UNCLASSIFIED

FINAL

REMEDIAL INVESTIGATION / FEASIBILITY STUDY REPORT

Kanaio Local Training Area (Area 1 and Area D)
AEDB-R Site ID HIHQ-006-R-01

Prepared for:

Army National Guard

Contracting Agency:

U.S. Army Corps of Engineers, Baltimore District

Contract No. W912DR-15-D-0020
Delivery Order No. W912DR19F0538

Prepared by:

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May 2022

Technical Review Signature Sheet

Project Name: Remedial Investigation/Feasibility Study Kanaio Local Training Area (Area 1 and Area D)

Site Location: Maui, Hawaii

Report Title: Remedial Investigation/Feasibility Study Report for Kanaio Local Training Area (Area 1 and Area D) Maui, Hawaii

Prepared For: Army National Guard

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Executive Summary

ES.1 BACKGROUND

ES.1.1 INTRODUCTION

ES.1.1.1 The United States (U.S.) Army Corps of Engineers (USACE) has performed a Remedial Investigation/Feasibility Study (RI/FS) of a 1,983-acre portion (“Area 1” and “Area D”) of the 4,771-acre Kanaio Local Training Area (LTA) munitions response site (MRS) located on Maui, Hawaii. The MRS is identified by Army Environmental Database Restoration Number HIHQ-006-R-01. The balance of the MRS acreage (designated as “Area 2”) was recommended for No Further Action (NFA) during the prior 2018 Site Inspection (SI) investigation phase based on the absence of potential explosive hazards as well as munitions constituent (MC) contamination. This RI/FS was conducted in accordance with the performance work statement (PWS) dated 22 March 2019 and the objectives and goals presented in the approved Final Uniform Federal Policy – Quality Assurance Project Plan Revision 4 (UFP-QAPP). In addition, it was performed in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Defense Environmental Restoration Program (DERP) statute (10 U.S. Code [U.S.C.] 2701, et seq.), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations Part 300), and the Military Munitions Response Program (MMRP), as administered by the USACE. This RI/FS Report has been prepared by Parsons for the USACE Baltimore District under the Army National Guard (ARNG) Contract No. W912DR-15-D-0020, Delivery Order No. W912DR19F0538.

ES.1.1.2 The primary objective of this RI/FS was to determine the nature and extent of munitions and explosives of concern (MEC) contamination and munitions constituent (MC) contamination within the MRS focus area (Area 1 and Area D), evaluate associated risks, and develop and evaluate potential remedial alternatives as warranted. Prior studies and investigations, to include the 2018 SI, confirmed the presence of MEC contamination in this area. The presence of MC contamination was not previously confirmed; however, further assessment was planned provided specific conditions were met and sufficient soil was present to collect a sample.

ES.1.1.3 To accomplish the RI/FS objective, subsurface anomaly data collection and intrusive investigations were conducted at the Kanaio LTA MRS (Area 1 and Area D) between 15 February 2021 and 04 May 2021. The field investigation was conducted in accordance with the UFP-QAPP developed, reviewed, and approved by the Systematic Planning Process (SPP) Team. The SPP Team consisted of representatives from the ARNG, Hawaii Army National Guard (HIARNG), Hawaii Department of Health (HDOH), United States Army Corps of Engineers (USACE) Sacramento District (CESPK), USACE Baltimore District, the Hawaii Department of Land and Natural Resources (DLNR), and Parsons.

ES.1.2 SITE DESCRIPTION

ES.1.2.1 The Kanaio LTA MRS is located on the southernmost extent of the Island of Maui, Hawaii (**Figure ES.1**). The RI investigation area includes the 1,946-acre “Area 1” portion of the Kanaio LTA MRS (as divided during the 2018 SI) and the 37-acre “Area D” Area of Interest (AOI); a noncontiguous parcel located due east of Area 1 and along the coastline and accessible via King’s Trail. For simplicity, the term “Kanaio LTA MRS” will be used throughout this document from here forward to specifically refer to the 1983-acre focus area comprised by Area 1 and Area D and not the entire 4,771-acre MRS.

ES.1.2.2 Aside from several small privately-owned parcels, the entire MRS is owned by the Hawaii DLNR. The investigation area is characterized by steep terrain with elevations ranging from sea-level in the south to 1800 feet above mean sea level (msl) to the north. Vegetation within the investigation area is largely nonexistent with the surface consisting mostly of a’a lava fields characterized by minimal to no surface soil.

ES.1.2.3 The Kanaio LTA MRS was utilized for live-fire practice as early as World War II by various branches of the military including the U.S. Army, U.S. Marine Corps, and the HIARNG and has been inactive since 2003. Area 1 was used from 1965 through the mid-1990s for training with 40-mm grenades and M72 light anti-armor weapon (LAW) rockets. In addition, evidence from prior studies indicated that recoilless rifles, high explosive anti-tank (HEAT) projectiles, various mortars, and artillery rounds may have also been used in Area 1. Historical accounts indicate Area D was predominately used as a livestock watering area (Na Ali`i, 2018). The area was reportedly declared off-limits to HIARNG personnel as early as the 1960s. Anecdotal evidence suggests that Area D may at one point have been the target area for 4.2-inch mortars from Area B (Na Ali`i, 2018).

ES.2 CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN

ES.2.1 Characterization of MEC consisted of a series of steps beginning with gathering both analog and digital geophysical mapping (DGM) data on preliminary transects strategically spaced across the MRS. Analog data collection techniques were not originally planned; however, due to the extreme adverse terrain and presence of a'a lava fields, data collection techniques were modified and documented in a Field Change Request (FCR-01, Appendix E). The transect geophysical data were used to identify both surface and subsurface geophysical anomalies indicating the potential presence of metallic objects. This data was used to evaluate the horizontal distribution across the MRS and subsequently to differentiate between high anomaly density (HD) and low anomaly density (LD) areas within the Kanaio LTA MRS based on threshold criteria.

ES.2.2 Following identification of both HD and LD areas, sampling grids were established at locations selected by the SPP Team for DGM and intrusive investigation. As experienced during transect mapping, grid mapping was also hindered by terrain and a'a lava fields. Therefore, modified analog techniques were significantly used to augment conventional DGM and Advanced Geophysical Classification (AGC) mapping. Grids were intrusively investigated to confirm if individual HD or LD areas represented a high-use area (HUA) (i.e., an area contaminated with MEC or a significant amount of munitions debris [MD]), low-use area (LUA), or neither. A determination of the vertical extent of MEC and MD contamination was also accomplished through the intrusive investigation.

ES.2.3 A single 36-acre HUA was identified based on the distribution of MEC and MD found during the RI and with consideration to known historical MD and MEC findings (where documented). The remaining 1947-acres were classified as an LUA. One MEC item, an 81-mm HE mortar (Grid 12), was discovered during the RI inside the boundary of the identified HUA. Two MEC items were identified during the 2017 SI field work. A 3.5-inch HEAT rocket warhead was recovered from along the western edge of Impact Area 2 (just north of the HUA) and an unexpended M84A1 Powder Train time fuze was recovered from within the northern portion of the HUA. Earlier historical studies and cleanup efforts documented in the Historical Records Review (HRR) prepared in support of the SI (Na Ali`i, 2018) confirmed MEC item recovery and removal actions as early as 1981 and continuing in 1988, 1995, and 1998. Reported findings included M72 LAW rockets, 105-mm projectiles, 106-mm projectiles, 40-mm HE projectiles, and 81-mm mortars. Various MD from LAW rockets, 3.5-inch rockets, 40-mm HE grenades, 105-mm projectiles, 106-mm HEAT projectiles 4.2-inch mortars, 81-mm white phosphorus (WP) mortars, and 81-mm HE mortars were also identified during previous investigations and studies. Most of the findings, where identified, were within the RI HUA or in proximity. All prior MEC were reported as removed or detonated.

ES.2.4 During the RI, a total of 854 MD items were recovered of which 371 were associated with the transect survey. The balance of the MD consisted of 357 MD items from 5 HD area grids and 96 MD items from 8 LD area grids. Additionally, a cache of 30 MD items (US Rocket Practice M29 Series rockets) were discovered by the field team while traversing the site on the way to Grid 4. All MD was recovered from depths of less than 34 cm (~13.4 inches) below ground surface (bgs) and 92.5 percent of MD was recovered at less than 15 cm bgs (~6 inches). Within much of the project area to include all of the HUA, as noted in Subsection ES.1.2.2, minimal to no surface soil was present due to the presence of a'a lava fields. As such, the MD recovered in this area (transects and grids) was generally located on the surface.

ES.3 CHARACTERIZATION OF MUNITIONS CONSTITUENTS

ES.3.1 The presence of soil within the investigation area was largely nonexistent with the surface consisting primarily of a'a lava fields. Most of the Kanaio LTA MRS is dominated by recent lava flows with very little soil development on the fresh Hana flow surfaces. Over 60% of the greater Kanaio LTA MRS, and the almost the entirety of Area 1 and Area D, are covered with a'a lava and characterized by a rough, spiny surface that is extremely difficult to traverse and devoid of soil. Samples were collected where soil was present during the SI and was determined to not to pose a risk to human health or the environment (Na Ali`i, 2018). The SI sampled areas were outside of the suspect impact areas (1,946-acre “Area 1” and the 37-acre “Area D”) which were the focus of this RI. During this RI, MC samples were planned to be collected in accordance with the UFP-QAPP if low-order detonation munitions were encountered, suspected contamination sources (e.g., a cache of discarded military munitions [DMM]) were identified, or if blow-in-place (BIP) activities were conducted and sufficient soil to collect a sample was present. During the RI fieldwork, a single BIP (intact 81-mm HE mortar from Grid 12) was conducted and a stockpile of US Rocket Practice M29 Series rockets (MD) was located; however, in both cases no sampleable soil was present. Therefore, no samples were collected and no MC contamination was identified at the Kanaio LTA during the RI.

ES.4 MUNITIONS AND EXPLOSIVES OF CONCERN RISK ASSESSMENT

ES.4.1 MEC Risk Management Methodology (RMM) included in the *Final Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives for Munitions Response Sites* (USACE, 2016) was applied to the Kanaio LTA MRS in accordance with the interim guidance document *Trial Period for Risk Management Methodology at Formerly Used Defense Sites Military Munitions Response Program Projects* (Department of the Army, 2017). Based on the presence of confirmed historical munitions finds in conjunction with the single MEC item and extensive MD found during the RI, an unacceptable risk for human receptors from explosive hazards at Kanaio LTA MRS was identified.

ES.5 MUNITIONS CONSTITUENTS RISK ASSESSMENT

ES.5.1 The absence of soil precluded MC sampling during this RI. Combined with the results of the limited soil sampling conducted during the SI and absence of surface soil to provide a complete exposure pathway throughout most of the site, no MC contamination was identified within the project area.

ES.6 RI CONCLUSIONS AND RECOMMENDATIONS

ES.6.1 This RI identified MEC contamination at the Kanaio LTA MRS that potentially poses an unacceptable risk from explosive hazards to current and future human receptors. The absence of soil, in conjunction with the prior SI NFA conclusion for MC, supports the assertion of no unacceptable risks to human health or the environment from MC. As such, remedial actions evaluated in the FS were restrict to MEC hazards only.

ES.6.2 The presence of MEC hazards negates the potential acceptability of the “no-action” response alternative. Therefore, conduct of an FS was warranted to evaluate viable response actions that could be implemented to address the MEC contamination and associated hazards that have been identified at the Kanaio LTA MRS. The MEC data collected during the RI were determined to be sufficient to fully characterize the MRS, to identify and evaluate any associated potential MEC hazards, and to fully support the FS.

