park is present in the area investigated, and schools and housing are nearby. The areas investigated are publicly accessible; however, warning signs are present in some areas.
- **Sensitivity:** Some of the MEC encountered function using a point-detonating fuze; others (if armed) are pressure or trip-sensitive. A receptor could kick, step on, or pick up one of these items and cause it to function.

A MEC hazard including sensitive munitions that are accessible to the public is present at this site.

1.7.2 MC Risk Assessment

An HHRA and SLERA were performed for the RI to evaluate the potential risks to human and ecological receptors for investigation soil samples collected within the MRS. Details on these assessments can be found in the RI Report (Bay West, 2017).

1.7.2.1 HHRA

The HHRA evaluated the current and potential future exposure of receptors (same as those listed above under **Section 1.7.1**) to site media, including subsurface soil, sediment, surface water, and groundwater. The HHRA considered the contributions from background constituents in addition to the potential effects associated with the site contaminants. In summary, arsenic was the only constituent that exceeded screening levels and was selected as a chemical of potential concern (COPC) in investigative area soil, sediment, and groundwater. No COPCs were identified in surface water.

- **Noncancer Risk**: A "total" noncancer estimate or hazard index (HI) was calculated for a resident and a non-resident by summing hazard quotient (HQ) values for investigative area soil, sediment, and groundwater. The total noncancer HI exceeded the regulatory level of concern (an HI of 1) with an HI of 2 observed for the resident but did not exceed the regulatory level of concern (an HI of 1) with an HI of 0.01 for the non-resident (industrial) user.
- **Cancer Risk**: Cumulative cancer risk estimates were calculated for a resident and a non-resident by summing cancer risk estimates for soil, sediment, and groundwater. The total cancer risk for the residential receptor group (2×10^{-4}) exceeded the 10^{-6} to 10^{-4} risk management range for adverse cancer effects while the total cancer risk for the non-residential receptor group (2×10^{-6}) fell within the 10^{-6} to 10^{-4} risk management range.

These risks were driven by the risk associated with arsenic in groundwater. While arsenic concentrations in investigative area soil, sediment, and groundwater exceeded human health-based screening levels, the concentrations found were below natural background. The maximum investigative area soil and sediment concentrations (3.8 mg/kg and 2.2 mg/kg, respectively) were below the site-specific background level for arsenic in soil of 5 mg/kg. The maximum groundwater concentration (11 micrograms per liter [µg/L]) is below the site-specific background level for arsenic in groundwater (20 µg/L) and slightly exceeds the MCL for arsenic (10 µg/L). Similarly, chromium was detected in soil and sediment above the human health-based screening level of 0.3 mg/kg (maximum concentrations of 3.1 mg/kg and 1.1 mg/kg, respectively). However, all results were below the site-specific background level of 24 mg/kg for soil, and additionally, within sediment, chromium did not exceed a 1E-04 excess cancer risk. For groundwater and surface, elevated chromium detections did not exceed the MCL.

Because the detected analytes were typically detected in concentrations below their respective human health screening levels and/or background concentrations, investigative area soil, sediment, surface water, and groundwater at the CFLFA2 do not contain MC in concentrations that would pose an increased risk to residents, FTRI personnel, recreational users, authorized contractors, and trespassers. No contaminants of concern are present at CFLFA2.

1.7.2.2 SLERA

The assessment endpoint for the SLERA is the protection of local populations and communities of biota from adverse impacts from explosives and metals in soil, sediment, surface water, and groundwater potentially discharging to surface water.

- **Investigative Area Soil**: metals and explosives detected in investigative area soil were below screening levels and/or natural background levels, indicating negligible potential for risk to ecological receptors. No chemicals of potential ecological concern (COPECs).
- **Sediment**: metals and explosives detected in sediment were below screening levels and/or natural background levels, indicating negligible potential for risk to ecological receptors. No COPECs.
- **Surface Water**: selenium was identified as a COPEC in upgradient surface water. The selenium concentrations did not exceed ESLs for higher level organisms. Downgradient/crossgradient surface water samples did not exceed surface water screening levels.
- **Groundwater**: selenium was identified as a COPEC in groundwater. The concentration of selenium in one of nine wells slightly exceeded surface water quality criteria. There is not a complete pathway for ecological receptors to have direct access to groundwater at the site. Dilution and mixing would occur as groundwater discharges to surface water. The selenium concentration did not exceed ESLs for higher level organisms.

Selenium was not detected in soil and sediment samples collected from the MRS. Selenium was measured in two of seven surface water samples. The surface water upgradient from the site contained a higher concentration of selenium than the sample collected crossgradient from site activities. A 1998 USGS study of sediments in Milford Lake as well as other lakes in its drainage basin noted an increase in selenium concentrations due to irrigation of areas within the watershed (Juracek and Ziegler, 1998). In the Republican River Basin, selenium is an environmental concern due to the presence of seleniferous soils, outcrops of the Pierre Shale, and wide-spread irrigation (Juracek and Ziegler, 1998). The sediment concentration associated with Milford Lake during the USGS study (0.8 mg/kg) is greater than the soil background concentration for selenium at FTRI (0.6 mg/kg). Upgradient sediments and waters impacted by irrigation water may be contributing to the selenium detected in surface water and groundwater at CFLFA2.

No other chemicals were detected in investigative area soil, sediment, surface water and groundwater at concentrations above risk-based ESLs. Several non-detect analytes (antimony in sediment, cadmium in surface water, lead in surface water, and selenium in soil and sediment) were identified as COPECs, which may overestimate potential for ecological risk. However, antimony is not known to be associated with the munitions encountered at the site. Selenium is common in the area due to the presence of seleniferous soils, outcrops of the Pierre Shale, and wide-spread irrigation (Juracek and Ziegler, 1998). While the LOD for cadmium and lead slightly exceed surface water screening levels, these metals are not considered to be of concern as site-specific screening levels based on hardness levels in the Republican River are expected to be higher than the LOD. Although selenium is considered a COPEC in groundwater, dilution and mixing will minimize ecological exposure through existing pathways. Therefore, no adverse impacts to ecological receptors exposed to MC in investigative area soil, sediment, groundwater, and surface water are expected at the MRS.

2 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES AND GENERAL RESPONSE ACTIONS

RAOs consist of qualitative media-specific statements for reducing human health and environmental risks and/or meeting established regulatory requirements. GRAs are developed to satisfy the RAOs and relate to basic methods of protection such as treatment or containment. The RAO and GRAs were developed based on the nature and extent of contamination at the CFLFA2 MRS (**Section 1.6**), risk assessment findings (**Section 1.7**), current and anticipated land use (**Section 1.5**), and the ARARs and to be considered (TBC) information (**Section 2.1**).

2.1 Applicable or Relevant and Appropriate Requirements, and "To Be Considered" Information

Pursuant to 40 CFR Part 300.400(g) of the NCP, a list of ARARs and other TBC information is developed for sites to identify the requirements that may apply to a removal or remedial action. CERCLA Section 121 (d)(2)(A) requires that remedial actions meet any federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. CERCLA Section 121 (d)(2)(A)(ii) requires state ARARs to be met if they are more stringent than federal requirements. Lead and support agencies may, as appropriate, identify other advisories, criteria, or guidance TBC.

ARARs are defined as follows:

- *Applicable requirements* – Those cleanup standards, standards of control, and other substantive environmental protection requirements promulgated under federal or state environmental law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site.
- *Relevant and appropriate requirements* – Those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state environmental law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to a particular site.

ARARs are identified on a site-specific basis using a two-part analysis. It is first determined whether an ARAR is applicable for the site. If it is not applicable, then it is determined whether the ARAR is both relevant and appropriate (USEPA, 1988). The procedure for determining whether a requirement is relevant and appropriate is a two-step process. First, to determine relevance, the requirement is evaluated for sufficient similarity and relevance to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made about whether the requirement would also be well-suited to the conditions of the site. In some cases, only a portion of a requirement would be both relevant and appropriate. Once a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR. "Applicable requirements" and "relevant and appropriate requirements" are considered to have the same weight under CERCLA. Section 121(d) of CERCLA, as amended by the SARA, requires attainment of federal ARARs and of state ARARs in environmental or facility siting laws where the state requirements are promulgated, more stringent than federal laws, and identified by the state in a timely manner.

CERCLA and the NCP also recognize the TBC category, which includes non-promulgated advisories or guidance issued by Federal and State government that are not legally binding and do not have the status of potential ARARs. However, TBCs are considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of cleanup for protection on health or the environment.

When this is the case, they can be specified as TBC criteria. TBC criteria can be taken into consideration during evaluation of remedial alternatives but, unlike ARARs, identification of TBCs is not mandatory nor is compliance with TBCs a selection criterion for a remedial action.

The USEPA identifies three basic types of ARARs, chemical-, location- and action-specific ARARs. The ARARs identified for the CFLFA2 MRS for the FS based on the results of the RI are summarized on **Table 2-1**. The ARAR definition and their applicability to the MRSs are defined below along with TBC criteria.

- **Chemical**: Chemical-specific ARARs are usually health- or risk-based numerical values which, when applied to site-specific conditions, result in the establishment of an acceptable amount or concentration of a chemical that may be found in, or discharged to, the ambient environment. Preliminary chemical-specific ARARs are typically identified in the RI to provide benchmarks with which to compare environmental sampling results for metals and explosives. MC were not identified as a risk to human health or the environment in the RI; therefore, there are no chemical-specific ARARs to be evaluated in this FS.
- **Location**: Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. Typical examples of location-specific ARARs include protection of historical and archaeological resources and protection of wildlife and habitat resources, including endangered species, fish, migratory birds, and wetlands. Potential location-specific ARARs related to conducting MEC remedial actions were evaluated.
- **Action**: Action-specific ARARs are usually technology- or activity-based requirements or limitations placed on actions taken with respect to cleanup actions, or requirements to conduct certain actions to address specific circumstances at a site. These requirements are triggered by the remedial activities that are selected to accomplish a remedy. Since there are usually several alternative actions for any remedial site, very different requirements can come into play. These action-specific requirements do not themselves determine the cleanup alternative, but define how the chosen cleanup alternative should be achieved. Potential action-specific ARARs related to conducting MEC remedial actions were evaluated.
- **TBC**: Non-promulgated policies, criteria, advisories, guidance, and proposed standards developed by Federal and State environmental and public health agencies that are not legally enforceable but contain helpful information are collectively referred to as TBC criteria. They can be helpful in carrying out selected remedies or in determining the level of protectiveness of selected remedies. The TBCs are meant to complement the use of ARARs, not compete with or replace them. Action-specific TBC guidance relevant to MEC was evaluated.

Table 2-1 ARARs and TBC Criteria

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments
Chemical-Specific ARARs			
None identified	Not applicable (N/A)	N/A	Chemical-specific ARARs do not relate to the type of MEC found (i.e., no elevated explosives considered to be MEC). Further, the HHRA and SLERA demonstrated that COPCs present in soil, sediment, groundwater, and/or surface water at the MRS do not pose threaten unacceptable risk to human health or the environment. Therefore, there are no chemical-specific ARARs.
Location-Specific ARARs			
Endangered species	Federal – Endangered Species Act, 16 USC 1531 Migratory Bird Treaty Act: 16 USC 703 et seq Bald and Golden Eagle Protection Act: 16 USC 668 et seq State – Kansas Threatened and Endangered Species Regulations: K.S.A. 32-963, Kansas Non-game and Endangered Species Conservation Action	Requires action to conserve threatened or endangered species and their habitat.	*Applicable* Applicable if endangered or threatened species are identified in or surrounding the water at the CFLFA2 MRS.
Action-Specific ARARs			
Environmental Performance Standards	Subpart X – Miscellaneous Units: 40 CFR 264.601	Miscellaneous Units will be required to be located, designed, constructed, operated, maintained, and closed in a manner that will prevent any release that may have adverse effects on human health and the environment.	*Relevant and Appropriate* Relevant and Appropriate if actions require treatment of explosives by open detonation.

2.2 Remedial Action Objectives

The NCP CFR 300.430 (e)(2)(i) specifies that RAOs be developed to address: (1) contaminants of concern, (2) media of concern, (3) potential exposure pathways, and (4) preliminary remediation levels. The RAOs are defined to determine the effectiveness of the remedial actions. The HHRA and SLERA demonstrated that subsurface soil, sediment, and surface water at the CFLFA2 MRS does not pose a threat to human health or the environment. Therefore, RAOs for MC were not developed and were not carried forward for evaluation in the remainder of this FS.

RAOs are developed for MEC based on the MRS requirements and exposure pathways, and focused on limiting or removing exposure pathways for MEC (U.S. Army, 2009). The RAO for the CFLFA2 addresses the overall goal of managing risk and protecting human health based on the results of the RI. The RAO for the MRS is based on the following:

- **Items of Concern:** The following MEC items are potentially present in the area included in this FS: 2.36-inch rockets, 3.5-inch AT rockets, 4.2" mortar, dynamite, and miscellaneous AT round components, grenades (rifle and hand), and AP and AT landmines.
- **Media of Concern:** MEC at the site was found in the top 2 feet of soil/sediment, which in many portions of the site is not vegetated. Some activities (e.g., conducting intrusive activities) could result in contact with MEC. Exposure media include surface and subsurface soil and sediment.
- **Exposure Routes and Receptors:** Access to the MRS is unrestricted. A pedestrian nature trail provides recreational access to the Republican River. The trail is maintained by the City of Junction City through an easement with FTRI. FTRI posted a series of warning signs between the riverbank stabilization area and the nature trail to notify the public of the site conditions. The current orange warning signs state "Caution Potential Unexploded Ordnance May Be Present in the Area, Avoid Entry." The potential receptors at this MRS are likely to include FTRI residents, recreational users (including residents walking on the nature trail adjacent to the site), FTRI personnel, authorized contractors, and trespassers. Depth of impact is likely six inches (during anchoring), but deeper depths may be contacted during construction of piers/docks. Further, given the dynamic nature of the water bodies, which is evidence by the change in the river bank over the years, MEC currently present at 2 feet may migrate to shallower depths if left in place. Therefore, receptor contact with MEC, if present in the top 2 feet, is considered possible.
- **Preliminary Remediation Goals:** Prevent direct contact with MEC and comply with ARARs.