ES.7 FEASIBILITY STUDY SUMMARY

ES.7.1 OVERVIEW

ES.7.1.1 The objectives of the FS are to ensure that appropriate remedial alternatives are developed and evaluated for the MRS acreage that is recommended for continuance to the FS phase. Remedial alternatives were developed for the primary contaminant (MEC) identified at the Kanaio LTA MRS. No MC contamination or exposure pathways were identified based on the SI soil sampling results and absence of soil at potential sampling locations during the RI. Therefore, no Remedial Action Objective (RAO) or response actions for MC at the Kanaio LTA MRS were developed. Based on the known current conditions and the site-specific explosive safety hazards, a site-specific RAO was developed to address the goals for reducing the MEC hazards to ensure protection of human health, safety, and the environment.

ES.7.1.2 A range of remedial technologies was evaluated. Technologies considered implementable were assembled into remedial alternatives which were screened based upon effectiveness, implementability, and cost. Section 300.430(e) of the NCP lists nine CERCLA criteria against which each remedial alternative was assessed.

ES.7.1.3 The comparative analysis of alternatives was conducted using the current conceptual site model (CSM), which was based on the present state of knowledge concerning contamination and both current and reasonably anticipated future land use. The detailed analysis of remedial alternatives is summarized in **Tables ES.1** and a brief description of each alternative is provided below.

ES.7.2 REMEDIAL ALTERNATIVES

ES.7.2.1 The remedial alternatives developed to address MEC at the Kanaio LTA MRS are as follows:

- Alternative 1: No Action;
- Alternative 2: Public Education and Warning Signs (Land Use Controls [LUCs]);
- Alternative 3: Complete Surface MEC Removal and LUCs;
- Alternative 4: Focused Surface and Subsurface MEC Removal and LUCs; and
- Alternative 5: Complete Surface and Subsurface MEC Removal (unlimited use/unrestricted exposure [UU/UE]).

ES.7.2.2 The detailed analysis of remedial alternatives for MEC (**Table ES.1**) indicated that Alternatives 2, 3, 4 and 5 would be effective at addressing MEC risk at the Kanaio LTA MRS. The final alternative selection will involve a trade-off analysis with input from stakeholders and the public.

ES.7.3 CONCLUSIONS

ES.7.3.1 Based on the analyses of remedial alternatives conducted in this FS, a Proposed Plan (PP) will be developed to convey the findings of the RI and recommend a preferred alternative for implementation to the public, The PP will be followed by a Decision Document (DD) to formally memorialize the selected remedy at this MRS.

Table ES.1 Comparison of Remedial Alternatives

CERCLA Evaluation Criteria	Alternative 1 No Action	Alternative 2 LUCs	Alternative 3 Surface MEC Removal with LUCs	Alternative 4 Focused Surface and Subsurface MEC Removal with LUCs	Alternative 5 Complete Surface and Subsurface MEC Removal
Protective of Human Health and the Environment	No	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)
Complies with Applicable or Relevant and Appropriate Requirements	Yes	Yes	Yes	Yes	Yes
Effective and Permanent	No	Medium	High	High	Highest
Reduces Toxicity, Mobility, or Volume through Treatment	None (no treatment)	None (no treatment)	Reduction in volume of MEC on ground surface	Reduction in volume of MEC on ground surface and in subsurface in 126-acre “focused” area	Reduction in volume of MEC on ground surface and in subsurface
Short-Term Effectiveness	No short-term hazards to workers and surrounding area	Some short-term hazards to workers and surrounding area	Significant short-term hazards to workers and surrounding area	Significant short-term hazards to workers and surrounding area	Greatest short-term hazards to workers and surrounding area
Implementable	Readily Implementable	Readily Implementable	Readily Implementable	Readily Implementable	Readily Implementable
State Acceptance	To be determined during preparation of the Proposed Plan				
Community Acceptance	To be determined during preparation of the Proposed Plan				
Cost (1)	$0	$639,694	$15,128,084	$3,344,876	$23,256,301

(1) Costs shown are based on alternative implementation duration estimates with recurring costs based on 30-year planning horizons specified in the RI/FS Guidance (USEPA, 1988) for the purposes of evaluating and comparing alternatives with a 20% contingency reported as a Total Present Value (TPV). The TPV is based on a discount rate of 7 percent. Details of the cost estimates and the development of the TPVs are provided in Appendix J.

Figure ES.1

Kanaio Local Training Area Munitions Response Site ("Area 1") and Area of Interest ("Area D") Site Location Map

Maui, Hawaii

Legend

🟥 Kanaio Local Training Area MRS (Area 1 and Area D) Boundary

🟩 King's Trail

1,000 500 0 1,000
Meters

N
W E
S

PARSONS

U.S. ARMY CORPS
OF ENGINEERS
HUNTSVILLE CENTER

DESIGNED BY: BT
DRAWN BY: BT
CHECKED BY: DS
SUBMITTED BY: DS

Site Location Map

SCALE: As Shown
DATE: July 2021
FILE:
PROJECT NUMBER: 100087.0538.110208.02002
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Acronyms and Abbreviations

^{o}F	degrees Fahrenheit
AGC	Advanced Geophysical Classification
AOI	Area of Interest
APA	anomalies per acre
ARAR	applicable or relevant and appropriate requirements
ARNG	Army National Guard
bgs	below ground surface
BIP	blown-in-place
CD	compact disc
CENAB	U.S. Army Corps of Engineers, Baltimore District
CESPK	U.S. Army Corps of Engineers, Sacramento District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CHE	CWM Hazard Evaluation
cm	centimeters
COEC	chemicals of ecological concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
CWM	Chemical Warfare Materiel
DAGCAP	DoD Advanced Geophysical Classification Accreditation Program
DD	Decision Document
DDESB	DoD Explosives Safety Board
DERP	Defense Environmental Restoration Program
DFW	definable feature of work
DGM	digital geophysical mapping
DID	data item description
DLNR	Hawaii Department of Land and Natural Resources
DMM	Discarded Military Munitions
DoD	Department of Defense
DQO	data quality objective
DU	Decision Unit
DUA	data usability assessment
EAL	Environmental Action Level
EHE	Explosive Hazard Evaluation
EM	Engineer Manual
EOD	Explosive Ordnance Disposal
EP	Engineering Pamphlet
EPA	Environmental Protection Agency
ER	Engineer Regulation
ESP	Explosives Site Plan
EZ	exclusion zone
FCR	field change request
FRTR	Federal Remediation Technologies Roundtable
FS	Feasibility Study
ft	feet
FUDS	formerly used defense site

Acronyms and Abbreviations (*continued*)

GIS	geographic information system
GPS	global positioning system
GRA	General Response Actions
GSV	geophysical system verification
H	high
HAR	Hawaii Administrative Rules
HDOH	Hawaii Department of Health
HD	high anomaly density
HE	high explosive
HEAT	high explosive anti-tank
HEER	Hazard Evaluation and Emergency Response
HERL	Hawaii Environmental Response Law
HFD	hazardous fragment distance
HHCOC	human health chemical of concern
HHE	Health Hazard Evaluation
HI	Hawaii
HIARNG	Hawaii Army National Guard
HRR	Historical Records Review
HRS	Hawaii Revised Statutes
HUA	high use area
IC	institutional controls
in	inches
IPaC	Information for Planning and Consultation
ISO	industry standard object
ISM	Incremental Sampling Method
ITRC	Interstate Technology & Regulatory Council
IVS	instrument verification strip
L	low
LAW	light anti-armor weapon
Ib	pounds
LD	low anomaly density
LTA	Local Training Area
LUA	low use area
LUC	Land Use Controls
M	medium
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MEC	munitions and explosives of concern
MECHA	Munitions and Explosives of Concern Hazard Assessment
MGFD	munition with the greatest fragmentation distance
mm	millimeter
MMRP	Military Munitions Response Program
MPC	measurement performance criteria
MPPEH	material potentially presenting an explosive hazard
MPV	man portable vector
MQO	measurement quality objective

MRS	munitions response site

Acronyms and Abbreviations *(continued)*

MRSPP	Munitions Response Site Prioritization Protocol
MSD	minimum separation distance
msl	mean sea level
NA	not applicable
NCP	National Contingency Plan
NEU	no evidence of use (area)
NFA	No Further Action
NKSH	No Known or Suspected Hazard
NMRD	non-munitions-related debris
OD	other debris
OE	ordinance and explosives
OESS	Ordnance and Explosives Safety Specialist
OSWER	Office of Solid Waste and Emergency Response
PAL	project action limit
PARCC	Precision, Accuracy, Representativeness, Comparability, and Completeness
PP	Proposed Plan
PRG	preliminary remediation goal
PTTF	powder train time fuze
PWS	performance work statement
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RCA	root cause analysis
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROE	right-of-entry
RMM	Risk Management Methodology
RRD	range-related debris
RSL	Regional Screening Levels
RTK	real-time kinematic
RTS	Robotic Total Station
SCP	State Contingency Plan
SI	Site Inspection
SOP	standard operating procedure
SPP	systematic planning process
SUXOS	Senior UXO Supervisor
TBC	to be considered
TGM	Technical Guidance Manual
TMV	toxicity, mobility, or volume through treatment
TO	Task Order
TOI	target of interest
TP	Target Practice
TPP	Technical Project Planning
TPV	total present value

Acronyms and Abbreviations *(continued)*

T&E	threatened or endangered
UFP	Uniform Federal Policy
U.S.	United States
USACE	U.S. Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventative Medicine
U.S.C.	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UU/UE	unlimited use/unrestricted exposure
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Specialist
UXOSO	UXO Safety Officer
VOC	volatile organic compound
VSP	Visual Sample Plan
WP	White Phosphorus

1.0 Introduction

1.1 PROJECT AUTHORIZATION

1.1.0.1 This Remedial Investigation (RI)/Feasibility Study (FS) report has been prepared by Parsons to support the long-term management of the National Guard Bureau, Kanaio Local Training Area (LTA) Munitions Response Site (MRS), Site ID HIHQ-006-R-01. This work is being conducted for the United States (U.S.) Army Corps of Engineers (USACE), Baltimore District (CENAB) under Contract No. W912DR-15-D-0020, Delivery Order No. W912DR19F0538. This project is being executed by Parsons.

1.1.0.2 Based on the findings of the 2018 Site Inspection (SI), the Army National Guard (ARNG) determined an RI/FS of a 1,983-acre portion ("Area 1" and "Area D") of the 4,771-acre Kanaio LTA MRS under the Military Munitions Response Program (MMRP) Munitions Response Services. The balance of the MRS acreage (designated as "Area 2") was recommended for No Further Action (NFA) during the prior 2018 SI investigation phase based on the absence of potential explosive hazards as well as munitions constituent (MC) contamination. This RI/FS was conducted in accordance with the performance work statement (PWS) dated 22 March 2019 and the objectives and goals presented in the approved Final Uniform Federal Policy – Quality Assurance Project Plan Revision 4 (UFP-QAPP, Parsons, 2021a). In addition, it was performed in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the Defense Environmental Restoration Program (DERP) statute (10 U.S. Code [U.S.C.] 2701, et seq.), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 Code of Federal Regulations Part 300), and the Military Munitions Response Program (MMRP), as administered by the USACE. This RI/FS Report has been prepared by Parsons for the USACE Baltimore District under the Army National Guard (ARNG) Contract No. W912DR-15-D-0020, Delivery Order No. W912DR19F0538.

1.2 PROJECT PURPOSE AND SCOPE

1.2.0.1 The primary objective of this RI/FS was to determine the nature and extent of munitions and explosives of concern (MEC) contamination and MC contamination within the MRS focus area (Area 1 and Area D), evaluate associated risks, and develop and evaluate potential remedial alternatives as warranted. Prior studies and investigations, to include the 2018 SI, confirmed the presence of MEC contamination in this area. The presence of MC contamination was not previously confirmed; however, further assessment was planned provided specific conditions were met and sufficient soil was present to collect a sample.