Therefore, the RAO for the CFLFA2 MRS is:

- Minimize FTRI residents, recreational users (including residents walking on the nature trail adjacent to the site), FTRI personnel, authorized contractors, and trespassers contact with MEC in the top two feet of the Republic River and Breakneck Creek and surrounding banks while maintaining the intended future land use which is primarily recreational use.

2.3 General Response Actions

GRAs are selected to satisfy the RAOs for each contaminant type (i.e., MEC), the medium of concern (soil and sediments) and MRS use (see **Section 1.5**). The basic method of protection is either to prevent or manage activities that may encounter MEC or to remove the MEC hazard at the MRS. GRAs may be combined to form remedial alternatives such as LUCs and MEC clearance. The following GRAs will be considered for the MRS:

- **No Action** — No action means that no remedial action will be undertaken at the MRS and is evaluated to satisfy 40 CFR 300.430(e)(6), which requires consideration of no action as a baseline for comparison against other alternatives.
- **Land Use Controls (LUCs)** — LUCs may include legal mechanisms (e.g., deed restrictions), administrative controls (e.g., dig permit reviews), engineering controls (e.g., signs) and educational controls (e.g., fact sheets and worker training) that limit access to the site and/or limit site activities to prevent exposure to MEC potentially present.
- **Monitoring** — Monitoring may be performed to assess the long-term effectiveness of the LUCs.
- **MEC Clearance** — MEC can be detected and removed from below the ground surface. Alternatives for MEC clearance will include technologies for MEC detection, positioning, removal, and disposal. However, no method of MEC clearance in sediments has proven 100% effective.

Technologies and process options developed to support the GRAs are presented and screened in **Section 3**.

3 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies the applicable remedial technologies and process options for each GRA that are appropriate for MEC at the CFLFA2 MRS. Remedial technologies, as used in this FS, refer to general categories of technologies. Process options refer to specific technologies. For example, the "Institutional Controls" GRA includes "Access Restrictions" as a remedial technology, which subsequently includes such process options as fencing, warning signs, security patrols, and deed/zoning restrictions. Several broad remedial technology types may be identified for each GRA.

The GRAs are first screened, and then they may be combined into remedial alternatives which are further analyzed in Development and Screening of Alternatives (**Section 4**) and the Detailed Analysis of Alternatives (**Section 5**) of this report. Each technology identified in this section is screened for effectiveness, implementability, and cost to evaluate its viability.

Screening of technologies and process options consists of presenting and evaluating those potentially applicable technology types and process options that could be used on a site. As provided for in the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (USEPA, 1988), site-specific conditions determine the range of process options available at a given intrusive investigation area. These are "cases where there may be so few realistic options that a screening process is not needed and only a detailed analysis is conducted" (U.S. Army, 2009). Hazards associated with the MRSs are limited to potential encounters with MEC. Potential technologies and process options focus on LUCs, monitoring, and MEC clearance.

3.1 Screening Criteria

Technologies and/or process options are first evaluated against the general categories of effectiveness, implementability, and cost to ensure that they meet the minimum standards of the criteria (USEPA, 1988). The three general categories are described below.

Effectiveness — Technologies that have been identified should be evaluated further on their effectiveness relative to other processes within the same technology type. This evaluation should focus on: (1) the potential effectiveness of technologies in handling the estimated areas or volumes of media and meeting the RAOs; (2) the potential impacts to human health and the environment during the removal or implementation phase; and (3) how proven and reliable the technology is with respect to the MEC and conditions at the site.

Implementability — Implementability, as a measure of both the technical and administrative feasibility of constructing, operating, and maintaining a remedial action alternative, is used during screening to evaluate the combinations of technologies with respect to conditions at a specific site. Technical feasibility refers to the ability to construct, reliably operate, and meet technology-specific regulations for technologies until a remedial action is complete. It also includes operation, maintenance, replacement, and monitoring of technical components of a technology/alternative, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, and disposal services and capacity; and the requirements for, and availability of, specific equipment and technical specialists (USEPA, 1988).

The determination that a technology/alternative is not technically feasible will usually preclude it from further consideration unless steps can be taken to change the conditions responsible for the determination. Typically, this type of "fatal flaw" will be identified during technology screening, and an alternative consisting of an infeasible technology will not be retained. Negative factors affecting administrative feasibility will normally involve coordination steps to lessen the negative aspects of the technology/alternative but will not necessarily eliminate a technology/alternative from consideration.

Cost — Typically, technologies/alternatives are defined sufficiently prior to screening so that estimates of cost are available for developing comparisons among technologies/alternatives. However, because uncertainties associated with the definition of technologies/alternatives often remain, it may not be practical to define the costs of technologies/alternatives with the desired accuracy.

According to USEPA guidance, a high level of accuracy in cost estimates during screening is not required. The focus should be to make comparative estimates for technologies/alternatives with relative accuracy so that cost decisions among technologies/alternatives will be sustained as the accuracy of cost estimates improves beyond the screening process. Detailed cost estimates of retained alternatives will be provided in **Section 5**.

3.2 Evaluation of Land Use Controls Technologies

LUCs can be used in cases where it may not be possible or practical to physically remove munitions, or in combination with removal actions if warranted. LUCs were developed using USACE guidance Engineer Pamphlet 1110-1-24 for *Establishing and Maintaining Institutional Controls for Ordnance and Explosive Projects* (USACE, 2000) as a reference. Risks related to potential explosives hazards may be managed through LUCs. LUCs protect property owners and the public from potential hazards present at the MRS by warning of potential MEC hazard and/or limiting access to, or use of, the MRS. LUCs may include legal mechanisms, engineering controls, and educational controls. Examples of LUCs evaluated for the MRS include the following:

- Legal Controls
    - Deed Restrictions
    - Environmental Covenants
    - Zoning
- Administrative Controls
    - Update Base Geographic Information System (GIS)/Master Plan
    - Dig Permit System
    - Contractor Control Policies
    - Construction Support
- Engineering Controls
    - Fencing
    - Warning Signs
    - Physical Barriers to Access
- Educational Controls
    - Public Notices
    - Management Plans
    - Community Awareness Meetings
    - Letter Notifications, Informational Pamphlets, and Fact Sheets
    - Formal Education Sessions
    - Website

The effectiveness of LUCs depends on the support, involvement, and willingness of local agencies and landowners to participate in LUCs based on the location of the MRS abutting the installation boundary with privately owned parcels to the south. LUCs already in-place or that have been used during the implementation of investigative activities at the MRS include:

- Administrative Controls
    - Dig Permit System
    - Contractor Control Policies
    - Construction Support
- Engineering Controls
    - Warning Signs
- Educational Controls
    - Signage
    - Informational Pamphlets and Fact Sheets

FTRI posted a series of warning signs between the riverbank stabilization area and the nature trail to notify the public of the site conditions. The current orange warning signs state "Caution Potential Unexploded Ordnance May Be Present in the Area, Avoid Entry."

Fences are used to physically restrict or discourage access to a site. The effectiveness of the fence depends on the size, type, and maintenance of the fence. Increased height and barbed wire increase the effectiveness, although a determined individual can cross virtually any fence. The main advantage to fencing is that it prevents inadvertent access. Although fences are technically feasible for the CFLFA2 MRS and surrounding waters, they are not administratively feasible as they would alter the natural environment, be an eyesore to the local community, affect navigable waterways, and render valuable resources inaccessible. Furthermore, they would have limited benefit on land because signs that have been placed have been noted as effective. They would have limited benefit in water because the water already serves as a partial barrier to MEC. Extensive maintenance in the riverine environment and changing shoreline would drive costs. Therefore, fences are screened from further consideration.

3.2.1 Retained LUCs

A summary of the LUCs retained for development of remedial action alternatives are:

- Administrative Controls
    - Update Base GIS/Master Plan
    - Dig Permit System
    - Contractor Control Policies
    - Construction Support
- Engineering Controls
    - Warning Signs
- Educational Controls
    - Public Notices
    - Community Awareness Meetings
    - Letter Notifications, Informational Pamphlets, and Fact Sheets
    - Formal Education Sessions
    - Website

Posting of additional warning signs (along fences, access roads, gates) was retained. Warning signs would serve as educational controls for educating the public of the potential MEC hazards at the MRS. Other educational controls include informational pamphlets and fact sheets for distribution at key times during any MRS remediation activities. In addition, fact sheets and pamphlets are recommended for distribution to public officials, emergency management agencies, and the local/regional Department of Natural Resources offices notifying hunters, fishermen, recreation users and permittees of potential MEC. Information pamphlets could also accompany large game permits issued for areas near the MRS. A website will be created and maintained providing copies of pertinent documentation for the MRS related to the final remedy and future educational materials for public access.

Current land use for the MRS includes recreational activities such as fishing, hiking, and boating. The primary land owner that would be affected by the LUCs is FTRI, however the south side of the Republican River is owned by Bayer Construction Company Inc. Initial discussions with FTRI indicated that they are open to the above-listed LUCs and that they will be responsible for long-term implementation of LUCs. To date, no discussions with Bayer Construction Company Inc have occurred, but this would be required prior to placing signs or other restrictions on the property. The roles, responsibilities, and authorities that each organization would have in implementing, maintaining, monitoring, and enforcing LUCs will need to be assessed in an Institutional Analysis to be included in the final Land Use Control Implementation Plan (LUCIP) in order for LUCs to be effective.

3.2.2 Activities Affecting Land Use Controls

Construction Support — When activities are required that may affect the LUCs established for the MRS, UXO construction support activities would be necessary. Discussions with FTRI staff indicated that they have provided UXO construction support activities at the site in the past and will continue to do so as needed. UXO construction support would be used to ensure the safety of workers or the public in the event that MEC items are discovered at the MRS. In accordance with DoD 6055.09-M (DoD, 2008), the level of construction support changes in relation to the location and the probability for encountering potential MEC. Each activity occurrence would be reviewed with FTRI Safety Office through the dig permit process to ensure the appropriate support is provided based upon the type of activity planned. In areas having a low probability of encountering MEC, UXO-qualified technicians provide support either on an on-call basis to respond to MEC that was incidentally encountered, or on a standby basis to monitor construction activities. If the probability of encountering MEC is moderate to high, removal of MEC from the construction footprint is required.

3.3 Evaluation of Monitoring Technologies

Surface Sweeps — Surface sweeps are performed to assess whether MEC are exposed at the surface at a future date after MEC removal is performed. It is intended to assess the permanence of the MEC removal. Surface MEC, which is the most accessible, may begin to reappear in areas previously cleared of MEC due to frost heave and erosion which expose items from below, and lateral transport from other areas (i.e., water transport in dynamic environments). Periodic surface sweeps can assess whether such mechanisms are occurring, and should be part of CERCLA five-year reviews to evaluate permanence following MEC removal.

CERCLA Five-Year Reviews — If the potential for MEC remains, CERCLA requires the review of remedial actions no less than every five years to assure that human health and the environment are being protected. For LUC alternatives, five-year reviews would be required including inspections to assess condition and effectiveness of the LUCs.

Recurring reviews will be completed by the Army and will include the following general steps:

- Prepare Recurring Review Plan;
- Establish project delivery team and begin community involvement activities;

- Review existing documentation;
- Identify/review new information and current site conditions;
- Prepare preliminary Site Analysis and Work Plan;
- Conduct site visit; and
- Prepare Recurring Review Report.

3.4 Evaluation of MEC Removal Technologies

MEC remediation activities include three steps: detection and positioning, removal, and disposal. A description of the technologies used in each step is presented in the following subsections.

3.4.1 MEC Detection

MEC detection involves the locating of hazardous items (i.e., MEC) in the environment. This can include a broad-scale investigation to locate areas where items are densely clustered, or a focused-scale investigation to locate individual items. Detection is normally used in conjunction with removal and disposal to meet RAOs, but can also be used to identify areas for containment and/or LUCs.

Current state-of-the-art detection methods cannot detect all MEC items. Some technologies can only detect items that are on the surface, and those that can detect buried items have depth limitations. In general, the deeper an item is buried and the smaller an item is, the harder it is to detect. If an item is small enough or deep enough, it might not be detected and may remain after the removal. MEC detection remedial technologies and process options are discussed below.

3.4.1.1 Surface Detection

Detection of MEC on the surface is far easier than MEC in the subsurface. A variety of process options may be employed.

Visual Search — Visual searches for surface MEC consists simply of a line of UXO technicians walking across the property in a systematic manner to identify items by sight. UXO technicians would be appropriately spaced to ensure 100 percent visual inspection of the ground. This option is only applicable for areas without vegetation or other ground cover, such as the open shorelines of the Republican River and Breakneck Creek. It can also be used in water with clear visibility, although it may not be cost effective in areas where diving is necessary. Such areas could be more efficiently investigated with a remote camera or acoustical methods. It would be effective at removing surface hazards, but subsurface items will remain. It would be easily implemented in areas with little or no vegetation such as shorelines of the Republican River and Breakneck Creek, but not appropriate in wetland areas surrounding the water bodies due to heavy vegetation and standing water. Costs would be relatively low.

Instrument Aided Surface Sweep — This would consist of a systematic search for surface MEC with a magnetometer or other instrument that identifies metallic items. UXO technicians would work in well-defined search lanes that cover the entire area. This approach is necessary for the areas where there is vegetation that cannot be removed. It can also be used in shallow water. It would be effective at removing surface hazards, but subsurface items will remain if not excavated. This technology would be easily implemented and relatively low cost on land and in shallow water. It may not be cost effective in areas where diving is necessary. Such areas could be more efficiently investigated with a remote camera or acoustical methods.

Optical Camera Surveys — Optical cameras could be used in the water bodies to minimize diver requirements. The camera would identify MEC and other metallic items sitting proud on the bottom. Optical cameras would be mounted on boats or other platforms. Since the effectiveness can be poor in turbid water, acoustic imaging is preferred and optical cameras are screened from further consideration.

Acoustic Imaging — could be used in the water bodies to minimize diver requirements. MEC and other metallic items sitting proud on the bottom can be identified with side scan sonar or high frequency underwater “cameras.” This technology can be effective at locating and potentially identifying items sitting proud on the substrate, but no ability to detect items just under the sediment. It provides improved visibility over optical cameras in turbid water. It is implementable and cost effective compared to using divers.

3.4.1.2 Subsurface Analog Detection

Hand-held analog geophysical instruments are used in sweep mode as the instrument is passed back and forth by UXO technicians in well-defined search lanes of 5-ft wide or less. Analog instruments emit an audible signal as the instrument is moved past a metallic item. The UXO technician progresses along the search lane and stops when an anomaly is encountered. Anomalies identified are either flagged or immediately excavated. This process can be performed on land or under water. For the latter, UXO technicians in dive gear search lanes and grids defined with ropes and weights.

Analog Magnetometers — Analog magnetometer detect irregularities (anomalies) in the earth's magnetic field due to the presence of surface and/or subsurface ferrous metallic items. A gradiometer consists of two or more magnetometer sensors configured to measure the spatial rate of change in the magnetic field. An analog version of a magnetometer/gradiometer emits an audible signal that changes in pitch as the instrument is moved past a metallic item. Detection depth is likely limited to 2 to 4 ft. Cost is relatively low on land but high in water because of the need for divers. Where divers are needed, this technology may be best reserved for cluttered areas where individual DGM anomalies are hard to distinguish and reliably reacquire. Due to its effectiveness, simple operation, and availability of hand-held units, magnetometry is the most commonly used technology for locating buried UXO. However, at the CFCLA2 MRS, analog magnetometers cannot be used as a standalone technology as not all the MEC items of interest are ferrous. Analog magnetometers are retained for consideration, especially for use in water to support MEC removal alternatives, but require combined uses with alternative technologies to ensure all MEC items are detectable.

Analog Electromagnetic — Analog electromagnetic (EM) instruments involve the use of an EM induction system to transmit electrical current. The system measures either the secondary magnetic field induced in metal objects or the difference between the electrical conductivity of the soil and the object. Since EM instruments detect non-ferrous as well as ferrous metallic items, they will detect all the munitions items reported used at the CFCLA2 MRS. This was the technology used during the RI and verified to be effective so was retained for consideration.

3.4.1.3 Subsurface Digital Detection

As opposed to analog instruments, DGM instruments log geo-referenced sensor data that can be analyzed, processed, and used to identify targets with known location coordinates. Anomalies identified in the data can be analyzed to estimate the size and depth of the item(s). Anomalies can be classified from most likely to least likely to be the size and shape of munitions known to have been used at the site. If done properly with the appropriate quality control, the number of anomalies to investigate may be reduced to create a target anomaly list. Since coordinates are known, the target anomalies can be reacquired and excavated at a later date. These instruments can be adapted to an underwater platform operated on or near the substrate in water MRSs. Navigation control is generally more difficult in deep water, or water with obstacles proud of the bottom, which can make reacquisition of anomalies difficult.

Digital Magnetometers — Digital magnetometers work on the same principle as analog magnetometers, detecting irregularities (anomalies) in the earth's magnetic field or the spatial rate of change in the magnetic field. These instruments also provide maximum depth detection for large bombs and defensible anomaly discrimination. The instruments are effective at detecting MEC items of concern within 4 ft or more into the subsurface. These instruments are available and can be easily implemented with medium relative cost. However, digital magnetometers are not applicable because not all the CFCLA2 MRS items of interest are ferrous and so were screened from consideration.

Digital Electromagnetic — Digital EM instruments work on the same principle as analog EM instruments, transmitting electrical current and measuring either the secondary magnetic field induced in metal objects or the difference between the electrical conductivity of the soil and the object. Since EM instruments detect non-ferrous as well as ferrous metallic items, they will detect all the munitions items reportedly used at the CFCLA2 MRS. This technology was used for the RI and proven effective so was retained in the FS.

3.4.2 MEC Removal

Removal technologies involve the movement of hazardous items (i.e., MEC) from the source area to another location either on-site or off-site. Removal is used in conjunction with detection and disposal. If it can be performed safely, removal is generally considered to be the most effective form of remediation for MEC. Obviously, if the MEC no longer exists, it can never present a risk to the public. This makes MEC removal the best traditional method of protecting the community in the long-term.

MEC removal can be performed in a targeted fashion, where individual items are detected, identified, and removed one at a time in a focused manner. Alternatively, bulk removal can be performed in known cluttered areas. Due to the potential for accidental detonation and the sensitive nature of UXO with armed fuzing, bulk removal technologies may not be appropriate unless adequate precautions such as engineering controls can be employed. Various MEC removal remedial technologies and process options are discussed below.

3.4.2.1 In-Situ Excavation

In-situ excavation during MEC removal refers to the focused, intrusive investigation of a single anomaly that could represent MEC. The metallic item causing the anomaly is left in-place with as little disturbance as possible until it is positively identified and its condition with regard to safety is assessed by qualified UXO technicians. Only then is a decision made to either remove it or if a MEC item, detonate it in-place. This technology is appropriate when the items of interest may be fuzed and armed.

Manual Excavation — Manual excavation consists of hand digging methods performed by UXO technicians. Manual excavations in the wetlands and shores surrounding the Republican River and Breakneck Creek are limited to 2 to 3 ft or less due to muddy conditions and shallow water table. Manual excavations under water would require divers and are restricted to less than 2 ft into the substrate because of flowing sand. When excavating an anomaly manually, non-essential personnel must be evacuated to the hazardous fragment distance (HFD). This technology is effective at removing MEC and implementable, although large or entrenched items may be difficult to remove manually.

Heavy Equipment — Heavy equipment such as excavators or other earth moving machinery can be used to excavate to an anomaly. When heavy equipment is used, the exclusion zone (EZ) increases from the HFD to the maximum fragment distance (MFD). During the RI, heavy equipment excavation was performed using a hydraulic excavator that was located on the bank of the river. To access anomalies located beyond the reach of the heavy equipment from the bank, ramps were created for ingress and egress onto the sandbars. This provided access to the remaining underwater anomalies, however, costs are relatively high.

3.4.2.2 Remote Retrieval

Remote retrieval technologies are utilized if the potential for accidental detonation is high enough to warrant evacuation of all personnel from the work site. These technologies are inherently more involved and expensive, but may prove to be cost effective if faster production with fewer people can be achieved, especially if it eliminates or minimizes the need for divers.

Remote Electromagnet — This is a technology in which an electromagnet is used robotically to retrieve and excavate buried MEC and other metallic items while allowing the operator to remain at a safe distance. This system, named the Magnetic UXO Recovery System (MURS), was designed by the Air Force Research Laboratory working in conjunction with the National Defense Center for Energy and Environment. It consists of a remotely operated excavator with an electromagnet capable of lifting a 2000-lb bomb from the surface, 500-lb bomb from 6 inches below ground, and 5-inch projectiles from 18 inches below ground. It also has a claw to scrape the surface for recovery of larger items to 48 inches below ground in clay soils. On board video cameras provide real-time data for remote operators. Remote operation is required because UXO exposure to MURS generated magnetic fields and the impact of UXO striking the magnet during extraction may cause inadvertent detonation. The MURS system is intended for land based operation, but could potentially be mounted on a ramp and used for underwater targets from shallow water depths of 15 ft or less. Remote operation at FTRI would not be implementable due to unstable work platforms and large EZs. On land, the excavator would require a stable work platform. Frequent repositioning of the ramps and work platform cannot be done remotely and would be cost prohibitive to achieve by personnel constantly travelling in and out of the MFD EZ to reposition for each target. Due to these difficulties, this technology is screened from further consideration at the site.

Robotic Arm Technology — This is an underwater technology that consists of a remote-controlled robotic arm that rests on the substrate and is positioned into place with a crane atop a boat/barge. The arm can recover items as large as 2,000-lb bombs from water depths to 250 ft. The arm picks up munitions and delivers them to a lift basket for surface disposal. The robotic system includes lighted underwater cameras so that the item can be identified. Since the item is identified under water, a decision is made whether it is safe to bring aboard. Therefore, personnel do not need to be kept outside the work area. This technology reduces or eliminates the need for divers, and therefore could prove to be cost effective if used for a large-scale removal effort. The technology has been used effectively in testing, but has not been proven during a large-scale removal. It is potentially implementable, but availability is low. Cost is high and it may be more appropriate for deeper water than the less than 30 ft expected in the CFCLA2 MRS. With such shallow water, divers may prove to be more cost effective. Due to limited availability and uncertain performance capability, the implementability is uncertain. A pilot study would need to be conducted before an evaluation could be made regarding its viability as a remedial option at the site. Therefore, this technology is screened from further consideration.

3.4.2.3 Diver Salvage

Diver salvage consists of methods of recovering individual MEC items and other debris from underwater in a controlled fashion by UXO-qualified divers who have determined that the item is safe to move without remote operation.

Winch/Float Lift Bags — This is a method of salvage in which a UXO-qualified diver either fastens straps to the item to be raised by a winch or float lift bags, or places the item in a basket to be raised by a winch mounted on a boat or barge. The best approach may vary from item to item, so all tools are generally provided and considered as one technology. This technology will generally work only for items within arm's reach by the diver, and even so, a suction device may be necessary to excavate enough sediment to attach straps.

Diver with Electromagnet — This is a method of salvage in which a UXO-qualified diver directs an electromagnet to remove the item from the substrate. This technology will only work on ferrous metallic items, and may not be as effective on items that are heavily corroded. The advantage over the previous technologies is that no straps are needed; therefore, a lift can be done quicker and with little if any excavation. However, it would not be appropriate for sites where fuzed items could be present underneath or near the targeted item for removal. The magnetic field and impact of UXO striking the magnet poses a safety concern for the diver. This technology is therefore screened from further consideration.

3.4.2.4 Ex-Situ Sifting

Ex-situ sifting consists of excavation of contaminated media (i.e., soil or sediment) to the desired depth for processing through a sifter to screen out MEC and other debris. This approach is efficient at removing MEC, but is also damaging to the environment. As soil/sediment is processed through a screen, UXO technicians monitor the operation and check the screen for MEC and MD. If MEC/MD is recovered, the UXO technicians take appropriate steps to segregate and dispose of the items. The sifted soil/sediment is then returned to the environment. This process inherently removes and jostles all items before a determination is made that the item is safe to move, so it generally cannot be used on fuzed items unless either done remotely or with engineering controls to protect personnel. Remote operation will raise costs considerably, especially if unintentional detonations occur and damage the equipment. Excavation of soil or sediment would utilize one of the methods discussed below.

Excavator/Sifting Plant — This technology utilizes standard excavators to remove soil and process through a screen. Use of excavators was used during the RI. However, the materials were manually inspected and a sifting plant was not utilized. The approach, used during the RI, proved effective and is lower in cost than using a mechanized sifting plant, so ex-situ sifting was screened from further consideration.

Suction Dredges — Suction dredges remove sediment from the substrate by sucking material through a pipe. These types of dredges are often used for beach replenishment and often pick up small munitions and transport them to the beach. However, this technology would not be useful for the rockets at the CFCLA2 MRS, which are too large to intentionally remove with this equipment. This technology is not technically feasible and is screened out of further consideration.

Bucket Dredges — Bucket dredges remove sediment from the substrate with circulating buckets on a bar or wheel. These types of dredges create violent action in the substrate and would not be appropriate where MEC may be present. This technology is not administratively implementable because it is an unsafe approach. It is screened from further consideration.

Grab Dredges — Grab dredges remove sediment from the substrate with iterative loads from an excavator or clamshell bucket. This approach can remove lifts of sediment so that MEC at deeper depths in the sediment can be accessed. While a detonation under water might not be catastrophic due to dampening by the water, it poses a serious safety concern if fuzed MEC are dropped into the screen. Remote operation or engineering controls would be necessary along with evacuation to the MFD during operation. This technology is not considered further because it would be costly to implement remotely and process so much sediment.

3.4.2.5 Bulk Debris Removal

Bulk debris removal technologies consist of methods of excavating MEC, MD, and other debris from contaminated media (i.e., soil or sediment). It is like ex-situ sifting, with the difference that only debris is removed while leaving the soil/sediment in-place to the greatest extent possible. If MEC/MD are recovered, UXO technicians take appropriate steps to segregate and dispose of the items. This process inherently removes and jostles all items before a determination is made that an item is safe to move, so it generally cannot be used on fuzed items unless done remotely or with engineering controls to protect personnel. Remote operation will raise costs considerably, especially if unintentional detonations occur and damage the equipment. Bulk removal of debris would utilize one of the methods discussed below.

Scallop Dredges — Scallop dredges are dragged along the substrate to harvest scallops while leaving the sediment in-place. They use teeth or a cutting bar followed by a net or basket to catch debris. This is a technology that has not been used for MEC removal, but could potentially be adapted for such a purpose. It would require a certain degree of research and development to implement on a full-scale MEC removal. The technology is not considered to be viable at this time and is screened from further consideration.

Modified Grab Dredges — A modified grab dredge is a grab dredge modified by perforating the bucket or clamshell so that sediment is allowed to escape and remain in the water. This dredge essentially screens as it operates to minimize sediment handling. There is a potential for encountering fuzed items, which poses a risk to workers and the barge platform and equipment. Remote operation is plausible to protect workers, but the barge and equipment is still at risk. This technology has not been widely used and may require a certain degree of research and development to implement on a full-scale MEC removal. It is not considered to be viable at this time and is screened from further consideration.