1.2.0.3 To accomplish the RI/FS objective, subsurface anomaly data collection and intrusive investigations were conducted at the Kanaio LTA MRS (Area 1 and Area D) between 15 February 2021 and 04 May 2021. The field investigation was conducted in accordance with the UFP-QAPP developed, reviewed, and approved by the Systematic Planning Process (SPP) Team. The SPP Team consisted of representatives from the ARNG, Hawaii Army National Guard (HIARNG), Hawaii Department of Health (HDOH), United States Army Corps of Engineers (USACE) Sacramento District (CESPK), USACE Baltimore District, the Hawaii Department of Land and Natural Resources (DLNR), and Parsons.

1.3 REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT ORGANIZATION

1.3.0.1 Organization of this RI/FS Report follows requirements identified in Data Item Description (DID) WERS-010.01 (USACE, 2012) and Engineering Pamphlet (EP) 1110-1-18, Military Munitions Response Process for RI Reports (USACE, 2006). Chapters include:

Executive Summary;

Chapter 1: Introduction;

Chapter 2: Munitions Response Site Description;

Chapter 3: Project Technical Approach;

Chapter 4: Data Quality Assessment;

Chapter 5: Remedial Investigation Results;

Chapter 6: Contaminant Fate and Transport;

Chapter 7: Baseline Risk Assessment;

Chapter 8: Summary of Remedial Investigation Results & Munitions Response Site Prioritization Protocol (MRSPP);

Chapter 9: Identification and Screening of Remedial Technologies;

Chapter 10: Development of Remedial Alternatives;

Chapter 11: Detailed Analysis of Remedial Alternatives; and

Chapter 12: References.

Appendix A: Geophysical Data (on compact disc [CD])

Appendix B: Munitions and Explosives of Concern and Munitions Debris

Appendix C: Archaeological and Biological Reports

Appendix D: Root Cause Analysis

Appendix E: Field Work Variances

Appendix F: Daily Reports

Appendix G: Risk Management Methodology

Appendix H: Munitions Response Site Prioritization Protocol Worksheets

Appendix I: Risk Management Methodology Alternatives Matrices

Appendix J: Cost Backup

Appendix K: Photo Log

Appendix L: Regulatory Correspondence

2.0 Munitions Response Site Description

2.1 PROJECT LOCATION AND SETTING

2.1.0.1 The Kanaio LTA MRS is located on the southernmost extent of the Island of Maui, Hawaii (**Figure 2.1**). This RI/FS investigation area includes the 1,946-acre "Area 1" portion of the Kanaio LTA MRS (as divided during the 2018 SI) and the 37-acre "Area D" Area of Interest (AOI); a noncontiguous parcel located due east of Area 1 and along the coastline and accessible via King's Trail. For simplicity, the term "Kanaio LTA MRS" will be used throughout this document from here forward to specifically refer to the 1983-acre focus area comprised by Area 1 and Area D and not the entire 4,771-acre MRS.

2.1.0.2 Aside from several small privately-owned parcels, the entire MRS is owned by the Hawaii DLNR. The investigation area is characterized by steep terrain with elevations ranging from sea-level in the south to 1800 feet above mean sea level (msl) to the north. Vegetation within the investigation area is largely nonexistent with the surface consisting mostly of a'a lava fields characterized by minimal to no surface soil.

2.2 HISTORICAL USE

2.2.0.1 The Kanaio LTA MRS was utilized for live-fire practice as early as World War II by various branches of the military including the U.S. Army, U.S. Marine Corps, and the HIARNG and has been inactive since 2003. Area 1 was used from 1965 through the mid-1990s for training with 40-mm grenades and M72 light anti-armor weapon (LAW) rockets. In addition, evidence from prior studies indicated that recoilless rifles, high explosive anti-tank (HEAT) projectiles, various mortars, and artillery rounds may have also been used in Area 1. Historical accounts indicate Area D was predominately used as a livestock watering area (Na Ali`i, 2017c). The area was reportedly declared off-limits to HIARNG personnel as early as the 1960s. Anecdotal evidence suggests that Area D may at one point have been the target area for 4.2-inch mortars from Area B (Na Ali`i, 2017c).

2.2.0.2 During the Historical Records Review (HRR) (Na Ali`i, 2017c) performed during the SI, the HRR determined that MEC has been found outside the Kanaio LTA border established in 2000 (by executive order). These MEC item locations established during the HRR, while outside the established boundary still fell within the historical boundary. Based on the findings of the HRR the investigation boundary for the SI was revised to include areas within the historical boundary that were not technically part of the MRS boundary established by executive order in 2000. The HRR also confirmed that prior to the SI no MC investigation had been completed at the Kanaio LTA.

2.2.0.3 Earlier historical studies and cleanup efforts documented in the HRR prepared in support of the SI (Na Ali`i, 2017c) confirmed MEC item recovery and removal actions as early as 1981 and continuing in 1988, 1995, and 1998. Reported findings included M72 LAW rockets, 105-mm projectiles, 106-mm projectiles, 40-mm HE projectiles, and 81-mm mortars. Various MD from LAW rockets, 3.5-inch rockets, 40-mm HE grenades, 105-mm projectiles, 106-mm HEAT projectiles 4.2-inch mortars, 81-mm white phosphorus (WP) mortars, and 81-mm HE mortars were also identified during previous investigations and studies. Most of the findings, where identified, were within the RI/FS investigation area. All prior MEC were reported as removed or detonated.

2.3 ENVIRONMENTAL SETTING

2.3.1 TOPOGRAPHY AND VEGETATION

The Kanaio LTA MRS is characterized by steep terrain with elevations ranging from sea-level in the south to 1800 feet above mean sea level to the north. Vegetation within the investigation area is largely non-existent with the surface consisting mostly of a'a lava fields with loose rock, boulders, small cliffs, and several caves and tubes that have formed within lava voids. The most prominent features are two cinder cones in the northwest portion of the Kanaio LTA. No surface water bodies are present but trenchlike channels that align downslope have formed throughout the site.

2.3.2 CLIMATE

The training area is located on the leeward side of east Maui, opposite prevailing trade winds (prevailing winds are from the northeast), thus the climate is generally arid and wind-swept, with a mean annual rainfall ranging from about 25-30 inches at approximately 1,800 feet above mean sea level (msl), to about 20 inches at the coast. Despite the arid climate, almost daily cloud cover collects over the mountain slopes, producing a heavy mist. The mean daily average temperature is between 70 and 75 degrees Fahrenheit (ºF), with a mean daily temperature range of 65 to 85ºF (U.S. Army Center for Health Promotion and Preventative Medicine [USACHPPM], 2003).

2.3.3 GEOLOGY AND SOILS

The Kanaio LTA is on the southwestern slope of Haleakala, the younger of the two volcanoes that form eastern Maui. Haleakala was formed during the Pleistocene Era, approximately 1.1 million years ago, by Kula series volcanic eruptions. Kula andesitic rocks were deposited on top of the Honomanu basal basalts and olivines. The current landscape of the Kanaio area was formed when the Hana volcanic series was deposited on the deeply eroded Kula volcanic shield surface (Na Ali'i, 2018). The Kanaio LTA MRS lies in an area of very recent volcanic activity. The estimated age of Pu'u Pimo'e cinder cone in the northwest region of the range is approximately 1,000 years old. The substrate, primarily a'a lava with some cinder deposits is probably less than 10,000 years old. Most of the Kanaio LTA MRS is dominated by recent lava flows with very little soil development on the fresh Hana flow surfaces. Over 60% of the Kanaio LTA MRS, and the entirety of Area 1, is covered with a'a lava, a type of cooled, hardened volcanic rock that is formed as lava flows downhill. The top layer of the flow begins to harden and fracture as the molten core continues to flow. Ultimately this hardens into a rough, spiny surface that is extremely difficult to traverse with a solid core underneath, examples of these flows can be observed in the photo log **(Appendix K)**. Some locations on site composed of older pahoehoe flows are covered with a thin layer of soil and ash materials.

2.3.4 HYDROGEOLOGY AND HYDROLOGY

2.3.4.1 The interconnected void spaces in the pahoehoe, and layers of clinker (a typed of partially melted sedimentary rock that can form shale-like sheets) between highly fractured a'a flows result in high permeability. The lava in the core of an a'a flow is generally a massive, solid body of rock; the resulting lower permeability may inhibit vertical groundwater flow. The formation beneath the Hana, the Kulu formation, is known to act as an aquitard in some locations, and an aquifer in others. Perched freshwater lenses are possible in this area; the Hana may also contain basal groundwater near the coast. Depth to groundwater at the site is not known (Na Ali'i, 2018).

2.3.4.2 On a regional scale, the Kanaio area is underlain by the Lualailua aquifer system. Basal groundwater within the Lualailua occurs mostly within the underlying Honomanu series basalts. The Honomanu aquifer is one of the principal developable aquifers of eastern Maui; where it is unconfined, it is susceptible to contamination from surface sources. The Honomanu may be recharged in upcountry areas, due to increased surface water infiltration, as well as in deeply eroded gulches where the unit is exposed. The depth to groundwater in this unit has not been established; groundwater flow is assumed to be towards the coast (Na Ali'I, 2018).

2.3.4.3 Due to the lack of precipitation and the permeable nature of the surface lava, there are few surface water features within the Kanaio LTA MRS. A channel, which crosses Piilani Highway about 0.75 miles east of the site reportedly fills with water and flows during rain events. Anchialine pools, landlocked bodies of water formed in porous lava, having an underground connection to the ocean, reportedly exist along the coast to the south of the Kanaio LTA MRS. The water in these pools is brackish due to their connection with the ocean (Na Ali'i, 2018). According to the U.S. Fish and Wildlife Service (USFWS) Information for Planning and Consultation (IPaC) there are no known wetlands within the MRS (USFWS, 2021).

2.3.5 ENDANGERED SPECIES, SENSITIVE HABITATS, AND HISTORICAL OR CULTURAL RESOURCES

2.3.5.1 The Biological Awareness Plan (Na Ali'i, 2017a) identified five rare plant species and four rare animal species that are known or potentially present within the Kanaio LTA MRS. In addition, five species located outside the MRS boundary were also identified due to their known proximity to the area. The four animal species in the area and their status according to the U.S. Fish and Wildlife Service (ecos.fws.gov) are presented in **Table 2.1**.

2.3.5.2 This critical habitat unit is described in the Federal Register (USFWS, 2016) to be occupied by six endangered plant species, *Bonamia menziesii*, *Cenchrus agrimonioides*, *Flueggea neowawraea*, and *Melicope adscendens*, *Santalum haleakalae* var. *lanaiense*, and *Spermolepis hawaiiensis*. Additionally, it has been designated as suitable habitat for species that do not currently reside in the area, including: *Alectryon micrococcus*, *Bidens micrantha ssp. Kalealaha*, *Canavalia pubescens*, *Colubrina oppositifolia*, *Ctenitis squamigera*, *Hibiscus brackenridgei*, *Melanthera kamolensis*, *Melicope mucrunulata*, *Neraudia sericea*, *Notothrichium humile*, *Sesbania tomentosa*, *Solanum incompletum*, and *Zanthoxylum hawaiiense*.

2.3.5.3 On site biological monitoring was performed by a biologist from AECOS, Inc. with the Parsons field team to (1) insure that any action taken during field activities is not likely to jeopardize the continued existence of any threatened or endangered (T&E) species or result in the destruction or adverse modification of designated critical habitat, and (2) prohibit any action that results in a "take" of a T&E species without a determination that any "take" is not likely to jeopardize the continued existence of any T&E species, in accordance with 16 U.S.C. 1538(a)(1)(B), 50 CFR 17.21(a), and 16 U.S.C. 703(a). A biologist joined the survey team daily in order to support avoidance of T&E species and redirect field activities as necessary away from sensitive habitat (**Appendix C**). The majority of the MRS is characterized by a`a lava fields that are mostly depauperate of plants. No T&E plant or animal species were encountered.

2.3.5.4 The Archaeological Awareness Plan (Na Ali'i, 2017b) concluded that previous studies found multiple archaeological sites within the project area, several which contained human remains. These studies also recommended additional studies to determine if additional sites or features exist in the area. Caution should be exercised to avoid potential or known sites, as the area contains numerous traditional Hawaiian burial and religious sites, in addition to historic sites (Na Ali'i, 2017b).

2.3.5.5 Pacific Legacy, Inc., at the request of WCP, Inc., conducted archaeological monitoring services to support RI/FS field activities to ensure that those activities avoided potentially significant known and previously unknown archaeological resources (**Appendix C**). During transect mapping, ten archaeological sites that did not appear to be previously documented were identified and crossed over by RI/FS teams. The Pacific Legacy archaeologist was able to assist the team in avoiding impacts or disturbances to these cultural resources. Other stone features were observed that do not appear to be part of previously recorded sites. These were avoided by RI/FS teams.

Table 2.1 Endangered Species

Species		Federal Status	General Information
Hoary Bat (r Ōpea‘ape‘a)		Endangered	The Hawaiian Hoary Bat is the only land mammal native to Hawai’i. Males and females have a wingspan of approximately 4.7 cm (12 in) and weigh between 12.4-20 g (0.4-0.7 oz); females are typically larger than males Both sexes have a coat of brown to gray fur and individual hairs are tipped or frosted with white; “hoary” means frosted. The Hawaiian name refers to a half taro leaf or canoe sail shape which is somewhat similar to the bat’s shape in flight. Hawaiian hoary bats roost in native and non-native vegetation and rarely in lava tubes, cracks in rocks, or man-made structures.
Hawaiian Owl (Pueo)		Rare	Pueo are easily distinguished from the introduced Barn Owl by their piercing yellow eyes and the mottled brown patterns across their head, wings, back and chest, as well as the white ring that frames their face. Feathers on this species extends down to their talons.
Blackburn’s Sphinx Moth		Endangered	With a wingspan of up to 5 inches (12 cm), Blackburn’s Sphinx Moth is Hawaii’s largest native insect. Like other sphinx moths, it has long, narrow forewings and a thick, spindle shaped body that tapers at both ends. The moth is grayish brown in color with black bands across the top margins of the hindwings and five orange spots along each side of the abdomen. The moth’s caterpillar is large and occurs in two color morphs, bright green or gray. Both morphs have scattered white speckles throughout the back and a horizontal white stripe on the side margin of each segment.

Species		Federal Status	General Information
Koa Bug		Rare	The koa bug is a rare endemic “stinkless” stink bug found on the islands of Hawai’i, Maui, O’ahu, Kaua’i, and Moloka’i. Its iridescent, blue, green, maroon, and yellow coloring are unique identifiers of this endemic arthropod; measuring almost an inch in length, *Coleotichus blackburniae* is the largest native true bug of Hawaii.

Source: USFWS, 2021

Figure 2.1

Kanaio Local Training Area Munitions Response Site ("Area 1") and Area of Interest ("Area D") Site Location Map

Maui, Hawaii

Legend

🟥 Kanaio Local Training Area MRS (Area 1 and Area D) Boundary

🟩 King's Trail

1,000 500 0 1,000

Meters

N
W E
S

PARSONS

U.S. ARMY CORPS
OF ENGINEERS
HUNTSVILLE CENTER

DESIGNED BY: BT
DRAWN BY: BT
CHECKED BY: DS
SUBMITTED BY: DS

Site Location Map

SCALE: As Shown
DATE: July 2021
FILE:
PROJECT NUMBER: 100087.0538.110208.02002
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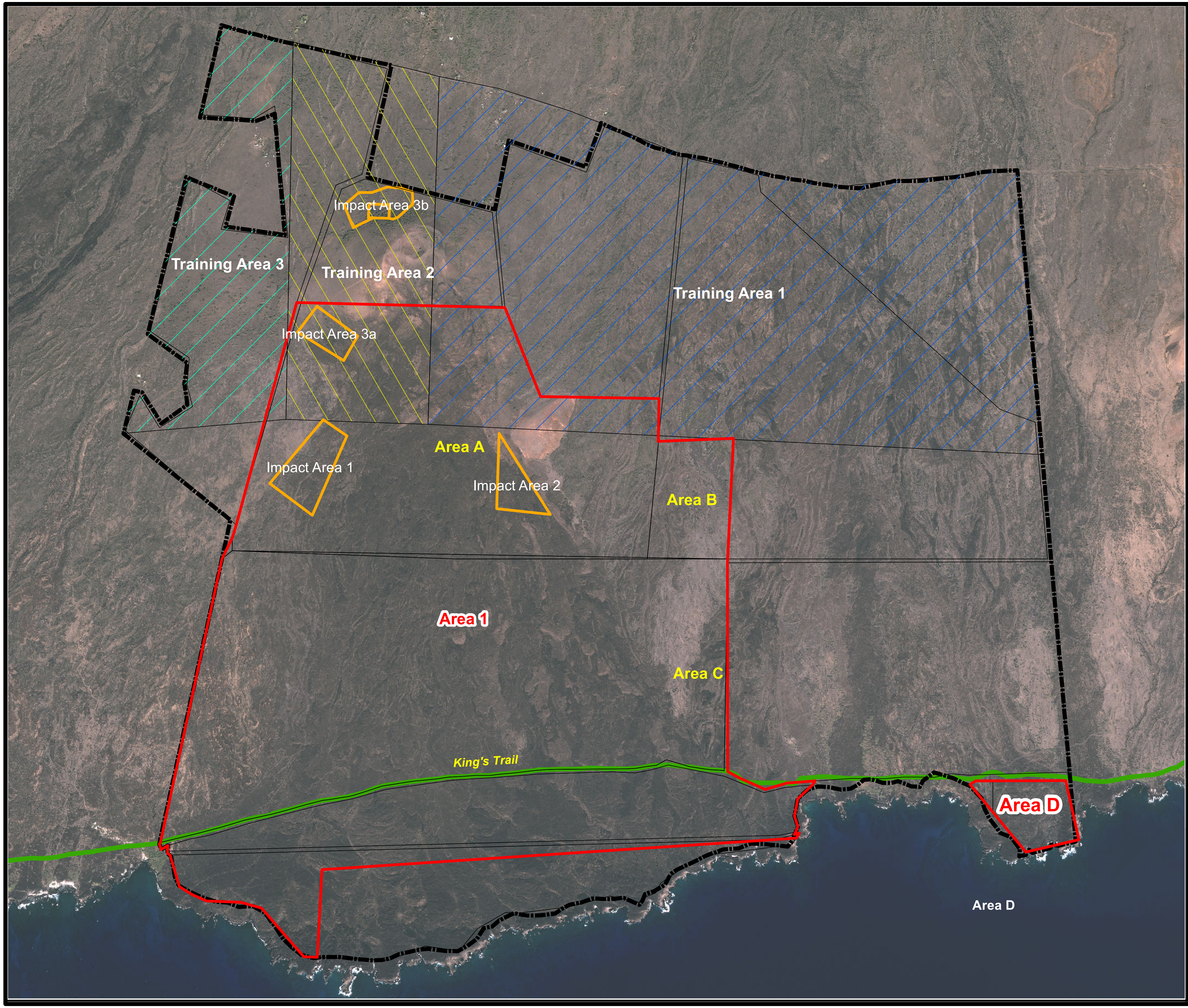

Figure 2.2

Kanaio Local Training Area Munitions Response Site ("Area 1") and Area of Interest ("Area D") Site Layout

Maui, Hawaii

Legend

- Kanaio Local Training Area MRS (Area 1 and Area D) Boundary
- King's Trail
- Impact Area
- Historic MRS Boundary
- ▨ Training Area 1
- ▨ Training Area 2
- ▨ Training Area 3

500 250 0 500
Meters

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PARSONS

U.S. ARMY CORPS
OF ENGINEERS
HUNTSVILLE CENTER

DESIGNED BY: BT

DRAWN BY: BT

CHECKED BY: DS

SUBMITTED BY: DS

Site Layout

SCALE: As Shown

DATE: July 2021

FILE:

PROJECT NUMBER: 100087.0538.110208.02002

PAGE NUMBER: 25

2.4 PREVIOUS INVESTIGATIONS

2.4.0.1 Six relevant investigations/incidents have occurred at Kanaio LTA MRS. These include:

2.4.1 1981 HIARNG CLEARANCE

2.4.1.1 In August and September 1981, HIARNG personnel, assisted by US Army munitions disposal specialists, conducted an on-foot sweep of the general firing range area. Two areas of the LTA, Impact Areas 1 and 2, were deemed “unclearable” by the munitions specialists, who suspected the presence of sub-surface unexploded munitions. The explosive ordnance disposal (EOD) team concluded that the brittle a’a lava potentially allowed high-angle steel-cased and delay fuzed mortars to penetrate and detonate underground, resulting in a heaving effect, covering debris and UXO from the surface. The sweep of the King’s Trail produced debris from various projectiles. Sweeps along fishermen’s trails and the area between King’s Trail and the ocean produced no UXO. A sweep of the 3.5-inch rocket range produced practice rounds, which contain no explosive hazards. Several UXO were reportedly located and destroyed in place; the locations of these munitions were not specified (HIARNG, 1996).

2.4.2 1988 UXO CONSOLIDATION PLAN

2.4.2.1 HIARNG planned to conduct a UXO removal action during August through September 1988, including onsite detonation of UXO, and consolidation of inert ordnance and other scrap metal into a single location for abandonment. No direct follow-up to this plan was located on record, however prior to a 1998 removal operation, practice and illumination rounds were located in a pile within a ravine at the northern part of Impact Area 2. EOD experts concluded that consolidation was likely carried out as planned and that the material was carried in sandbags to a consolidation point to be detonated (USACHPPM, 2003).

2.4.3 1996 ORDNANCE REMOVAL PLAN

2.4.3.1 In September 1995, an Ordnance Field Survey, an Archaeological Inventory Survey, and a Biological Resources Survey of Impact Areas 1, 2, 3A and 3B were conducted to prepare an Ordnance Removal Plan for these areas of the Kanaio LTA (HIARNG, 1996). The surveys characterized the nature and extent of surface and subsurface UXO in the four recognized impact areas, identified targets for removal and disposal, documented perceived immediate hazards, and identified any rare/endangered wildlife or plants and archaeological sites that may impact ordnance removal activities.

Outside of the four surveyed impact areas, teams located discarded unexpended blank and expended munitions, mainly near former firing points or in areas where troops had been maneuvering in the past. Also noted were car-related debris, scrap material, and trash, including three cars, a small dumpster, and a trash-filled lava tube near the entrance to the range on a privately-owned parcel. This investigation discovered several MEC including: two unexploded M72 LAW anti-tank rockets and one unexploded 40-mm M79 grenade.

The surveys ultimately concluded that no significant cultural resources were located within the surveyed impact areas that would preclude ordnance removal, but that areas outside the surveyed impact areas would require archaeological inventory prior to ordnance clearing. Because one of the plants known to occur on the Kanaio LTA MRS was not visible at the time of the surveys, biological monitoring was recommended during removal activities to reduce the potential of impacts. Activities outside of the impact areas require biological surveys to determine the presence or absence of rare or endangered species on site.