3.4.3 MEC Disposal

Disposal technologies are methods of rendering MEC inert and usually consist of controlled detonation. Disposal technologies are used in conjunction with removal to comprise a remedial alternative. MEC disposal remedial technologies and process options are discussed below.

3.4.3.1 On-Site

On-site disposal of MEC is generally the only option because of the difficulties and hazards with transporting MEC.

BIP — BIPs are the most common method of MEC disposal for items found on land. It is the safest approach, especially for fuzed items, because it does not require moving or transporting the item. A donor explosive is attached to the item and used to trigger a high order detonation to result in complete destruction. Specific safety controls would be in-place to protect the public, the project team, and the environment. For MEC that is found underwater, BIP is generally not acceptable due to potential damage to the environment. Underwater blasting creates rapid and significant positive and negative pressure changes that can cause injury in marine animals. If the item is unsafe to move, an underwater detonation may not be avoidable. Engineering controls such as bubble curtains and other physical barriers may be considered to attenuate the blast wave. This technology is effective, implementable, and relatively low cost.

Consolidated Detonations — Consolidated detonations are controlled detonations of a number of MEC items that are safe to move and transport to a single disposal site where they are destroyed. This approach reduces the number of detonations and therefore limits impacts to the environment. It also allows for detonations to occur in areas where conditions are favorable for site control, evacuation, access, and fire control. If a detonation location is repeatedly used, it may be considered a disposal area that must be sited. Environmental sampling and restoration may be necessary.

Blast Chambers — Blast chambers are engineering controls used to contain detonations and minimize impacts to the environment. Blast chambers cannot handle larger MEC items and they are both technically more difficult to secure and costlier to utilize; therefore, this technology is technically unfeasible and screened from further consideration.

Water Jet Cutting/Flash Burn — This is an alternative method of disposal to detonation that is applicable to the large munitions like bombs. This method uses remotely controlled water jet cutting that will cut through steel casings. The water jet is used to first remove/disable the fuze, and then to cut the items into smaller pieces. If explosive fillers are present, the items are flash burned, which is an inefficient process compared to detonation. Water would likely become contaminated with explosives and would be collected, tested, and disposed off-site. This process could be done on-site, and the technology could be developed to perform this remotely underwater. Although this technology is effective and implementable, it is screened from further consideration because detonation is lower cost and preferred. Further, the size of the items anticipated at the CFCLA2 MRS are not large enough to warrant consideration of this technology.

3.4.3.2 Off-Site

Off-site disposal is considered as a potential MEC disposal approach; however, it poses a significant problem with transportation, which is not an option on public roads. On-site disposal is preferred; therefore, off-site disposal is screened from further consideration.

3.5 Evaluation of MEC Containment Technologies

Containment includes technologies that reduce the mobility or accessibility of MEC items. Containment may prevent migration pathways such as frost heave and shoreline erosion that may otherwise expose MEC present in the subsurface, or containment may place a physical barrier between the MEC and potential receptors. These types of technologies do not address the hazardous nature or quantity of MEC, they simply reduce accessibility. Containment remedial technologies and process options are discussed below.

3.5.1 Surface Barrier

Surface barriers are technologies that place a physical barrier between MEC and potential receptors.

Covers — Covers include a simple physical barrier of natural material such as sand or stone placed over the areas of concern to limit or prevent the direct exposure to MEC items. The majority of the land within the CFCLA2 MRS is wetland, so constructing a cover would not be possible as it would negatively impact the habitat and be cost prohibitive. For underwater areas, the cover would need to be a course stone because sand would erode in the dynamic environment. Large volumes of material would be needed which would alter the environment and potentially affect navigable channels. Although technically feasible and effective, this technology is not administratively feasible on land because it would drastically affect the habitat. In water areas, it would be cost prohibitive and would affect the ecological habitat and navigable waterways. This technology is screened from further consideration.

RCRA Caps — These are multi-layer, impermeable covers that minimize infiltration of rainfall so that potentially hazardous chemicals are not leached out of the material underneath. A RCRA cap consists of compacted clay or other engineered low permeability material, a drainage layer, animal barrier and vegetative cover. Although technically feasible and effective, this technology is not administratively feasible on land because it would drastically affect the habitat. This technology is screened from further consideration.

3.5.2 Shoreline Stabilization

Shoreline stabilization consists of technologies that reduce the mobility and accessibility of MEC in the dynamic shoreline environment which is subject to frequent erosion, especially during storm events. These technologies are intended to preserve the existing cover for subsurface MEC by limiting erosion.

Breakwaters — Breakwaters are strips of land constructed offshore to reduce the intensity of wave action. Breakwaters require engineering study and permitting to construct. While movement of the Republican River shoreline has been observed, use of breakwaters to prevent further movement is not applicable as breakwaters are utilized in primarily oceanic areas and in large freshwater areas like the Great Lakes. Wave action is not considered significant enough in the water bodies at the CFCLA2 MRS to make this technology useful. It is screened from further consideration.

Seawalls — Seawalls are covers of riprap or other resistant materials placed directly on the shoreline to cap subsurface MEC and prevent further erosion of the shoreline and the MEC underneath. This will significantly alter the appearance of the natural environment and may affect endangered species populations in the waterways. This technology is potentially effective and technically feasible, but is screened from further consideration because it is administratively unfeasible. It would significantly affect the natural environment and is anticipated to be unacceptable to the U.S. Fish and Wildlife Service.

4 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, the retained GRAs and technologies are combined to form remedial alternatives. In accordance with DoD (DoD, 2012), an FS must consider at least the following three alternatives: 1) No Action (baseline), 2) LUCs, and 3) remediation to an unlimited use/unrestricted exposure (UU/UE) condition. For the purpose of this evaluation, UU/UE is defined as: "site conditions that indicate a 'no probability' of encountering MEC based on a comprehensive assessment of current and previous land use". Therefore, the GRAs and technologies were combined into the following alternatives:

- Alternative 1: No Action
- Alternative 2: LUCs
- Alternative 3: MEC Clearance in Breakneck Creek and LUCs
- Alternative 4: MEC Clearance for Republican River and Breakneck Creek and LUCs
- Alternative 5: MEC Clearance to Support UU/UE

The areas included in this evaluation area presented in **Figure 1-5**.

Each alternative was evaluated with respect to the three screening criteria (effectiveness, implementability, and cost) as presented in NCP 40 CFR Part 300.430 (e)(7) and as described in **Section 3**. The purpose of the screening evaluation is to reduce the number of alternatives that will undergo the detailed analysis against the nine criteria, alternatives were evaluated more generally during the screening. The alternatives remaining after the screening were carried forward to the detailed analysis (**Section 5**).

As described in **Section 3.2** and **Section 3.3**, for remedial alternatives that do not allow for UU/UE, construction support and CERCLA Five-Year Reviews are required.

4.1 Alternative 1 – No Action

In accordance with NCP and USEPA guidance (USEPA, 1988), a No Action alternative must be developed as a baseline to compare to other alternatives. In a CERCLA FS evaluation, a No Action alternative equates with a determination to do no remediation or controls and does not consider any existing controls. No public awareness or education training would be initiated with regard to the hazards associated with MEC. Site access is assumed to be unrestricted and there are no limitations on current or future site use or activities, including transfer of the property. It is important to note that the government may not respond to any future MEC discoveries at the CFCLA2 MRS under the No Action alternative. Further, the No Action alternative does not require identification and screening for MEC during construction activities. There are no costs associated with this alternative.

As this is required per the NCP, no preliminary screening is necessary, and this alternative will be retained for detailed analysis in **Section 5**.

4.2 Alternative 2 – LUCs

Under Alternative 2, risks related to potential explosives hazards would be managed through:

- Administrative Controls
    - Update Base GIS/Master Plan
    - Dig Permit System
    - Contractor Control Policies
    - Construction Support

- Engineering Controls
    - Warning Signs
- Educational Controls
    - Public Notices
    - Community Awareness Meetings
    - Letter Notifications, Informational Pamphlets, and Fact Sheets
    - Formal Education Sessions
    - Website

The Army would implement Administrative, Engineering and Educational Controls as part of Alternative 2. However, successful implementation of LUCs is contingent upon the cooperation and active participation of the existing land users (i.e., Bayer Construction Company Inc.) and coordination with authorities of the Army and other government agencies to protect the public from explosives hazards.

Warning signs would be installed and maintained by FTRI around the MRS, notifying the public of the area in which MEC are likely to be present, and of the hazards associated with MEC. Some of this signage is already in-place as the Army installed signs between the hiking trail and the Republican River previously. A total of 71 signs (one every 200 ft) were estimated for cost estimating purposes in the FS. The signs would be placed around the perimeter of the MRS as shown in **Figure 4-1**. A website would be created and maintained for public access with relevant final remedy documentation, copies of educational materials that are developed and reports generated in the future (five-year reviews).

Due to the dynamic nature of the Republican River, surface sweeps are recommended as a means of monitoring. CERCLA five-year reviews would also be required. Five-year reviews would include inspections/surface sweeps to assess conditions of LUCs, erosion, and potential migration of MEC from the subsurface due to frost heave. Detailed specifications for implementation and monitoring would be determined during the remedial design phase of response and documented in a LUCIP. Costs for this alternative are expected to be low to moderate compared to the other alternatives screened. Additional details on the administrative and educational controls proposed for Alternative 2 are provided below.

Administrative Controls:

- Land Use Restrictions: Restrictions would be implemented to restrict the types of activities that can occur within the MRS. These restrictions would be implemented by the Army through the KDHE and other state agencies. Prohibited activities include, but are not limited to anchoring, dredging, the intentional/unintentional beaching or grounding of vessels, or walking on the bottom. However, restrictions on fishing are not required as these activities are not likely to bring MEC to the surface.
- Dig Permit System: The Base Master Plan and the GIS will be annotated to show where LUCs are required. The Master Plan would be used to review proposed actions in the Republican River portion of the CFCLA2 MRS. In conjunction with this, the FTRI Directorate of Public Works will review the Base Master Plan and GIS to determine whether future projects are consistent with the LUCs implemented at the MRS.
- Contractor Control Policies: Contractors performing intrusive activities on the MRS that have the potential to contact MEC will be required to receive training. The DoD educational message for explosive safety is referred to as “the 3Rs:” recognize, retreat, and report any future munitions that are encountered while performing maintenance, improvement, or construction activities on their property.

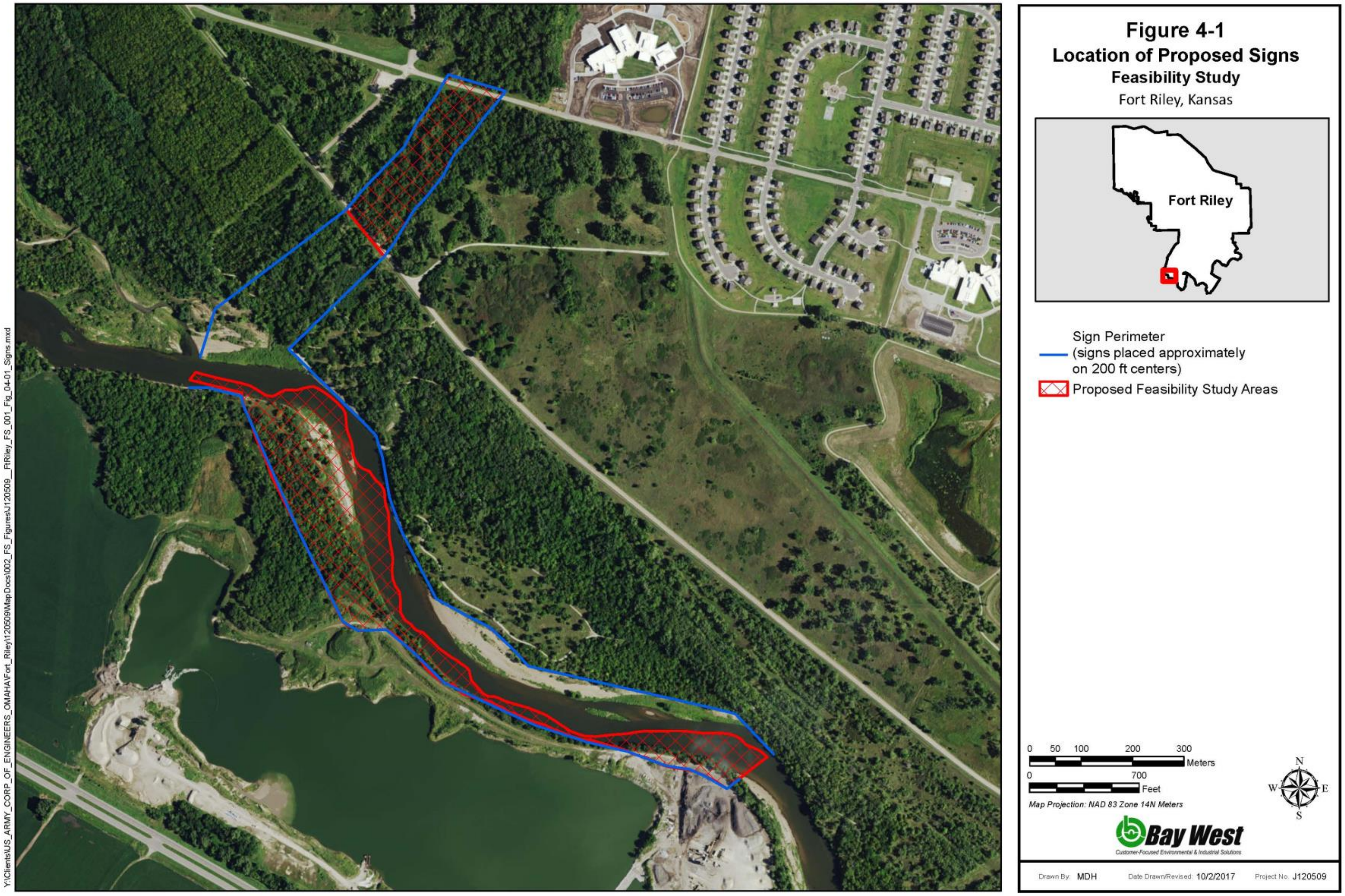

Figure 4-1
Location of Proposed Signs
Feasibility Study
Fort Riley, Kansas

Monitoring:

- Construction Support: Construction support would be a requirement for personnel performing certain activities on the property. Activities may include for example, pier construction, duck blind construction, or dredging. This is an ongoing cost that would need to be funded by the entity performing the activity. It would be required through the use of zoning restrictions. The requirements are per DoDM 6055.09-M-V7, and would consist of the following.
    - For intrusive activities in areas where the likelihood of encountering MEC is low, EOD personnel or UXO-qualified personnel must be contacted to ensure their availability, advised about the project, and placed "on call" to assist if suspected UXO are encountered during construction.
    - For intrusive activities in areas where the likelihood of encountering MEC is moderate to high, EOD personnel or UXO-qualified personnel must attempt to identify and remove any explosive hazards in the construction footprint prior to any intrusive construction activities. Alternatively, anomaly avoidance may be used to avoid surface explosive and subsurface anomalies when working in the area (e.g., to install pilings).
- Surface Sweeps: Periodic sweeps of the banks (i.e., annually as well as after a heavy rain) would be required in order to locate and remove any items that have become exposed at the surface. Additional sweeps may be required during drought years should it be determined that the river height has been lowered, potentially exposing items, and an annual sweep is not scheduled.

Education Controls:

- Public Notices: Notices will be placed in the local newspapers to notify the public of selection of a final remedy and if any changes to the remedy occur in accordance with 40 CFR Section 300.430.
- Community Awareness Meetings: FTRI has an active Restoration Advisory Board (RAB). The RAB works with FTRI on matters related to its environmental cleanup program. Its responsibilities include reviewing Army documents and plans, working with the Army to develop cleanup priorities, and sharing information with and soliciting feedback from members of the community. RAB meetings are open to the public.
- Letter Notifications, Informational Pamphlets, and Fact Sheets: Development and distribution of informational materials to periodically provide awareness to property owners and town authorities of the presence of munitions. It is anticipated the materials will be distributed annually at the onset of LUC implementation but reduced to once every five years if determined to be acceptable during the five-year review. In addition, informational materials will be made available to recreational users of the Republican River and Breakneck Creek.
- Formal Education Sessions: An educational program is also considered under Alternative 2, including providing periodic training for the local community to promote awareness on the munitions characterized at the MRS. Attendance will be open to the public. In addition, formal education sessions will be held to train employees (e.g., grounds crew) at the golf course on the recognition of munitions and procedures to follow should MEC be identified.

4.2.1 Screening

***Effectiveness*:** Alternative 2 would mitigate exposure to MEC in the Republican River portion of the CFCLA2 MRS by limiting access and activities on the MRS and educating users of the potential risks. The FTRI Safety Office will determine if UXO support is required during the dig permit process. EOD personnel would provide a preliminary assessment of any potential MEC items discovered as to whether it is safe or if it requires additional assessment and disposal.

Alternative 2 would not include intentional removal or treatment, but MEC items would be removed upon discovery (via inspection by EOD personnel, as needed) as well as during construction support and surface sweep activities. Therefore, the number of items remaining may decrease with time.

Implementability: The LUCs included in Alternative 2 are considered to be implementable. There would be no technical or administrative limitations to prevent implementation of LUCs. However, coordination with Junction City and other landowners would be required.

Cost*:* The total present-worth cost to perform Alternative 2 would be low compared to the other alternatives screened.

Assessment: LUCs would be effective, implementable, and low cost. Therefore, Alternative 2 has been retained for detailed analysis in **Section 5**.

4.3 Alternative 3 – MEC Clearance in Breakneck Creek and LUCs

This alternative includes the systematic search and removal of all MEC that are detectable and feasibly removable from Breakneck Creek. Breakneck Creek is a shallow, intermittent stream that is located on FTRI property. The stream was confirmed to contain MEC and is located near a school and residential areas. A hiking trail runs near the creek. Therefore, this area has the highest potential for contact with MEC and also is the easiest to clear as the work can be done using primarily traditional (i.e., terrestrial) MEC clearance techniques. No MEC removal would occur from the Republican River. LUCs would be used to prevent contact with MEC in the Republican River.

<u>MEC Detection</u> as Breakneck Creek is shallow (i.e., less than 1 ft) the MEC detection would be completed by experienced UXO-qualified personnel who would search the Breakneck Creek for MEC and remove all MEC and MD. The team would divide the MRS into convenient work grids that would allow for work to be optimized in the water environment. UXO technicians would wade into the water wearing hip boots and systematically search each grid with a waterproof, handheld analog magnetometer and/or EM instrument and mark, identify, and record the locations of all MEC and MD found for removal or subsequent disposal. However, as the majority of Breakneck Creek is shallow and intermittent in nature, the removal could be scheduled during dry times such that location and removal of MEC could be performed using standard land-based practices.

<u>MEC Removal</u> would be performed manually. Where a target anomaly is present, the coordinates would be located with a stake placed in the water or other buoy for subsequent anomaly investigation and MEC/MD removal. In severely cluttered areas, it would be difficult and time consuming to attempt to reacquire individual anomalies. These areas would be divided into convenient work grids defined by ropes and weights. Objects that are not visible on the bottom would be investigated within arm's reach by UXO-qualified divers into the sediment. If needed, suction devices would be used to remove sediment.

<u>MEC Disposal</u> would be performed on all MPPEH. If safe to move, any MPPEH would be removed from the water for on land disposal using Department of Defense Explosives Safety Board (DDESB)-approved MEC detonation procedures. If the item is unsafe to move, underwater detonation may be necessary. This would be evaluated on a case-by-case basis. BIP is generally not acceptable due to potential damage to the environment. Underwater blasting creates rapid and significant positive and negative pressure changes that can cause injury to marine animals. Engineering controls such as bubble curtains and other physical barriers may be considered to

attenuate the blast wave. For areas with no standing water, standard land-based MEC detonation practices would be followed.

All MD would also be collected for disposal so that it does not remain in the environment and interfere with future monitoring sweeps or cause future munitions response action.

LUCs are included in this alternative in addition to removal of MEC. The LUCs would be as described in **Section 4.2**. Warning signs, MEC recognition training, surface sweeps, and informational displays would continue to be needed as MEC could remain in the Republican River and Breakneck Creek. A total of 71 signs were estimated for cost estimating purposes in the FS. The signs would be placed around the perimeter of the MRS as shown in **Figure 4-1**.

4.3.1 Screening

Effectiveness: This alternative is effective at reducing the risks in Breakneck Creek by removing MEC at the site that is most accessible, while LUCs would provide added protection from receptors accessing residual MEC. This alternative is effective at reducing the mobility and volume of MEC and explosive compounds, which is a CERCLA preference.

Implementability: This type of removal action is technically and administratively feasible to implement, with an estimated time of approximately 2 years for planning and implementation.

Cost: The capital cost of this alternative is considered high in comparison to Alternative 2. This alternative does not allow for unrestricted site use and unlimited exposure; therefore, CERCLA five-year reviews would be required to determine whether transport of MEC has occurred such that new items are exposed.

Assessment: The subsurface MEC removal alternative is effective and implementable. Costs are relatively high; however, this alternative is retained for detailed analysis in **Section 5**.

4.4 Alternative 4 – MEC Clearance for Republican River and Breakneck Creek and LUCs

This alternative includes the systematic search and removal of all MEC that are detectable and feasibly removable in the substrate as described in Alternative 3, but the removal would occur in all areas where MEC was concluded to be present as shown on **Figure 1-5**.

MEC Detection would be performed as described in Alternative 3 for Breakneck Creek. For the Republican River, the water depth varies, and can exceed 5 ft. MEC removal from shallow water (i.e., less than 2-3 ft) would be completed by experienced UXO-qualified personnel who would search the entire MRS for MEC and remove all MEC and MD. The team would divide the MRS into convenient work grids that would allow for work to be optimized in the water environment. UXO technicians would systematically search each grid with a waterproof, handheld analog magnetometer and/or EM instrument and mark, identify, and record the locations of all MEC and MD found for removal or subsequent disposal.

In areas deeper than 3 ft of water, MEC detection would be accomplished with a combination of DGM and analog instruments. DGM instruments adapted to an underwater platform would be used to collect data of sufficient resolution to generate a map of all metallic items in the MRS. The data would be collected, processed, evaluated, and analyzed to select target anomalies likely to represent munitions of interest within the upper 2 ft of the substrate. Approximately 10-15 acres can be surveyed per day at a 10-ft lane spacing, using a magnetometer system with two sensors separated by 5 ft and RTK Global Positioning System (GPS) for positioning.

Where a target anomaly is present, the coordinates would be located with a stake placed in the water or other buoy for subsequent anomaly investigation and MEC/MD removal. In severely cluttered areas, it would be difficult and time consuming to attempt to reacquire individual anomalies. These areas would be divided into convenient work grids defined by ropes and weights. UXO-qualified divers would use marine metal detectors and follow a line of rope (a jackstay) placed on the bottom to define grid lanes. When an anomaly is detected, the diver would identify the item using visual observation when possible. If visibility is poor, the diver would use touch and feel techniques taught as part of underwater UXO diver training. Objects that are not proud on the bottom would be investigated within arm's reach into the sediment. If needed, suction devices would be used to remove sediment.

<u>MEC Removal</u> would be performed by UXO-qualified divers using standard salvage techniques. Divers would first make a positive identification of the item and ensure that it is safe to move. The diver would then place the item in a basket to be raised by a winch mounted on a boat. If the item is too large for the diver to move, he would fasten straps to the item so that it can be raised directly by a winch or float lift bag. Assuming there are 40 MEC/MD items per acre or less, it is plausible that a 4-man dive team can search and clear 0.25 acres each day.

<u>MEC Disposal</u> would be performed on all MPPEH. If safe to move, any MPPEH would be removed from the water for on land disposal using DDESB-approved MEC detonation procedures. If the item is unsafe to move, underwater detonation may be necessary. This would be evaluated on a case-by-case basis. BIP is generally not acceptable due to potential damage to the environment. Underwater blasting creates rapid and significant positive and negative pressure changes that can cause injury to marine animals. Engineering controls such as bubble curtains and other physical barriers may be considered to attenuate the blast wave.

All MD would also be collected for disposal so that it does not remain in the environment and interfere with future monitoring sweeps or cause future munitions response action.

<u>LUCs</u> are included in this alternative in addition to removal of MEC. The LUCs would be as described in **Section 4.2**. Warning signs, MEC recognition training, surface sweeps, and informational displays would still be needed as there is a potential MEC to migrate into areas that were previously cleared. A total of 71 signs were estimated for cost estimating purposes in the FS. The signs would be placed around the perimeter of the MRS as shown in **Figure 4-1**.

4.4.1 <u>Screening</u>

Effectiveness: This alternative is effective at reducing the risks by removing MEC at the site that is most accessible, while LUCs would provide added protection from receptors accessing residual MEC. This alternative is effective at reducing the mobility and volume of MEC and explosive compounds, which is a CERCLA preference.

Implementability: This type of removal action is technically and administratively feasible to implement, with an estimated time of approximately 3 years for planning and implementation.

Cost: The capital cost of this alternative is considered high in comparison with Alternatives 2 or 3. This alternative does not allow for unrestricted site use and exposure; therefore, CERCLA five-year reviews would be required to determine whether transport of MEC has occurred such that new items are exposed.

Assessment: The subsurface MEC removal alternative is effective and implementable. Costs are relatively high; however, this alternative is retained for detailed analysis in **Section 5**.

4.5 Alternative 5 – MEC Clearance to Support UU/UE

Removal of MEC from sediments is limited by the technologies available to locate and remove MEC from waterways. In order to guarantee all MEC has been located and removed, the removal would need to be performed as a terrestrial action. This would require temporary diversion of the Republican River and drying of the sediments. Based on the topography and landfill present on the FTRI property, the river would need to be diverted into the private property located on the southwest of the MRS.

MEC Detection would be performed once the river was diverted and the sediments provided sufficient time to dry, DGM methods would be used to locate MEC in the subsurface. The dataset would be reviewed and evaluated.

MEC Removal by UXO technicians using either manual (e.g., shovels) or mechanical-assisted hand digging techniques, where equipment would not dig within 1 ft of the MEC items.

MEC Disposal would be performed using DDESB-approved MEC detonation procedures.

4.5.1 Screening

Effectiveness: This alternative is effective at reducing the risks by removing MEC at the site. The site is anticipated to achieve UU/UE following implementation of the remedy.

Implementability: This remedy is not implementable as the properties located southwest of the MRS, where the river would need to be diverted through, are privately owned and commercially used.

Cost: The capital cost of this alternative is considered very high in comparison with the other alternatives evaluated. However, as this alternative allows for unrestricted site use and exposure, CERCLA five-year reviews would not be required. No O&M costs would result.

Assessment: The complete subsurface MEC removal alternative is effective but is not implementable. Costs are extremely high relative to other options evaluated. This alternative is therefore not retained for detailed analysis in **Section 5**.

5 DETAILED ANALYSIS OF ALTERNATIVES

During the detailed analysis, each retained alternative is assessed against the NCP evaluation criteria described in **Section 5.1**. The results of the detailed analysis are compared to the alternatives in order to identify their relative strengths and weaknesses. This detailed analysis approach is designed to provide decision makers sufficient information to adequately compare the alternatives, to select an appropriate remedy for the CFLFA2 MRS, and to demonstrate satisfaction of the CERCLA remedy selection requirements in the ROD.