2.4.4 1998 SURFACE ORDNANCE REMOVAL

2.4.4.1 During the 1998 Ordnance Removal, erosion and sediment control measures, as well as pollution control measures were followed. The access road to the Kanaio LTA was reconstructed prior to field activities (HIARNG 1999). The four impact areas were swept; a 100% surface inspection was conducted by teams moving at 5-foot separation intervals. Live ordnance items that could not be moved were marked with flagging tape, and the coordinates recorded. Scrap metal was removed from all areas of the site. No high explosive (HE) items were found in the areas outside of the impact areas, though considerable live, blank small arms cartridges were recovered. The four abandoned cars and small dumpster were removed and properly disposed of, as well as the refuse in the lava tube. Three biased soil samples were collected from depths of 1-15 inches below ground surface (bgs) in areas expected to have heaviest range use in Impact Area 3B. Samples indicated lead concentrations below action levels. A soil sample was also collected from the bottom of the lava tube and analyzed for volatile organic compounds (VOCs); sample results were non-detect. In all 997-lbs of scrap were removed and 10 MEC items were disposed of by detonation.

2.4.5 2003-2004 UXO SURVEYS AND CLEARANCE

2.4.5.1 During 2003 through 2004, 1,500 acres were surveyed for UXO in conjunction with archaeological and biological monitoring at Kanaio LTA MRS. Due to targeting inaccuracy and the uncertainty of firing points, areas surrounding the formally delineated impact areas were suspected to contain ordinance and explosives (OE). The surveys took place in three separate phases, each covering 500 acres. Based on the map provided with the report, Phase 1 encompassed Impact Areas 1, 2, and 3A. As a result of the findings of Phase 1, which identified 81-mm illumination and 81-mm HE munitions debris (MD), the survey was extended south. Phase 2 extended south encompassing a portion of Area C, including the Target Site. The results of Phase 2 also indicated the need to extend the survey further. Phase 3 covered the southwestern portion of Area C south to the King’s Trail, the southeastern portion of Area A, and the southwestern portion of Area B. The surveys were conducted to identify and report expended munitions, live or potentially live munitions, dispose of OE scrap, and dispose of any live and potentially live munitions (HIARNG 2005). The surveys/clearance did not cover the entire Kanaio LTA MRS.

Approximately 2,470 lbs of scrap was collected during Phases 1 and 2. Two unexploded 81-mm HE mortars and one unexploded 81-mm white phosphorus mortar were identified and disposed of by detonation. Five 3.5-inch rockets were found buried in a crevice adjacent to several sensitive archaeological features; this site was named T-26 Burial Complex. One 3.5-inch rocket was imbedded in a vertical rock face above this discovered cache; due to potential for impact on the identified cultural features these items were not disposed by detonation. The site, southeast of Pu`u Pimo`e, is roughly 60 meters long by 50 meters wide, and consists of a minimum of 24 features identified by the project archaeologist as burial terraces. Based on the findings of the first two phases, additional survey and disposal were recommended, particularly beyond the southern and eastern boundaries of the Phase 2 survey (HIARNG 2004). Approximately 500 lb of OE scrap were collected during the Phase 3 survey. These OE items were dispersed throughout the Phase 3 boundary and outside the previously delineated boundaries for the Impact Areas and the 3.5-inch Rocket Range.

Over all three phases, more than 3,000 ordnance and ordnance-related items were collected, inspected, and de-militarized. More than 40 UXO items including LAWs, 3.5-inch rockets, 60-mm mortars, and 81-mm mortars were detonated in place. Confirmation soil sampling performed following the single de-militarization detonation to vent OE scrap indicated no significant environmental impact. Further OE surveying was recommended to the east and south of the Phase 3 investigation boundary due to the presence of OE scrap and potential target drums at the eastern and southern boundaries of the Phase 3 area (HIARNG 2005).

2.4.6 2018 SITE INSPECTION

2.4.6.1 The SI fieldwork was conducted in November 2017 to gather data and determine whether the site warrants further response actions. Inspection included an instrument-assisted visual survey along predetermined transects covering approximately 1 percent of the total site area. Transects were completed in areas not previously investigated, as well as in known impact areas. Much of the eastern half of the Kanaio LTA, particularly the southern area, was deemed inaccessible due to terrain and limited access. The instrument-assisted visual survey resulted in the discovery of one MEC item, and one material potentially presenting an explosive hazard (MPPEH) item, requiring EOD response, and 61 MD items. These items were predominately located in the central to southern portion of the site. Survey results and HRR data were used to identify 10 Decision Units (DUs) within the investigation area. One Incremental Sampling Method (ISM) surface soil sample was collected from each DU containing soil, to evaluate the presence and concentration of MC. Many of the proposed sample locations lacked sufficient soil for sample collection; only six of the intended 10 samples could be collected. Antimony, lead, and explosive compounds were not detected in any of the samples. Copper and zinc did not exceed the project action limits (PALs).

Based on the historical data and SI findings, it was recommended that Kanaio LTA be managed as two distinct areas:

- Area 1, Approximately 1,946 acres comprised of DUs 4, 6, 8, and the western third of DU9. This area contains the highest density of potential explosive hazards based on the SI and historical findings. The SI recommended that Area 1 proceed to a RI/FS.
- Area 2, Approximately 2,268 acres comprised of DUs 1, 2, 3, 5, 7, 10, and the remainder of DU9. No explosive hazards have been identified in this area. Small arms debris has been detected but does not present an explosive hazard. No Further Action (NFA) is recommended for this area in the SI.

2.5 CURRENT AND FUTURE LAND USE

The land surrounding the Kanaio LTA MRS is primarily designated for conservation or is used as ranchland. Several homesteads are located adjacent to, northwest of, and within the area near the western border (Na Ali'i, 2017c). As noted in Section 2.3.1, the majority of the MRS is characterized by extremely adverse terrain with significant natural barriers limiting public access for recreational activities characteristic of the a'a lava conditions. With the exception of the extremely difficult hike within the footprint of King's Trail, the vast majority of the MRS is near impassible and does not represent a recreational attraction to current receptors. Further, the MRS is isolated and offers no amenities. The coastline, primarily south of the King's Trail, is visited for cultural artifact collection, scenic viewing, photography, and religious activities and study. Recreational and subsistence hunting, fishing, and non-authorized shooting occur within the Kanaio LTA MRS. Future land use is currently in flux. The DLNR is actively evaluating the establishment of a Forestry and Wildlife Management Area that would include a portion or all of the Kanaio LTA MRS. Per direct conversations with HI DLNR, this potential change in designation is not expected to have a significant impact on current and future recreational use of the area. If the designation moves forward, a moderate increase in site use could result to include potential seasonal hunters and support personnel. Some limited development could include boundary fence construction, access road installation/construction, hunter kiosks, and placement of game "water units". At present this potential change in land use is in the preliminary stages and has been under consideration for a number of years. Currently an Environmental Assessment (EA) is being developed which will outline the specifics of planned actions for the area.

2.6 CONCEPTUAL SITE MODEL

2.6.0.1 The conceptual site model (CSM) is a description of a site and its environment that depicts the MEC and MC migration/exposure pathways, and the possible human and ecological receptors for those pathways based on site-specific conditions and land use. The CSM provides inputs for evaluation of risks posed to potential receptors under current and future land use scenarios. A CSM is dynamic and represents the current understanding of the MRS. For this reason, the CSM is evaluated and revised each time new information is received.

2.6.0.2 For the purposes of this RI/FS, a preliminary CSM was developed for the Kanaio LTA MRS in accordance with Engineer Manual (EM) 200-1-12. This preliminary CSM, presented in **Table 10.1** of the approved Final UFP-QAPP (Parsons, 2021a), was based on what was known about the MRS prior to conducting the RI. This table described the known or suspected contamination sources, potential/suspected location and distribution of contamination, contamination source or exposure medium, current, and future receptors, and potentially complete exposure pathways. The CSM development process included reviewing historical data to identify data gaps, investigation areas, potential receptors, current land use, and potentially complete exposure pathways for MEC and MC (if present). This CSM was used to focus the development of the general Technical Approach for the RI. A visual CSM diagram and map were also developed to convey this information and facilitate communication with stakeholders in an easy-to-understand format (**Figures 10.4** and **10.5** of the approved Final UFP-QAPP [Parsons, 2021a]).

2.6.0.3 The preliminary CSM indicated that MEC, in the form of UXO, may be present in the MRS based on historical site usage and UXO discovered and removed in previous clearance and investigation efforts at the MRS starting in 1981. It was anticipated that MEC would most likely be found in an identified 36-acre "high-use area" (HUA) within the MRS. Areas outside the HUA that have the potential for low levels of MEC contamination would be designated as "low-use areas" (LUAs). Areas that are not suspected of MEC contamination based on the CSM and RI results would be considered "no evidence of use" (NEUs) areas.

2.6.0.4 The CSM presented in this subchapter represents the current understanding of the MRS subsequent to the conduct of the RI. The CSM summarizes which potential receptor exposure pathways for MEC and MC are (or may be) complete and which are (and are likely to remain) incomplete. An exposure pathway is considered incomplete unless all four of the following elements are present (USEPA, 1989):

- A source of contamination
    - An MRS has confirmed MEC or significant MD indicative of potential residual presence of MEC
    - An MRS, based on MEC or significant MD presence, has potential for MC to have leached and contaminated soil or other media.
- An environmental transport and/or exposure medium (MC in soil is shallow and transported via fugitive dust).
- A point of exposure at which the contaminant can interact with a receptor (areas of contaminated surface soil are present in where recreational activities or construction could occur).
- A receptor and a likely route of exposure at the exposure point (an on-site resident or recreational user disturbs the contaminated surface soil).

2.6.0.5 If all four factors are present, the exposure pathway is complete. If any single factor is not present, the specific pathway would be incomplete. An incomplete exposure pathway indicates there are no current means by which a receptor (human or ecological) can be exposed to either MEC or MC and, therefore, no risks from exposure to MEC or MC would be expected associated with that pathway.

2.6.0.6 Based on the results of the MEC and MC characterizations conducted and as presented in **Subchapters 5.1** and **5.2**, the preliminary CSM, described in the approved Final UFP-QAPP (Parsons, 2021a), was reviewed and updated to reflect any new applicable information. The preliminary CSM for Kanaio LTA MRS indicated potentially complete MEC and MC exposure pathways were present for receptors at the MRS. This subchapter describes the revised CSM as modified based on the results of this RI. Potential MEC exposure pathways remain potentially viable; however, human health and ecological MC exposure pathways are no longer considered complete due to absence of soil (incomplete pathway) in the impact areas. The results of the RI and revised CSM are summarized in **Table 2.2** and **Figures 2.3**, **2.4**, and **2.5**.

2.6.1 HUMAN AND ECOLOGICAL RECEPTORS

The Kanaio LTA MRS is owned by the Hawaii DLNR. Although no DLNR fences are in place, the MRS has significant natural barriers limiting public access for recreational activities to include adverse terrain and inhospitable topography associated characteristic of the a'a lava conditions. With the exception of the extremely difficult hike within the footprint of King's Trail, the vast majority of the MRS is near impassible and does not represent a recreational attraction to current and future receptors. Further, the MRS is isolated and offers no amenities. Potential future receptors could include hunters and support personnel as DLNR is considering the establishment of a Forestry and Wildlife Management Area within a portion of the Kanaio LTA MRS. Under this development scenario several extensive fence construction efforts arepossible; therefore, future construction workers are also potential future receptors.