The alternatives for evaluation for the CFLFA2 MRS are:

- Alternative 1: No Action
- Alternative 2: LUCs
- Alternative 3: MEC Clearance in Breakneck Creek and LUCs
- Alternative 4: MEC Clearance for Republican River and Breakneck Creek and LUCs

5.1 Evaluation Criteria

Evaluation criteria are described in the NCP, Section § 300.430(e)(9)(iii). These criteria were developed to address the CERCLA requirements and considerations, and to address the additional technical and policy considerations that are important in selecting remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during the FS and for selecting an appropriate remedial action. The evaluation criteria with the associated statutory considerations are described below.

5.1.1 Threshold Criteria

Threshold criteria are requirements that each alternative must meet or have specifically waived to be eligible for selection. Threshold criteria are as follows:

Overall Protectiveness of Human Health and the Environment—Assesses whether the alternatives can adequately protect human health and the environment, in both the short- and long-term, from unacceptable risks posed by hazardous substances, pollutants, or contaminants present at the site by eliminating, reducing, or controlling exposure. Overall protection of human health and the environment draws on the attainment of RAOs and assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs—Assesses whether the alternative meets federal and state environmental statutes, regulations, and other requirements that pertain to the site, or whether a waiver is justified. Potential site-specific ARARs are summarized in **Section 2.1**.

5.1.2 Balancing Criteria

The following "balancing criteria" are grouped together because they represent the primary criteria upon which the detailed analysis is based.

Long-Term Effectiveness and Permanence—Assesses the alternatives for the long-term effectiveness and permanence after remedial action has been implemented and the RAOs have been attained, along with the degree of certainty that the alternative will prove successful. Factors that will be considered, as appropriate, include the following:

- Magnitude of residual risks remaining from untreated waste or treatment residuals remaining at the conclusion of the remedial activities. The characteristics of the residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

- Adequacy and reliability of controls such as containment systems and institutional controls necessary to manage treatment residuals and untreated waste. This factor addresses, in particular, the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment of the potential need to replace technical components of the alternative; and the potential exposure pathways and risks posed should the remedial action need replacement.

For MRSs with potential explosives hazards, the ability to maintain protection of human health and the environment over time will typically fall into categories associated with LUCs. The evaluation of long-term effectiveness and permanence of LUCs will take into account the administrative feasibility of maintaining the LUCs and the potential risk/hazard should they fail, as well as mechanisms like the CERCLA Five-year review process to evaluate on a periodic basis the long-term effectiveness and permanence, as well as protectiveness, of the alternative.

Reduction of Toxicity, Mobility, or Volume (TMV) of Contaminants through Treatment— Assesses the degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume, including how treatment is used to address the principal threats posed by the site. Factors that will be considered, as appropriate, include the following:

- Treatment or recycling processes the alternatives employ and the materials they will treat;
- Amount of hazardous substances, pollutants, or contaminants that will be destroyed, treated, or recycled;
- Degree of expected reduction in toxicity, mobility, or volume of the waste due to treatment or recycling and the specification of which reduction(s) are occurring;
- Degree to which the treatment is irreversible;
- Type and quantity of residuals that will remain following treatment; and
- Degree to which treatment reduces the inherent hazards posed by the principal threats at the site.

For MRSs where the treatment options are generally limited to certain disposal options (BIP, consolidated shot, containerized version of these), the destruction of the MEC will be considered as constituting treatment that reduces the amount of MEC recovered. This is analogous to reduction in volume. Mobility in the context of hazardous, toxic, and radioactive waste treatment, where a hazardous substance is immobilized, does not have a direct analogy for MEC. Mobility may be considered a function of the ease of moving MEC. Transport mechanisms include: 1) picking up or moving of potential MEC by a person(s); 2) disturbance of potential MEC during construction, excavation, or other soil moving activities; and 3) natural processes such as erosion/deposition, uptake or frost heave, gravity, hydrologic effects, or degradation. Each process may affect movement of MEC from their original depth or location. To the extent that MEC are detected, recovered, and disposed of, their ability to move is reduced. MEC remaining after a removal activity would maintain their ability to move, based on the physical processes described above, and should be accounted for.

Short-Term Effectiveness—Assesses the short-term impacts of alternatives considering the following:

- Short-term risks that might be posed to the community during implementation of an alternative;
- Potential impacts on workers during remedial action and the effectiveness and reliability of mitigation measures during implementation;
- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation; and

- Time until remedial protection is achieved.

In addition, for MEC, safety considerations will include an evaluation of what is available from an administrative standpoint (e.g., access) and what is available from a technical standpoint (e.g., setbacks; are buildings too close for demolition; what will it take to bring the correct resources to the site to mitigate hazards of a demolition operation).

Implementability—Assesses the ease or difficulty of implementing the alternatives by considering the following types of factors as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.
- Administrative feasibility, including activities needed to coordinate with other offices and agencies, and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions).
- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies

Cost—Assessment includes the following:

- Capital costs, including both direct and indirect costs;
- Annual operation and maintenance (O&M) costs; and
- Net present value of capital and O&M costs.

Present value cost is the total cost of an alternative over time in terms of today's dollar value. Costs have been rounded to the nearest thousand dollars and estimates are expected to be accurate within a range of +50% to -30%. The basis for the costs is detailed in **Appendix A**. The costs developed for each alternative are based on vendor quotes, literature values, professional experience, and engineering judgment. The level of detail utilized in these elements is considered appropriate for choosing between alternatives, but the estimates are not intended for use in detailed budget planning. A 0.7% discount was applied for the 30-year present value calculations in accordance with the OMB Circular A-94 Appendix C for Real Discount Rates using the 30-year rate (Office of Management and Budget [OMB], 2016).

Final costs will depend on actual labor and material costs, actual site conditions, market conditions, final project scope, final project schedule, productivity, and other variable factors. As a result, the final costs will vary from the estimates presented in this FS; however, these factors should not affect the relative cost differences between the alternatives.

5.1.3 Modifying Criteria

The last two criteria, the “modifying criteria,” are usually evaluated following the receipt of comments on the FS, and thus are completed after the Proposed Plan and public comment period on the plan and are presented in the ROD.

Regulatory Agency Acceptance—Assesses the technical and administrative issues the state and USEPA may have regarding each of the alternatives evaluated in this FS, as well as the preferred alternative presented in the Proposed Plan. USEPA and state issues are considered and addressed as appropriate during the finalization of the FS and Proposed Plan. State and

USEPA acceptance of an alternative will be evaluated after the Proposed Plan is issued for public comment. Therefore, the regulatory acceptance criterion is not considered in this FS.

Community Acceptance—Assesses the issues and concerns the public may have regarding each of the alternatives evaluated in this FS as well as the preferred alternative presented in the Proposed Plan. Community acceptance of an alternative will be evaluated after the Proposed Plan is issued for public comment. Therefore, the community acceptance criterion is not considered in this FS.

5.2 Individual Analysis of Alternatives

This section presents an evaluation of the *four* alternatives retained for detailed analysis against the Threshold and Balancing Criteria listed above.

5.2.1 Alternative 1 – No Action

Overall Protectiveness of Human Health and the Environment— The MRS has hazards due to the presence of MEC in the subsurface. Current or future potential risks to human health or the environment from MEC would not change. As a result, Alternative 1 would not meet this criterion.

Compliance with ARARs—The identified ARARs and TBCs (**Table 2-1**) would only apply to alternatives that include active remediation. Therefore, since there are no actions under this alternative, Alternative 1 would meet this criterion.

Long-Term Effectiveness and Permanence— This alternative would not provide long-term effectiveness or permanence. RAOs would not be met as MEC hazards would still be present in the water bodies, and controls would not be implemented to maintain protection of human health or the environment. Alternative 1 would not meet this criterion.

Reduction of TMV of Contaminants through Treatment— No treatment would be provided. Therefore, there would be no reduction of the toxicity, mobility or number and density of MEC. The volume of MEC, if present, would not be reduced and would continue to pose a potential health hazard because it remains available for encounter. As a result, Alternative 1 would not meet this criterion.

Short-Term Effectiveness—No actions would be taken so there would be no short-term risks to the community or workers. Therefore, Alternative 1 would meet this criterion.

Implementability—No activities are proposed; therefore, Alternative 1 would be technically and administratively implementable.

Cost—There are no costs associated with Alternative 1. Therefore, the total present-worth cost to perform Alternative 1 is $0.

5.2.2 Alternative 2 – LUCs

Overall Protectiveness of Human Health and the Environment— Alternative 2 would be protective of human health because this alternative provides administrative measures and construction support to identify and remove MEC encountered during potential future intrusive activities. These measures would reduce the hazard associated with the remaining MEC. No environmental hazards are associated with MEC.

Compliance with ARARs—The identified ARARs and TBCs (**Table 2-1**) would only apply to alternatives that include active remediation. Therefore, since there is no active remediation under this alternative, Alternative 2 would meet this criterion. However, should MEC be identified during the shoreline sweeps, it will be handled in accordance with the ARARs in **Table 2-1**.

Long-Term Effectiveness and Permanence—This alternative would not provide a permanent remedy. However, LUCs administered under Alternative 2 would meet long-term effectiveness but would be contingent on the cooperation and active participation of the existing powers and authorities of government agencies. The remedial design would specify steps and controls to be put in-place that would ensure that the LUCs are maintained. Although the likelihood of MEC is low, it would not be zero. Therefore, Alternative 2 may not meet the RAOs of minimizing exposure to MEC while maintaining current land use. Construction support would be required and CERCLA Five-year reviews would be conducted to assess the site condition and the degree of protectiveness to human health and the environment.

Reduction of TMV of Contaminants through Treatment— No treatment would be provided; therefore, there would be no reduction of the TMV of MEC potentially present. However, in the unlikely event that MEC was identified during construction support activities, a very minor reduction in TMV through treatment would occur. Therefore, this alternative would meet this criterion.

Short-Term Effectiveness—There would be no additional risk to the community/workers because there are no construction or operation activities associated with Alternative 2. In addition, there are no short-term risks to the community or workers associated with the development of educational materials. Therefore, Alternative 2 would meet this criterion. The shoreline sweeps and potential MEC detonations would need to follow health and safety guidelines established in approved work planning documents to protect the community and site workers.

Implementability—A majority of the LUCs in Alternative 2 are already in-place and can be easily augmented. A plan outlining the design and implementation of administrative LUCs and maintaining a public information program would be developed. Educational materials and services are readily available. Therefore, LUCs would be technically and administratively feasible, thereby meeting this criterion.

Cost—Estimated costs to implement and maintain Alternative 2 are approximately $205,000 in capital costs, a total of $236,000 in O&M costs over a 30-year period, which yield a total of $441,000 for the 30-year present value (see cost calculations in **Appendix A**).

5.2.3 <u>Alternative 3 – MEC Clearance in Breakneck Creek and LUCs</u>

Overall Protectiveness of Human Health and the Environment – Alternative 3 would meet the threshold criteria of overall protection of human health by removing MEC from the Breakneck Creek and implementing LUCs to protect receptors on the Republican River. MEC would be removed from near the school, where signs and other LUCs may not be as effective, and LUCs would be used to protect exposure to any remaining MEC following partial removal.

Compliance with ARARs and TBCs – Alternative 3 would be compliant with ARARs as defined in **Section 2.1** and shown in **Table 2-1**. Therefore, Alternative 3 would meet this criterion.

Long-Term Effectiveness and Permanence – This alternative does not remove MEC hazards from the Republican River and it is unlikely that all MEC will be removed from the Breakneck Creek, but it does remove the most accessible MEC from Breakneck Creek. LUCs are anticipated to be effective for controlling contact with MEC in the Republican River. Therefore, the effectiveness is considered to be "acceptable." Migration of MEC through the sediments from below a depth of 2 ft may occur, so Alternative 3 is not considered a permanent solution. This alternative relies on LUCs to mitigate exposure to MEC in the Republican River as well as MEC that is deeper or otherwise remains in Breakneck Creek after the action. LUCs require continual implementation to be effective, and government ownership of the water bodies increases the likelihood that LUCs will be maintained in the future. If construction activities require intrusive activities below 2 ft (e.g., during construction of a bridge over Breakneck Creek), construction support would be required. In addition, surface sweeps would be required to confirm that MEC was not moved through the water body during heavy rain events. As MEC would potentially remain in the CFLFA2, CERCLA five-year reviews would be required. During the removal, any MEC encountered would be treated on-site with conventional MEC destruction techniques (e.g., BIP, consolidated shot). Sampling for MC may be performed to confirm that no residual impacts to the environment result. Therefore, this alternative is considered to be effective but not permanent.

Reduction of Toxicity, Mobility, or Volume through Treatment – Removal of MEC from the substrate, followed by detonation and disposal of recovered MEC and MD from Breakneck Creek, would reduce the number (or volume) of explosives hazards. Destruction of MEC would be irreversible and would satisfy the statutory preference for treatment. Material documented as safe (MDAS) would be recycled. No detectable explosives concentrations would be anticipated to remain following the detonations. Only very limited reduction of MEC from within or around the Republican River would occur as MEC would only be identified during the shoreline sweeps or during construction support efforts.

Short-Term Effectiveness – There is risk to UXO technicians conducting the MEC clearance in Breakneck Creek and the shoreline sweeps along the Republican River. However, this risk can be addressed using conventional MEC safety practices. There would also be an increase in risk to persons living near or working around the MRS while the removal action is conducted (estimated at 2 months). The increased risk to these persons would be mitigated, where possible, by the use of engineering controls and/or evacuations and/or road closures to maintain MSDs. Boats would not be permitted on the Republican River during shoreline sweep activities. The hazards to local residents and site workers during MEC disposal operations would be mitigated by the use of engineering controls and/or evacuations to maintain MSDs established in the ESS. Measures would be employed to protect and/or restoration natural resources. This alternative is not anticipated to impact community, habitats, or any rare, threatened, or endangered species.

Implementability – Removal of MEC would be performed with proven technologies. Manual removal of MEC/MD by UXO technicians is time consuming, but is the safest means of execution and the recommended option given the site conditions. It would also be the least disruptive to the natural environment. It would take approximately 2 months to clear Breakneck Creek using a 7-man UXO team. Therefore, Alternative 3 would be technically and administratively feasible, thereby meeting this criterion. However, work would have to be scheduled in the summer months.

Cost—Estimated costs to implement and maintain Alternative 3 are approximately $722,000 in capital costs, a total of $236,000 in O&M costs over a 30-year period, which yield a total of $958,000 for the 30-year present value (see cost calculations in **Appendix A**).

5.2.4 Alternative 4 – MEC Clearance for Republican River and Breakneck Creek and LUCs

Overall Protectiveness of Human Health and the Environment – Alternative 4 would meet the threshold criteria of overall protection of human health by removing MEC from both Breakneck Creek and the Republican River. This alternative offers the highest degree of protection because it addresses the most MEC that presents an explosive hazard. LUCs would be used to protect exposure to any remaining MEC following removal.

Compliance with ARARs and TBCs – Alternative 4 would be compliant with ARARs as defined in **Section 2.1** and shown in **Table 2-1**. Therefore, Alternative 4 would meet this criterion.

Long-Term Effectiveness and Permanence – This alternative does not remove all MEC hazards at MRS as MEC may remain below the depth at which it can be effectively removed from the water bodies, but it does remove the most accessible MEC in the substrate. Therefore, the effectiveness is considered to be "good" for the MRS. Migration of MEC through the sediments may occur, particularly during heavy rain events, so Alternative 4 is not considered a permanent solution. This alternative relies on LUCs to mitigate exposure to MEC that is deeper or otherwise remains after the action. LUCs require continual implementation to be effective, and government ownership of the water bodies increases the likelihood that LUCs will be maintained in the future. If construction activities require intrusive activities (e.g., during construction of a dock), construction support would be required. Surface sweeps would be required to confirm that MEC was not moved through the water body during heavy rain events. As MEC would potentially remain, CERCLA five-year reviews would be required. During the removal, any MEC encountered would be treated on-site with conventional MEC destruction techniques (e.g., BIP, consolidated shot). Sampling for MC may be performed to confirm that no residual impacts to the environment result. Therefore, this alternative is considered to be effective but not permanent for this MRS.

Reduction of Toxicity, Mobility, or Volume through Treatment – Removal of MEC from the substrate, followed by detonation and disposal of recovered MEC and MD, would reduce the number (or volume) of explosives hazards. Destruction of MEC would be irreversible and would satisfy the statutory preference for treatment. MDAS would be recycled. No detectable explosives concentrations would be anticipated to remain following the detonations.

Short-Term Effectiveness – There is risk to UXO technicians and divers conducting the operations at the MRS due to the dangerous nature of the underwater activities. These would be controlled by implementing safety measures detailed in a Dive Plan. There would also be an increase in risk to persons living near or working around the MRS while the removal action is conducted (estimated at 4 months). The increased risk to these persons would be mitigated, where possible, by the use of engineering controls and/or evacuations and/or road closures to maintain MSDs. Boats would not be permitted on the Republican River during removal activities. The hazards to local residents and site workers during MEC disposal operations would be mitigated by the use of engineering controls and/or evacuations to maintain MSDs established in the ESS. Measures would be employed to protect and/or restoration natural resources. This alternative is not anticipated to impact community, habitats, or any rare, threatened, or endangered species.

Implementability – Removal of MEC from the substrate would be performed with proven technologies. Manual removal of MEC/MD by UXO-qualified divers is time consuming, but is the safest means of execution and the recommended option given the site conditions. It would also be the least disruptive to the natural environment. It would take approximately 4 months to clear the area using 4 four-man UXO dive teams. Therefore, Alternative 4 would be technically and administratively feasible, thereby meeting this criterion. However, work would have to be scheduled in the summer months and may take as much as two field seasons.

Cost—Estimated costs to implement and maintain Alternative 4 are approximately $3,602,000 in capital costs, a total of $236,000 in O&M costs over a 30-year period, which yield a total of $3,838,000 for the 30-year present value (see cost calculations in **Appendix A**).

6 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

In this section, alternatives are compared to each other with respect to the nine NCP criteria listed in **Section 5.1** and the overall cost-effectiveness of risk/hazard reduction offered by the alternatives.

6.1 Overall Protection of Human Health and the Environment

No environmental hazards are associated with the type of MEC identified, so all four alternatives are protective of the environment. Alternative 4 would offer the highest level of protection of human health, as residual MEC would be removed from the all areas within the MRS where MEC was identified. Alternative 3 provides the next highest level of protection as MEC would be removed from Breakneck Creek, which is close to a school and use LUCs to prevent contact with MEC in the Republican River. Alternative 2 would use LUCs to reduce exposure to hazards but does not remove MEC. However, LUCs are effective at protecting human health when maintained, so Alternative 2 is also protective of human health. The No Action alternative, Alternative 1, consists of leaving the site in its current state. Due to the potential hazard posed by MEC, Alternative 1 is not considered to be protective of human health because there are no mechanisms included for mitigating potential exposure to MEC.

6.2 Compliance with ARARs

There are no ARARs or TBCs criteria associated with Alternative 1. Alternatives 2, 3, and 4 would be designed to comply with the ARARs in **Table 2-1**. As all alternatives will comply with ARARs, they are equally ranked.

6.3 Long-Term Effectiveness and Permanence

With respect to long-term effectiveness and permanence, Alternative 4 removes the greatest quantity of MEC from the MRS, followed by Alternative 3. The MEC removal provides an increased long-term effectiveness for the remedies, with Alternative 4 providing the greatest level of source removal. However, as MEC may still remain, LUCs would be required to provide long-term effectiveness and the remedies are not permanent. Alternative 2 does not provide permanence for the MRS, but would be long-term effective as long as the LUCs are maintained. Alternative 1 is neither effective nor permanent as MEC are anticipated to remain and there are no controls to prevent access to it.

6.4 Reduction in TMV

MEC removal at the Breakneck Creek under Alternatives 3 and 4, followed by detonation and disposal of recovered MEC and MD, would reduce the number (or volume) of explosives hazards. Alternative 4 provides an increased level of reduction in TMV and MEC would be removed from the Republican River as well. Destruction of MEC would be irreversible and would satisfy the statutory preference for treatment. No detectable explosives concentrations would be anticipated to remain following the detonations. MDAS would be recycled. For Alternative 2, no treatment would be provided unless MEC are identified during the shoreline sweeps or during construction support activities; therefore, there would be little or no reduction of the TMV of MEC potentially present. No reduction in TMV would be provided by Alternative 1.

6.5 Short-Term Effectiveness

There are no activities performed for Alternative 1, so it entails no risks during implementation. Alternative 2 would entail short-term hazards during sign installation and during shoreline sweep and construction support activities in the event future activities are planned. For Alternatives 3 and 4, there is risk to UXO technicians conducting the operations at the MRS. Alternative 4 provides an additional hazard as diving would occur. These hazards would be controlled by implementing safety measures detailed in approved work planning document, ESSs, and, for Alternative 4, a Dive Plan. EZs and health and safety requirements to protect local residents and site workers would be detailed in an ESS and work planning documents. Implementing the requirements of the ESS would protect the local public and site workers during remedy completion.

6.6 Implementability

Implementability addresses the feasibility of performing a remedial action given field conditions and other factors (e.g., administrative and technical). Alternatives 2, 3, and 4 would all be feasible with respect to their technology; MEC removal and LUCs are standard technologies that have been applied with success at various other DoD installations. Removal of MEC by UXO-qualified divers under Alternative 4 would require additional safety considerations than a primarily land-based MEC removal like that proposed for Alternative 3, but all of these safety considerations would be considered during the work planning process. Alternative 2 would be more feasible with regard to site logistics but would need to be coordinated with local land owners to ensure the LUCs could be implemented and maintained. No actions would be taken under Alternative 1, so it is the most implementable.

6.7 Cost

Alternative 1 has no capital or O&M cost because no remedial activity is performed. The estimated costs for each alternative are listed in **Table 6-1**. The ranking of alternatives with respect to cost, in order from most favorable to least favorable, is Alternative 1, Alternative 2, Alternative 3, Alternative 4.

Table 6-1 Comparative Analysis of Alternatives for CFLFA2 MRS

MRS	Type	Screening Criterion	Alternative 1: No Action	Alternative 2: LUCs	Alternative 3: MEC Clearance in Breakneck Creek and LUCs	Alternative 4: MEC Clearance for Republican River and Breakneck Creek and LUCs
CFLFA2	Threshold	Overall Protection of Human Health and the Environment	No	Yes	Yes	Yes
		Compliance with ARARs	Yes	Yes	Yes	Yes
	Balancing	Long-Term Effectiveness	○	◊ (Effective Not Permanent)	◊ (Effective Not Permanent)	● (Effective Not Permanent)
		Reduction of Toxicity, Mobility and Volume through Treatment	○	◊	◊	●
		Short-Term Effectiveness	●	●	●	●
		Implementability	●	●	●	●
		-Technical Feasibility	●	●	●	●
		-Administrative Feasibility	●	●	●	●
		-Availability of Materials and Services	●	●	●	●
		Cost[1]	$0	$441,000	$958,000	$3,838,000
	Modifying[2]	Regulatory Agency Acceptance	TBD	TBD	TBD	TBD
		Community Acceptance	TBD	TBD	TBD	TBD

● *In comparison with other alternatives, complies well with criteria.*

◊ *In comparison with other alternatives, partially complies with criteria.*

○ *In comparison with other alternatives, does not comply well with criteria.*

[1] *30-Year present worth costs assuming a 0.7% escalation factor (OMB, 2016). Costs are detailed in* ***Appendix A****.*

[2] *The modifying criteria of regulatory agency and community acceptance are to be determined (TBD) following review and input from these parties and will be evaluated in the ROD*

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APPENDIX A

CFLFA MRS ALTERNATIVE REMEDIAL ACTION COST ESTIMATES

Fort Riley

Alternative 1
No Action

COST ESTIMATE SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Capital Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
None	0	LS	$0	$0	Baseline for comparison

TOTAL CAPITAL COST **$0**

Annual Operation and Maintenance (O&M) Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
None	0	EA	$0	$0	Baseline for comparison

TOTAL ANNUAL COST **$0**

Periodic Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
None	0	EA	$0	$0	Baseline for comparison

TOTAL PERIODIC COST **$0**

TOTAL COST **$0**

Total Present Worth Cost: **$0**

Fort Riley

Alternative 2
Land Use Controls

COST ESTIMATE SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Capital Costs

Description	QTY	UNIT	UNIT COST		TOTAL		NOTES
Public meeting, LUCIP, Admin Record Update	1	LS	$	22,850	$	22,850	Update LUC Plan & travel
Master Plan Input	1	LS	$	500	$	500	Update Installation-wide planning
Signs	71	EA	$	110	$	7,810	Engr's Est; 14,113 LF, signs every 200 ft
Sign Installation/Survey	1	LS	$	102,871	$	102,871	See Cost Worksheet
Training/Education Materials	1	LS	$	7,500	$	7,500	Engineer's Estimate
Deed Notification and Recording	1	LS	$	5,000	$	5,000	Engineer's Estimate
Project Contingency	25%				$	36,632.75	
Program Management	15%				$	21,979.65	
			TOTAL CAPITAL COST		**$**	**205,000**	

Annual Operation and Maintenance (O&M) Costs

Description	QTY	UNIT	UNIT COST		TOTAL		NOTES
Annual Sign Maintenance	30	EA	$	5,944	$	178,320	Replace avg of 2 signs per year-MRS; 30 yrs
TOTAL ANNUAL COST (30 YEARS)					**$**	**178,000**	

Periodic Costs

Description	QTY	UNIT	UNIT COST		TOTAL		NOTES
Five Year Review	6	EA	$	12,000	$	72,000	Update every 5 years for 30 years (one report)
TOTAL PERIODIC COST					**$**	**72,000**	

TOTAL 30-YEAR O&M COST 1.5% DISCOUNT	**$**	**236,000**
TOTAL PRESENT WORTH COST (1.5% DISCOUNT)	**$**	**441,000**

Fort Riley

Alternative 2
Land Use Controls

PRESENT WORTH SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Present Value Analysis

Annual Percentage Rate 0.7%

YR	Capital -	O&M Annual	Periodic Cost	Total Costs -	Present Worth -
0	$205,000	-	-	$205,000	$205,000
1	-	$5,944	-	$5,944	$5,903
2	-	$5,944	-	$5,944	$5,882
3	-	$5,944	-	$5,944	$5,862
4	-	$5,944	-	$5,944	$5,841
5	-	$5,944	$ 12,000	$17,944	$17,573
6	-	$5,944	-	$5,944	$5,801
7	-	$5,944	-	$5,944	$5,781
8	-	$5,944	-	$5,944	$5,761
9	-	$5,944	-	$5,944	$5,741
10	-	$5,944	$ 12,000	$17,944	$17,272
11	-	$5,944	-	$5,944	$5,702
12	-	$5,944	-	$5,944	$5,682
13	-	$5,944	-	$5,944	$5,663
14	-	$5,944	-	$5,944	$5,643
15	-	$5,944	$ 12,000	$17,944	$16,978
16	-	$5,944	-	$5,944	$5,605
17	-	$5,944	-	$5,944	$5,586
18	-	$5,944	-	$5,944	$5,567
19	-	$5,944	-	$5,944	$5,548
20	-	$5,944	$ 12,000	$17,944	$16,690
21	-	$5,944	-	$5,944	$5,510
22	-	$5,944	-	$5,944	$5,491
23	-	$5,944	-	$5,944	$5,473
24	-	$5,944	-	$5,944	$5,454
25	-	$5,944	$ 12,000	$17,944	$16,409
26	-	$5,944	-	$5,944	$5,417
27	-	$5,944	-	$5,944	$5,399
28	-	$5,944	-	$5,944	$5,381
29	-	$5,944	-	$5,944	$5,363
30	-	$5,944	$ 12,000	$17,944	$16,134
TOTALS	**$205,000**	**$178,320**	**$72,000**	**$455,320**	**$441,110**