2.6.2 MEC EXPOSURE PATHWAYS

2.6.2.1 Three critical elements are required for a complete MEC exposure pathway: a source of MEC, a receptor, and the potential for interaction between the source and the receptor. The preliminary CSM for the Kanaio LTA MRS indicated potentially complete MEC exposure pathways were present for receptors at the MRS, including current recreational users (King's Trail hikers) and periodic site workers (DLNR). Potential future receptors could include hunters and support personnel as DLNR is considering the establishment of a Forestry and Wildlife Management Area within a portion of the Kanaio LTA MRS. Under this development scenario several extensive fence construction efforts are planned; therefore, construction workers are also potential future receptors.

2.6.2.2 Munitions in the form of UXO have been found during previous investigations and during the RI. **Table 2.2** presents the munitions known or suspected to have been used within the MRS. Due to the absence of a soil layer in the majority of the MRS (and completely within the HUA) due to the a'a lava, MEC is only expected on the surface.

2.6.2.3 Potential HUAs and LUAs at the Kanaio LTA MRS were characterized using a two-step process. First, geophysical data was used to designate high anomaly density (HD) and low anomaly density (LD) areas. Second, intrusive investigation within the HD areas was used to confirm the presence of MEC or large amounts of MD to determine if an HD area should be designated as an HUA. Confirmed HUAs would be considered MEC-contaminated. For the Kanaio LTA MRS 36-acres were designated HUA (based on MD findings within HD areas) and the remaining 1947-acres of the MRS footprint was designated as an LUA. No NEU areas were identified.

2.6.3 MC EXPOSURE PATHWAYS

Based on the results of the RI described in **Subchapter 5.2**, by default no chemicals of potential concern (COPCs) or chemicals of potential ecological concern (COPECs) were identified within the Kanaio LTA MRS due to the lack of sampleable soil in the impact areas in locations identified for sampling in accordance with the UFP-QAPP. Combined with the results of the limited soil sampling conducted during the SI and the absence of soil precluding MC sampling during this RI, no MC contamination was identified and the soil exposure pathway is considered incomplete.

2.7 PRELIMINARY REMEDIATION GOALS

2.7.1 Preliminary remediation goals are site-specific and contaminant-specific and define the conditions considered by stakeholders to be protective of human health and the environment. As with the CSM, preliminary remediation goals are reevaluated and refined throughout the RI/FS process as new information becomes available.

2.7.2 The preliminary remediation goal for MEC at the Kanaio LTA MRS is to limit any interaction between residual MEC and human receptors accessing the MRS. The preliminary remediation goals for MEC could be achieved by measures such as removing MEC present to a depth at which they no longer present a hazard to the anticipated human receptors, or by implementing land use controls (LUCs) that minimize the possibility of receptors being exposed to MEC.

Table 2.2 Conceptual Site Model Summary, Kanaio Local Training Area MRS (Area 1 and Area D)

Site Details	Details and Results of Remedial Investigation						Revised Conceptual Site Model Summary				
	Known or Suspected Contamination Source(s)	Potential/Suspected Location and Distribution	Investigation Method	Investigation Location(s)	Investigation Acreage / Number of Samples	Investigation Results	Confirmed or Suspected Contamination Source(s)	Confirmed Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Complete Exposure Pathway
NAME: Kanaio Local Training Area MRS **Acreage**: 1,983 acres - 1,946 acres in "Area 1" plus 37-acres "Area D" AOI **Suspected Past Department of Defense (DoD) Activities (*release mechanisms*)**: Live fire training. **Current and Future Land Use**: The MRS has limited public access for recreation. Future use by HI DLNR likely will be expanded to include a designation as a "Forestry and Wildlife Management Area" which would potentially increase the receptor population due to seasonal hunting and DLNR support personnel.	MEC and MD from the following munition types have been recovered on site: - *Projectile, 40-mm, sub-caliber* - *Grenade, 40-mm, Practice, M382; M385 &A1; M407A1; M781; M918* - *Grenade, 40-mm, High Explosive (HE), M381, M383, M384; M386, M397, M397A1, M406, M441, M684* - *Grenade, 40-mm, High Explosive Dual Purpose (HEDP), M430, M430A1, M433, M677* - *Rocket, 3.5-Inch, High Explosive Anti-Tank (HEAT), M28A2* - *Rocket, 3.5-inch, Practice, M29* - *Rocket, Light Anti-Tank Weapon (LAW), HEAT, M72 Series* - *Rocket, LAW, Practice, 35-mm Subcaliber, M73* - *Mortar, 4.2-inch, HE, M3 Series, M329 Series* - *Mortar, 4.2-inch Sub-caliber* - *Mortar, 60-mm, HE, M49 Series* - *Mortar, 60-mm, Smoke (White Phosphorus [WP]), M302 Series* - *Projectile, 75-mm, HE, M48* - *Mortar, 81-mm, Illumination, M301 Series* - *Mortar, 22-mm Subcaliber, Practice, M744, M745, M746, M747* - *Mortar, 81-mm, Smoke, WP, M57 Series, M370* - *Mortar, 81-mm, HE, M43 Series* - *Mortar, 81-mm, Target Practice (TP), M43* - *Mortar, 81-mm, Training, M68* - *Projectile, 90-mm, HEAT, M371A1* - *Projectile, 105-mm, HE, M1* - *Projectile, 105-mm, Illumination, M314 Series* - *Projectile, 106-mm, HEAT, M344 Series* - *Projectile, 155-mm, HE, M107* - *Signals, Illumination, Ground, Parachutes, Red Star, M131; White Star, M127A1; Green Star M195* - *Signals, Illumination, Ground, Clusters, Green Star,* - *M125A1; Red Star, M158; White Star M159* - *Signals, Smoke, Ground, Parachute, Green, M128A1; Red, M129A1; Yellow M194* - *Fuze, Time, M84 Series, Powder Train Time Fuze (PTTF)*	HD Areas: Increased potential to find residual MEC/ MPPEH. Based on the investigation results from the RI, the HD area was evaluated for potential to be: • A HUA potentially containing HE UXO • A HUA containing only practice munitions, or • Not a HUA (part of LD/LUA area) A 36-acre HUA was identified within the MRS.	Geophysical surveys using a combination of digital geophysical mapping (DGM), modified analog, intrusive investigation	Transects throughout the MRS and grids in the HD areas of the MRS (**Figure 3.1**)	1.15 acres of HD grids (5)	1 MEC item Blown in Place (Total of 377 MD items recovered)	MEC and MD types as listed in *Known or Suspected Contamination Source(s)* column of this table	During the RI fieldwork the highest concentration of MD and the only MEC item were found in the suspected HD grids and the suspected LD grids were much lower densities than the HD grids. As a result, the 36-acre HD area is retained as a HUA and the rest of the site is classified as a LUA.	Surface	Current and future receptors include recreational users and site workers with surface exposure generally confined to public trails. Both small private parcels are located well outside the HUA and are non-residential. Potential future receptors could include hunters and support personnel as DLNR is considering the establishment of a Forestry and Wildlife Management Area within a portion of the Kanaio LTA MRS. Under this development scenario several extensive fence construction efforts are planned; therefore, future construction workers are also potential future receptors.	**YES** Exposure to surface MEC (direct contact on surface, possible intrusive activities to 34 cm (~13.4 inches) bgs by on-site workers, site visitors/recreational users)
		LD Areas: areas of low anomaly density delineated using Visual Sample Plan (VSP). Based on the investigation results of the RI, the LD area was designated as a LUA. Both small private parcels (see Figure 3.1, subchapter 2.4.3) are non-residential and are located well outside of the HUA.	Geophysical surveys using a combination of DGM, modified analog, and Advanced Geophysical Classification (AGC) and intrusive investigation	Transects throughout the MRS and grids in the LD areas of the MRS (**Figure 3.1**)	1.84 acres of LD grids (8)	Total of 157 MD items recovered					

Site Details	Details and Results of Remedial Investigation						Revised Conceptual Site Model Summary				
	Known or Suspected Contamination Source(s)	Potential/Suspected Location and Distribution	Investigation Method	Investigation Location(s)	Investigation Acreage / Number of Samples	Investigation Results	Confirmed or Suspected Contamination Source(s)	Confirmed Location and Distribution	Source or Exposure Medium	Current and Future Receptors	Complete Exposure Pathway
	Previous investigations determined that throughout most of the Kanaio LTA there was not sufficient soil to collect MC samples, specifically in the impact areas. MC were evaluated in the SI where soil was present (outside the impact areas) and determined not to pose a risk to human health or the environment. In accordance with the Final UFP-QAPP for this RI, MC samples were to only be collected if low-order detonation munitions were encountered, suspected contamination sources (e.g., a cache of DMM) were present, or BIP activities were conducted and sufficient soil to collect a sample was present. A single BIP was conducted and one MD stockpile was encountered; however, in both instances insufficient soil was present to collect a sample. Therefore, no MC contamination was identified at the Kanaio LTA. Potential MC: Explosives; antimony, copper, lead, and zinc.	Potentially present in surface and subsurface soil associated with breached/low-order MEC/MPPEH, a cache of DMM, or at the location of demolition operations if soil was present.	Due to the absence of soil no MC sampling was conducted.	NA	NA	NA	*COPCs:* NA *COPECs:* NA	NA	Surface and subsurface soil	Current and future receptors include recreational users and site workers with surface exposure generally confined to public trails. Potential future receptors could include hunters and support personnel as DLNR is considering the establishment of a Forestry and Wildlife Management Area within a portion of the Kanaio LTA MRS. Under this development scenario several extensive fence construction efforts are planned; therefore, future construction workers are also potential future receptors.	**Human Health: NO** **Ecological: NO**