Fort Riley

Alternative 2
Land Use Controls

COST WORKSHEET

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Cost Analysis

Sign Installation

Description		QTY	UNIT	UNIT COST	TOTAL	NOTES
Planning Documents						
	Work Plan/APP	1	EA	$ 45,000	$ 45,000	
Field Work						
	Truck	10	Day	$ 175	$ 1,750	
	Fuel/Maintenance	60	gallon	$ 5	$ 300	
	Sales Tax			3%	$ 62	
Materials and Subcontractors						
	Analog metal detector	8	Day	$ 18	$ 144	
	Survey Equipment	8	Day	$ 200	$ 1,600	
	Misc Equipment/Supplies	1	LS	$ 2,500	$ 2,500	
Personnel						
	Mob/demob/Lodging/M&IE	20	EA	$ 156	$ 3,120	Lodging and M&IE
	Air Fare (2)	2	EA	$ 750	$ 1,500	RT airline tickets
	Project Management	1	LS	$ 1,000	$ 1,000	Project mgmt, coordination and procurement
	UXO Tech 3 (1)	104	HR	$ 95	$ 9,880	Install signs
	UXO Tech 2 (1)	104	HR	$ 85	$ 8,840	Install signs
	Surveyor	25	HR	$ 225	$ 5,625	Survey Signs
	Sign Subcontractor	67	EA	$ 250	$ 16,750	Engr's Est; drill holes, pour concrete, place signs
	Memo Report	1	LS	$ 4,800.00	$ 4,800	Includes figures and survey data
	TOTAL COST				**$ 102,871**	

Fort Riley

Alternative 3
Breakneck Creek MEC Clearance and Sign Installation

COST ESTIMATE SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Capital Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Public meeting, Admin Record Update	1	LS	$ 22,850	$ 22,850	Update LUC Plan & travel
Master Plan Input	1	LS	$ 500	$ 500	Update Installation-wide planning
Signs	71	EA	$ 110	$ 7,810	Engr's Est; 14,113 LF, signs every 200 ft
Field Work (MEC Clearance and Sign Install)	1	LS	$ 471,919	$ 471,919	See Cost Worksheet
Training/Education Materials	1	LS	$ 7,500	$ 7,500	Engineer's Estimate
Deed Notification and Recording	1	LS	$ 5,000	$ 5,000	Engineer's Estimate
Project Contingency	25%			$ 128,894.73	
Program Management	15%			$ 77,336.84	
			TOTAL CAPITAL COST	**$ 722,000**	

Annual Operation and Maintenance (O&M) Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Sign Maintenance	30	EA	$ 5,944	$ 178,320	Replace avg of 2 signs per year-MRS; 30 yrs
TOTAL ANNUAL COST				**$ 178,320**	

Periodic Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Five Year Review	6	EA	$ 12,000	$ 72,000	Update every 5 years for 30 years (one report)
TOTAL PERIODIC COST				**$ 72,000**	

TOTAL 30-YEAR O&M COST 1.5% DISCOUNT	**$ 236,000**
TOTAL PRESENT WORTH COST (1.5% DISCOUNT)	**$ 958,000**

Fort Riley

Alternative 3
Breakneck Creek MEC Clearance and Sign Installation

PRESENT WORTH SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Present Value Analysis

Annual Percentage Rate 0.7%

YR	Capital -	O&M Annual	Periodic Cost	Total Costs -	Present Worth -
0	$722,000	-	-	$722,000	$722,000
1	-	$5,944	-	$5,944	$5,903
2	-	$5,944	-	$5,944	$5,882
3	-	$5,944	-	$5,944	$5,862
4	-	$5,944	-	$5,944	$5,841
5	-	$5,944	$ 12,000	$17,944	$17,573
6	-	$5,944	-	$5,944	$5,801
7	-	$5,944	-	$5,944	$5,781
8	-	$5,944	-	$5,944	$5,761
9	-	$5,944	-	$5,944	$5,741
10	-	$5,944	$ 12,000	$17,944	$17,272
11	-	$5,944	-	$5,944	$5,702
12	-	$5,944	-	$5,944	$5,682
13	-	$5,944	-	$5,944	$5,663
14	-	$5,944	-	$5,944	$5,643
15	-	$5,944	$ 12,000	$17,944	$16,978
16	-	$5,944	-	$5,944	$5,605
17	-	$5,944	-	$5,944	$5,586
18	-	$5,944	-	$5,944	$5,567
19	-	$5,944	-	$5,944	$5,548
20	-	$5,944	$ 12,000	$17,944	$16,690
21	-	$5,944	-	$5,944	$5,510
22	-	$5,944	-	$5,944	$5,491
23	-	$5,944	-	$5,944	$5,473
24	-	$5,944	-	$5,944	$5,454
25	-	$5,944	$ 12,000	$17,944	$16,409
26	-	$5,944	-	$5,944	$5,417
27	-	$5,944	-	$5,944	$5,399
28	-	$5,944	-	$5,944	$5,381
29	-	$5,944	-	$5,944	$5,363
30	-	$5,944	$ 12,000	$17,944	$16,134
TOTALS	**$722,000**	**$178,320**	**$72,000**	**$972,320**	**$958,110**

Fort Riley

Alternative 3
Breakneck Creek MEC Clearance and Sign Installation

COST WORKSHEET

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Cost Analysis

Breakneck Creek MEC Clearance and Sign Installation

Description		QTY	UNIT	UNIT COST		TOTAL		NOTES
Planning Documents								
	UFP-QAPP and ESS	1	EA	$	103,000	$	103,000	
Field Work								
	Truck (x 3)	46	Day	$	175	$	8,050	
	Fuel/Maintenance	276	gallon	$	5	$	1,380	
	Sales Tax			3%		$	283	2.75
Materials and Subcontractors								
	Analog metal detector (x 7)	104	Day	$	18	$	1,872	
	Survey Equipment	22	Day	$	200	$	4,400	
	Misc Equipment/Supplies	1	LS	$	6,875	$	6,875	
Personnel								
	Mob/demob/Lodging/M&IE	104	EA	$	156	$	16,224	Lodging and M&IE
	Air Fare (7)	7	EA	$	750	$	5,250	RT airline tickets
	Project Management	1	LS	$	54,000	$	54,000	Project mgmt, coordination and procurement
	UXO Tech 2 (2)	340	HR	$	85	$	28,900	Install 52 signs; mag and dig 10 acres
	UXO Tech 1 (2)	252	HR	$	75	$	18,900	Mag and dig 10 acres
	UXO Tech 3 (1)	214	HR	$	95	$	20,330	Install 52 signs; mag and dig 10 acres
	UXOSO/QCS	136	HR	$	110	$	14,960	Mag and dig 10 acres
	SUXOS	136	HR	$	120	$	16,320	Mag and dig 10 acres
	Vegetation Removal	10	ACRE	$	5,500	$	55,000	10 acres and mob/demob
	Sign Subcontractor	52	EA	$	250	$	13,000	Engr's Est; drill holes, pour concrete, place signs
	MDAS Recycling	1	LS	$	7,500	$	7,500	Engineer's Estimate
	Explosives and Mag	1	LS	$	6,400	$	6,400	Engineer's Estimate
	Surveyor	19	HR	$	225	$	4,275	Survey Signs
Final Reporting								
	SSFR Report	1	LS	$	85,000.00	$	85,000	Includes figures and survey data
	TOTAL COST					**$**	**471,919**	

Fort Riley

Alternative 4
Breakneck Creek and Republican River MEC Clearance and Sign Installation

COST ESTIMATE SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Capital Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Public meeting, Admin Record Update	1	LS	$ 22,850	$ 22,850	Update LUC Plan & travel
Master Plan Input	1	LS	$ 500	$ 500	Update Installation-wide planning
Signs	71	EA	$ 110	$ 7,810	Engr's Est; 14,113 LF, signs every 200 ft
Field Work (MEC Clearance and Sign Install)	1	LS	$ 2,528,974	$ 2,528,974	See Cost Worksheet
Training/Education Materials	1	LS	$ 7,500	$ 7,500	Engineer's Estimate
Deed Notification and Recording	1	LS	$ 5,000	$ 5,000	Engineer's Estimate
Project Contingency	25%			$ 643,158.55	10% scope +15% bid
Program Management	15%			$ 385,895.13	
			TOTAL CAPITAL COST	**$ 3,602,000**	

Annual Operation and Maintenance (O&M) Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Sign Maintenance	30	EA	$ 5,944	$ 178,320	Replace avg of 2 signs per year-MRS; 30 yrs
TOTAL ANNUAL COST				**$ 178,320**	

Periodic Costs

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Five Year Review	6	EA	$ 12,000	$ 72,000	Update every 5 years for 30 years (one report)
TOTAL PERIODIC COST				**$ 72,000**	

TOTAL 30-YEAR O&M COST 1.5% DISCOUNT	**$ 236,000**
TOTAL PRESENT WORTH COST (1.5% DISCOUNT)	**$ 3,838,000**

Fort Riley

Alternative 4
Breakneck Creek and Republican River
MEC Clearance and Sign Installation

PRESENT WORTH SUMMARY

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Present Value Analysis

Annual Percentage Rate 0.7%

YR	Capital -	O&M Annual	Periodic Cost	Total Costs -	Present Worth -
0	$3,602,000	-	-	$3,602,000	$3,602,000
1	-	$5,944	-	$5,944	$5,903
2	-	$5,944	-	$5,944	$5,882
3	-	$5,944	-	$5,944	$5,862
4	-	$5,944	-	$5,944	$5,841
5	-	$5,944	$ 12,000	$17,944	$17,573
6	-	$5,944	-	$5,944	$5,801
7	-	$5,944	-	$5,944	$5,781
8	-	$5,944	-	$5,944	$5,761
9	-	$5,944	-	$5,944	$5,741
10	-	$5,944	$ 12,000	$17,944	$17,272
11	-	$5,944	-	$5,944	$5,702
12	-	$5,944	-	$5,944	$5,682
13	-	$5,944	-	$5,944	$5,663
14	-	$5,944	-	$5,944	$5,643
15	-	$5,944	$ 12,000	$17,944	$16,978
16	-	$5,944	-	$5,944	$5,605
17	-	$5,944	-	$5,944	$5,586
18	-	$5,944	-	$5,944	$5,567
19	-	$5,944	-	$5,944	$5,548
20	-	$5,944	$ 12,000	$17,944	$16,690
21	-	$5,944	-	$5,944	$5,510
22	-	$5,944	-	$5,944	$5,491
23	-	$5,944	-	$5,944	$5,473
24	-	$5,944	-	$5,944	$5,454
25	-	$5,944	$ 12,000	$17,944	$16,409
26	-	$5,944	-	$5,944	$5,417
27	-	$5,944	-	$5,944	$5,399
28	-	$5,944	-	$5,944	$5,381
29	-	$5,944	-	$5,944	$5,363
30	-	$5,944	$ 12,000	$17,944	$16,134
TOTALS	**$3,602,000**	**$178,320**	**$72,000**	**$3,852,320**	**$3,838,110**

Fort Riley

Alternative 4
Breakneck Creek and Republican River MEC Clearance and Sign Installation

COST WORKSHEET

Site: Camp Forsyth Landfill Area 2 (FTRI-003-R-01)
Location: Fort Riley, KS
Phase: Feasibility Study
Base Year: 2017

Cost Analysis

Breakneck Creek and Republican River MEC Clearance and Sign Installation

Description	QTY	UNIT	UNIT COST	TOTAL	NOTES
Planning Documents					
UFP-QAPP and ESS	1	EA	$ 153,000	$ 153,000	Includes Dive Plan
Field Work					
Boat/Dive Equipment	11	week	$ 123,000	$ 1,353,000	Dive Compressor, Decompression Chamber,
Truck (x 4)	168	Day	$ 175	$ 29,400	Dive Equipment, Pump
Fuel/Maintenance	1,008	gallon	$ 5	$ 5,040	
Sales Tax			3%	$ 1,033	2.75
Materials and Subcontractors					
Analog metal detector (x 7)	84	Day	$ 18	$ 1,512	
Underwater Metal Detector (x 7)	224	Day	$ 50	$ 11,200	
Survey Equipment	42	Day	$ 200	$ 8,400	
Misc Equipment/Supplies	1	LS	$ 13,125	$ 13,125	
Personnel					
Mob/demob/Lodging/M&IE	294	EA	$ 156	$ 45,864	Lodging and M&IE
Air Fare (7)	7	EA	$ 750	$ 5,250	RT airline tickets
Project Management	1	LS	$ 97,000	$ 97,000	Project mgmt, coordination and procurement
UXO Tech 2, diver (3)	1,368	HR	$ 85	$ 116,280	Mag and dig 10 acres; clear 14.9 acres water
UXO Tech 3, diver (2)	912	HR	$ 95	$ 86,640	Mag and dig 10 acres; clear 14.9 acres water
UXOSO/QCS	496	HR	$ 110	$ 54,560	Mag and dig 10 acres; clear 14.9 acres water
SUXOS	496	HR	$ 120	$ 59,520	Mag and dig 10 acres; clear 14.9 acres water
Vegetation Removal	10	ACRE	$ 5,500	$ 55,000	10 acres and mob/demob
Sign Subcontractor	52	EA	$ 250	$ 13,000	Engr's Est; drill holes, pour concrete, place signs
MDAS Recycling	1	LS	$ 12,500	$ 12,500	Engr's Est
Explosives and Mag	1	LS	$ 36,400	$ 36,400	Engr's Est
DGM	24.9	ACRE	$ 10,000	$ 249,000	Engr's Est
Surveyor	10	HR	$ 225	$ 2,250	Survey Boundary and Control Points
Final Reporting					
SSFR Report	1	LS	$ 85,000.00	$ 120,000	Includes figures and survey data

TOTAL COST **$ 2,528,974**