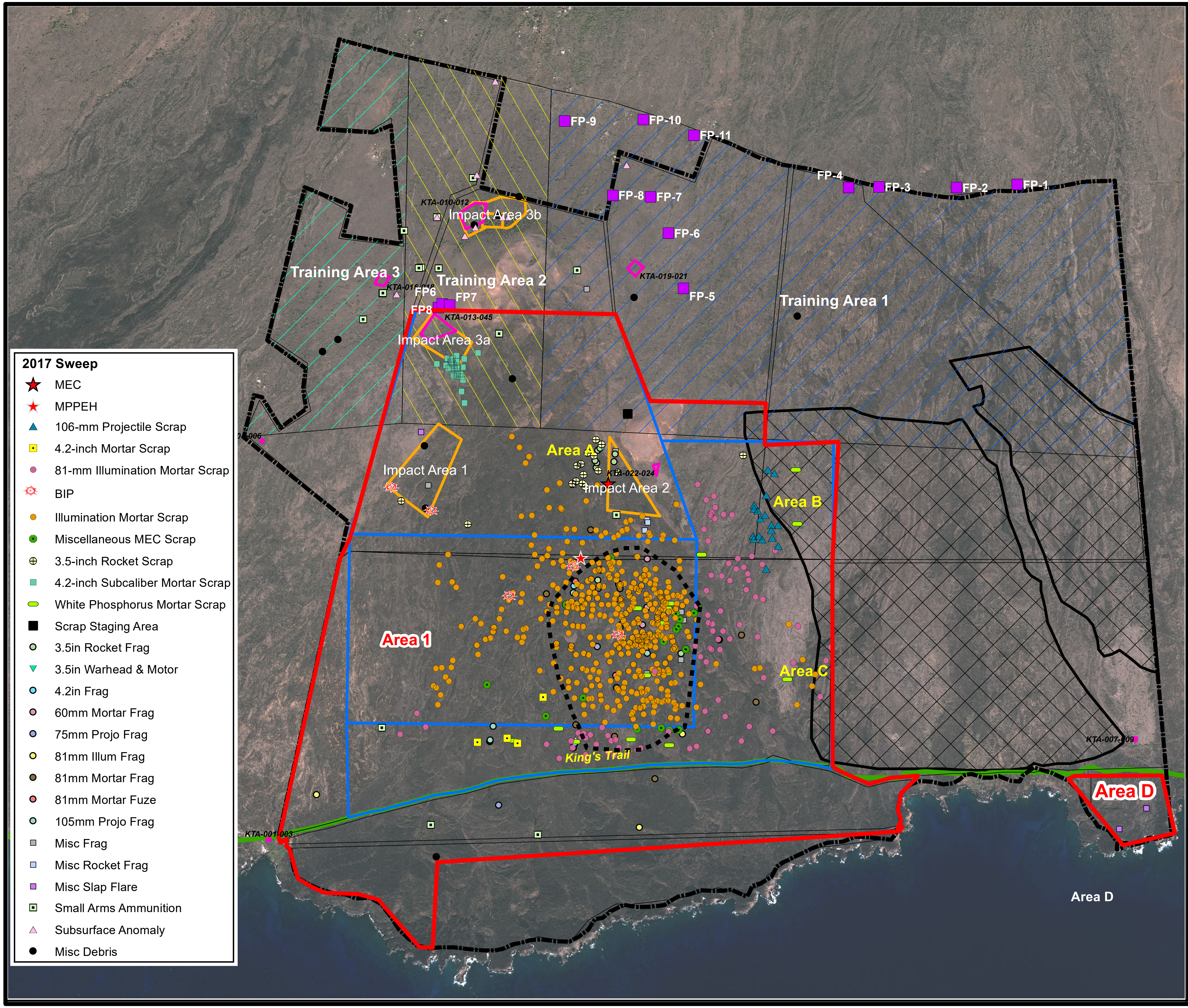


Figure 2.3

Kanaio Local Training Area Munitions Response Site ("Area 1") and Area of Interest ("Area D") Conceptual Site Model Map

Maui, Hawaii

Legend

- ■ Firing Point (FP)
- ▬ Kanaio Local Training Area MRS (Area 1 and Area D) Boundary
- ▬ King's Trail
- ▬ Impact Area
- ▬ Historic MRS Boundary
- ▨ Training Area 1
- ▨ Training Area 2
- ▨ Training Area 3
- ▩ Inaccessible Area
- ☐ 2003-2004 UXO Surveys and Clearance Boundary
- ☐ Soil Sampling Location (SI)
- ⬚ Expected High Use Area

500 250 0 500

Meters

N W E S

PARSONS

U.S. ARMY CORPS
OF ENGINEERS
HUNTSVILLE CENTER

DESIGNED BY:	BT
DRAWN BY:	BT
CHECKED BY:	DS
SUBMITTED BY:	DS

Conceptual Site Model

SCALE: As Shown

PROJECT NUMBER: 100087.0538.110208.02002

DATE: February 2021

PAGE NUMBER: 31

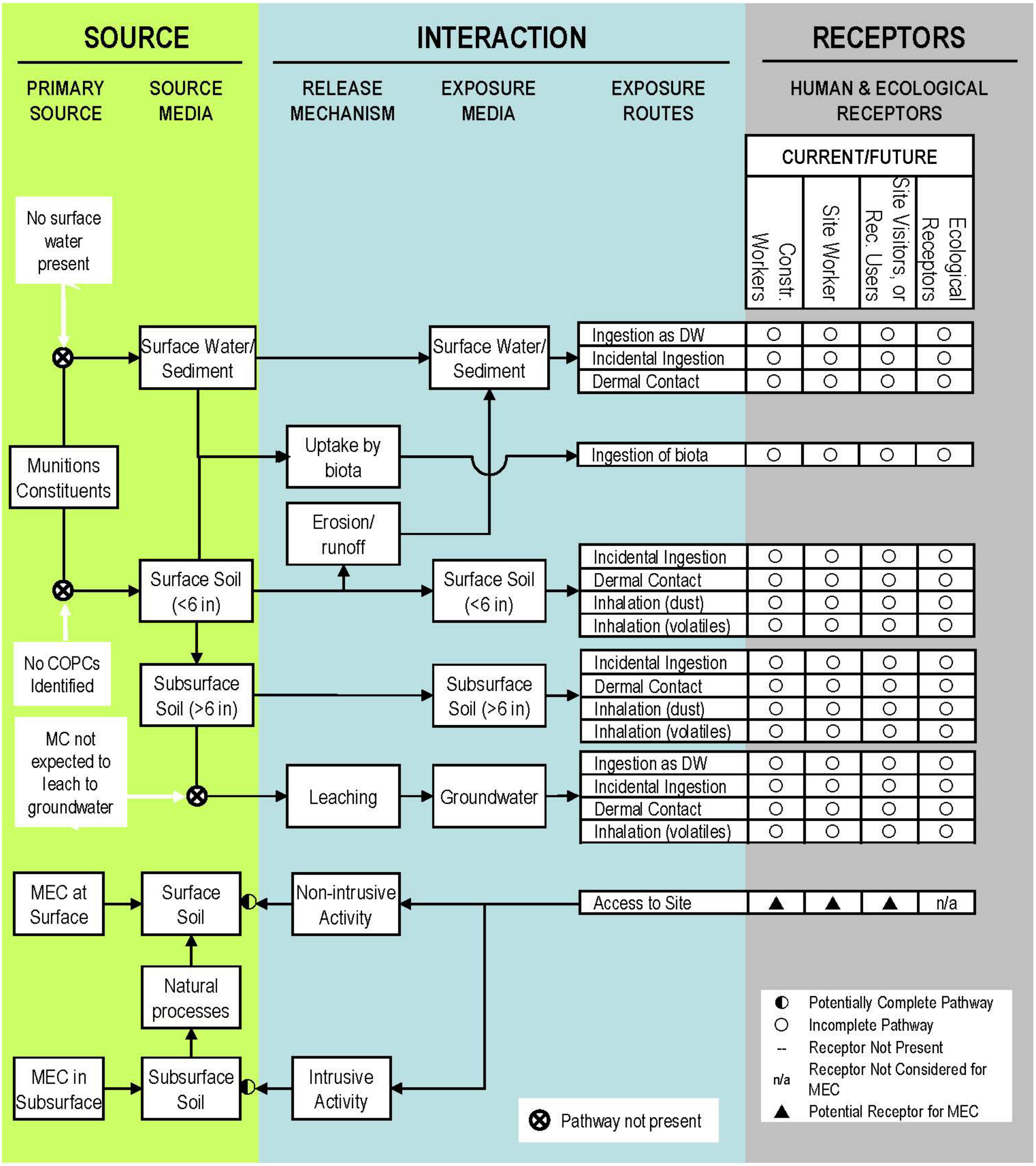
FILE:

Figure 2.4 Conceptual Site Model – Exposure Pathways Diagram

CONCEPTUAL SITE MODEL DIAGRAM

Site/MRS Name: Kanaio Local Training Area

Completed By: Steve Rembish, PARSONS ***Date Completed:*** August 24, 2021



EXPOSURE ROUTES	Constr. Workers	Site Worker	Site Visitors, or Rec. Users	Ecological Receptors
Ingestion as DW	○	○	○	○
Incidental Ingestion	○	○	○	○
Dermal Contact	○	○	○	○
Ingestion of biota	○	○	○	○
Incidental Ingestion	○	○	○	○
Dermal Contact	○	○	○	○
Inhalation (dust)	○	○	○	○
Inhalation (volatiles)	○	○	○	○
Incidental Ingestion	○	○	○	○
Dermal Contact	○	○	○	○
Inhalation (dust)	○	○	○	○
Inhalation (volatiles)	○	○	○	○
Ingestion as DW	○	○	○	○
Incidental Ingestion	○	○	○	○
Dermal Contact	○	○	○	○
Inhalation (volatiles)	○	○	○	○
Access to Site	▲	▲	▲	n/a

◐ Potentially Complete Pathway
○ Incomplete Pathway
-- Receptor Not Present
n/a Receptor Not Considered for MEC
▲ Potential Receptor for MEC

2.8 IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

2.8.1 Response actions must identify and attain or formally waive applicable or relevant and appropriate requirements (ARARs) under federal and state laws (Engineer Regulation [ER] 200-3-1) (USACE, 2004). ARARs must be complied with to the extent practicable. Although the RI is not considered a response action, preliminary identification of chemical-specific, location-specific, and action-specific ARARs is conducted by the lead and support agencies during RI site characterization as required by the NCP. ARARs are used as a starting point to determine the protectiveness of a site remedy (USAEC, 2009).

2.8.2 As the RI/FS process continues, the list of ARARs will be updated, particularly as guidance is issued by state and federal agencies. As part of the preparation of this RI/FS, the Project Team engaged HDOH (via formal inquiry dated July 7, 2021) regarding identification of candidate ARARs. HDOH provided potential ARARs for consideration on August 2, 2021 (see Appendix L). ARARs will be used as a guide to establish the appropriate extent of site cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative. As part of the FS, primary consideration should be given to remedial alternatives that attain or exceed the requirements of the identified ARARs. Throughout the CERCLA process, ARARs are identified and used by considering the following:

Contaminants suspected or identified to be at the MRS;

Chemical analysis performed or scheduled to be performed;

Types of media (air, soil, groundwater, surface water, and sediment);

Geology and other MRS characteristics;

Use of MRS resources and media;

Potential contaminant transport mechanisms;

Purpose and application of potential ARARs; and

Remedial alternatives considered for MRS cleanup.

2.8.3 Chemical-specific ARARs are promulgated health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Risk-based screening levels (e.g., USEPA risk screening levels [RSLs]) and HDOH Tier 1 Environmental Action Levels (EALs) (HDOH, 2017) are not considered chemical-specific ARARs because they are not promulgated. No chemical-specific ARARs have been identified for the Kanaio LTA MRS.

2.8.4 Location-specific ARARs generally are restrictions placed on the concentration of a hazardous substance or the conduct of activities solely because they are in special locations. Due to the presence of sensitive cultural and ecological resources present at the Kanaio LTA MRS, the Migratory Bird Treaty Act and the Archaeological Resources Protection Act (ARPA) are considered location-specific ARARs.

2.8.5 Action-specific ARARs are usually technology or activity-based requirements or limitations placed on actions taken with respect to remedial/removal actions, or requirements to conduct certain actions to address particular circumstances at a site. These actions include removal, decontamination, and/or control of such media. Given the known presence of MEC and the likely need to detonate MEC recovered during source removal actions, Detonation 40 CFR § 264.601 (RCRA, Subpart X) is applicable to any such remedial action (**Table 2.3**).

2.8.6 When ARARs do not exist for a particular chemical or remedial activity, other criteria, advisories, and guidance referred to as To Be Considered (TBC) are useful in designing and selecting a remedial alternative. TBCs are presented in **Table 2.3.**

Table 2.3 ARARs and TBCs

Requirement	Citation(s)	Description	Applicability or Relevance
Chemical-Specific ARARs			
None			
Chemical-Specific TBCs			
HDOH Environmental Action Levels (EALs) (HDOH 2017)	Tier 1 EALs	Concentrations of contaminants in soil, soil vapor and groundwater below which contaminants are assumed to not pose a significant threat to human health or the environment.	Exceeding the EAL does not necessarily indicate that contamination at the site poses environmental hazards; alternative action levels can be proposed on a case-specific basis and submitted to the Hazard Evaluation and Emergency Response (HEER) Office for review and approval. Given the lack of soil present throughout the MRS, it is unlikely that sampling of environmental media for MC contamination will be conducted with the possible exception associated with a BIP or low order detonation.
Location-Specific ARARs			
Endangered Species Act	Endangered Species Act 16 USC § 1538(a)(1)(B); 50 CFR §17.21(c)(1)	Prohibit the take[1] of any fish or wildlife species listed as threatened or endangered under the Act.	Multiple endangered species are located within the site, Formal consultation is not an ARAR because it is an administrative requirement. However, substantive requirements to avoid and minimize impacts to ESA-Listed species are part of the ARARs.
Migratory Bird Treaty Act	Migratory Bird Treaty Act 16 USC § 703(a)	Prohibits the take[2] and killing of migratory birds native to the United States or its territories and of any nest or egg of such bird.	Migratory birds frequent the site. Only substantive requirements are considered ARARs.
Protection of Archaeological Resources	Protection of Archaeological Resources 16 USC § 470ee(a)	Prohibits excavating, removing, damaging, or otherwise altering or defacing, or attempting to excavate, remove, damage, or otherwise alter or deface, any archaeological resource located on public lands.	Multiple archaeological sites are present within the site. Permits are not required for on-site response actions conducted under CERCLA. Only the substantive requirements of 43 CFR 7.4(a) are considered potential ARARs.
Location-Specific TBCs			
None			
Action-Specific ARARs			
Resource Conservation and Recovery Act (RCRA), Subpart X	40 CFR 264.601	Requires miscellaneous units for the management of hazardous waste, such as open burning/open detonation units, to be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment.	MEC recovered during a remedial action may need to be detonated or burned before offsite disposal. Permits are not required for on-site response actions conducted under CERCLA. Only the substantive requirements of Subpart X are considered potential ARARs.
Action-Specific TBCs			

Requirement	Citation(s)	Description	Applicability or Relevance
HEER Office Technical Guidance Manual (TGM) (HDOH 2016)		The HEER Office TGM provides in-depth guidance on environmental assessment and cleanup under HRS 128D.	This guidance includes detailed instructions for acceptable sample collection, handling, and analysis that are required by the HEER Office for adequate site characterization and final decision making. The guidance also provides an overview of the HEER Office Environmental Action Levels and environmental risk process (See Chemical-Specific TBCs)

[1] Under the Endangered Species Act Take is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct.”

[2] Under the Migratory Bird Treaty Act Take is similarly defined as under the ESA with the exception of the absence of “harm” or “harass” in the definition.

3.0 Project Technical Approach

3.1 OVERVIEW

3.1.1 The Technical Approach for this RI was based on the findings of previous investigations and other available historical information and was designed to obtain data to sufficiently characterize the nature and extent of MEC and MC contamination present at the Kanaio LTA MRS, and to evaluate potential hazards or risks related to MEC and MC identified in the preliminary CSM. Furthermore, the approach was planned to support the development of potential remedial alternatives where complete exposure pathways were identified.

3.2 MEC SAMPLING DESIGN

The primary components of the MEC sampling design for the RI at the Kanaio LTA MRS involved establishing grids using data from transects and investigating those grids using one of two separate processes, the first comprised of AGC surveys utilizing the man portable vector (MPV) sensor, intrusive investigation, and data evaluation as listed below wherever possible. The second, utilized wherever AGC was not possible, involved an analog survey where anomalies would be resolved as they were discovered. A more detailed look at the VSP parameters used to guide the sampling design can be found in the VSP Memorandum included in **Appendix A**.

- Transect Data were originally collected using PDM8® sensors on 0.6-m wide swathes for the first 10 miles of transects. However, due to the bulk of the PDM8® sensor and associated real-time kinematic (RTK) global positioning system (GPS), and the rough-ness of the terrain caused by a’a lava fields the remaining 60 miles of transects were collected utilizing a “modified analog” technique where 1-m wide transects were collected using an analog sensor alongside handheld GPS positioning and anomaly locations were be recorded by count. The transects were nominally spaced 600 ft apart in the expected HUA within Area 1 and 300 ft apart everywhere else on site for each method. Data collected along transects was evaluated using VSP software and used to divide the MRS into HD areas (potential HUAs) and LD areas (potential LUAs or NEUs) based on the anomaly density analysis. As a result of the RI data collection effort, 36-acres were designated HUA (based on MD findings) and the remaining 1947-acres of the MRS footprint was designated as an LUA. No NEU areas were identified.
- Five grids were surveyed in areas identified as HD (potential HUAs) in order to characterize potential MEC and, if present, the lateral and vertical extent of the MEC contamination (grids 8, 9, 10, 11 and 12 on **Figure 3.1**). 8 additional grids were surveyed in areas identified as LD (grids 1, 2, 3, 4, 5, 6, 7, and 13 on **Figure 3.1**) to confirm absence of MEC or significant MD in the non-HD area. Three of the LD grids (Grids 1, 2, and 3) were surveyed using the MPV sensor. Grid anomalies were then intrusively investigated. The remainder of the LD and HD grids (grids 4, 5, 6, 7, 8, 9, 10, 11, 12, and 13) were surveyed using analog equipment.
- Significant MD was recovered from within all five HD area grids within the 36-acre suspected HUA boundary. The only MEC item found during the RI was in one of these HD grids (Grid 12, 81-mm HE mortar) and all contained the highest density of anomalies found during the RI. As such, these HD areas confirmed the suspected HUA.
- Areas with low anomaly density (LD areas) were considered potential LUAs. LUAs were investigated in accordance with the approved Final UFP-QAPP (Parsons, 2021a) and Preliminary MRS Characterization Memorandums, with the intent of refining and confirming the CSM, amount of MEC for the baseline risk assessment, and the boundary of any HUA and NEU areas. As previously noted, the remaining 1947-acres of the MRS footprint was designated as an LUA.

No non-use areas were identified. Therefore, designation of an NEU area or areas was not warranted during the RI.

3.3 MC SAMPLING DESIGN

Previous investigations determined that throughout most of the Kanaio LTA MRS insufficient soil was present to collect MC samples. Where soil was present (generally outside the RI/FS project area), a total of eight individual locations were sampled for selected metals (lead, antimony, copper, and zinc) and explosives. Although a formal risk assessment was not conducted as part of the SI, the SI Report concluded "Based on the analytical results, MC does not pose a risk to human health or the environment." (Na Ali`i, 2018). Based on the SI conclusions and known absence of soil within the impact area (the subject of this RI) and in accordance with the approved UFP-QAPP, MC sampling was limited to following circumstances; encountering low-order detonation munitions, encountering suspected contamination sources (e.g., a cache of DMM), conducting BIP activities for single munitions, or conducting consolidated detonation events and only in areas where there was sufficient soil to collect a sample.

3.4 MUNITIONS AND EXPLOSIVES OF CONCERN CHARACTERIZATION

3.4.1 OVERVIEW

General MEC characterization tasks planned for this RI included conducting DGM and AGC surveys followed by intrusive investigation of subsurface sources. The following subchapters address these tasks, Geophysical System Verification (GSV), and MEC safety. **Table 3.1** summarizes the quantities of geophysical data collected at the Kanaio LTA MRS. **Figure 3.1** shows the locations of geophysical data collection.

Table 3.1 Geophysical Data Collected

Survey	Total Collected	Comments
Transects		
DGM Survey with PDM8®	10 miles	Data used for anomaly density calculations
Modified analog survey	60 miles	Data used for anomaly density calculations
Grids – AGC with MPV		
HD Grids	N/A	N/A
LD Grids	0.69 acres	3 grids (100 ft x 100 ft)
Grids – Analog		
HD Grids	1.15 acres	5 grids (100 ft x 100 ft)
LD Grids	1.15 acres	5 grids (100 ft x 100 ft)

3.4.2 GEOPHYSICAL SYSTEM VERIFICATION AND TARGET SELECTION CRITERIA

3.4.2.1 A GSV process was implemented at the Kanaio LTA MRS to demonstrate that the instruments and data collection strategies selected for the site function as intended for the duration of the field investigation. Within this process an Instrument Verification Strip (IVS) was used to verify the proper functioning of the geophysical systems used during the project. An IVS was constructed at the Kanaio LTA MRS to accomplish the following goals:

- Confirm that the analog, PDM8®, and AGC sensors used for geophysical data collection were functioning correctly, both at the start of the project and twice daily throughout the project;
- Demonstrate dynamic location repeatability over the IVS items; and

Confirm that detection survey measurement quality objectives in the QAPP are appropriate and achievable.

3.4.2.2 Details on IVS construction and the result of initial IVS testing for the PDM8® are contained in the IVS Technical Memorandum (**Appendix A**).

3.4.2.3 Based on the initial IVS background noise levels described in the Target Selection Memorandum (**Appendix A**), target selection on DGM transects was performed using a profile peak picking algorithm with a threshold of 55 counts. This threshold was ten times the RMS noise level of 5.5 counts measured on the noise line during initial IVS testing, as stated in the UFP-QAPP as the method for determining the target selection threshold. Additional targets were picked down to 21 counts to allow for further evaluation in VSP anomaly density models. Observed noise levels during the transect data collection were substantially higher that 5.5 counts, in rougher areas with a'a lava flows noise levels were several hundred counts. Targeted anomaly densities were evaluated in VSP and compared to the anomaly densities measured during the analog survey. Grid based targets were selected using specific thresholds for the MPV as described in the Target Selection Memorandum (**Appendix A**).

3.4.2.4 Analog targets were identified by the instrument operators using the audible tone produced by the analog sensor.

3.4.2.5 Target lists were compiled for the DGM transect data and the AGC grid-based data. Picked transect targets were only used for the delineation of target areas using VSP. Analog transect anomaly locations were recorded, along with information about any metallic objects recovered at the anomaly location. The quality control (QC) Geophysicist confirmed that all QC seeds had been detected as re-quired in the UFP-QAPP prior submittal of any final full-grid data to the USACE. Upon QC seed confirmation, target lists were submitted to the USACE Geophysicist for confirmation that all quality assurance seeds were detected. Additional detail regarding the target selection and the process used to determine the target selection threshold is contained in the Target Selection Technical Memorandum (**Appendix A**).

3.4.3 MEC INVESTIGATION

3.4.3.1 DGM AND ANALOG TRANSECT SURVEYS

3.4.3.1.1 The proposed transect coverage for the Kanaio LTA MRS was designed to identify a 335-ft radius target area with an average anomaly density of 200 anomalies/acre above background (assumed as 50 anomalies/acre) with 100% confidence per VSP. To achieve these objectives, DGM data were planned to be collected across the MRS at approximately 600-ft intervals in the Expected HUA within Area 1 and 300-ft intervals across the rest of the MRS. The first 10 miles of DGM transect data were collected with a combination of the PDM8® paired with differential GPS (**Table 3.1**). After this initial collection, due to site conditions, the remaining 60 miles of transects were collected using the modified analog method described in Section 3.2.

3.4.3.1.2 Once transect DGM data collection was complete, the data were processed and evaluated to identify anomalies with responses above the target selection criteria. DGM and analog transect data were then imported into VSP to generate anomaly density maps for each survey type. Overlapping results were compared, to confirm the high noise levels of the DGM survey due to the volcanic terrain/geology. The anomaly density results were analyzed to separate the MRS into LD and HD areas. Analysis of the data collected using the Post-Survey Probability of Traversal tool in VSP indicated that almost any target area meeting the assumed 335-ft radius requirement would have been traversed. Based on VSP analysis of the collected data, all potential minimum target areas were traversed by at least one transect, with the exception of a strip along the eastern edge of the MRS that was unsafe to access, as noted in previous investigations and clearances.

3.4.3.2 TRANSECT ANALYSIS AND AGC GRID PLACEMENT

3.4.3.2.1 The primary objectives of the transect data analysis were to confirm that the collected transect data were sufficient to identify high use areas with 100% confidence, create a map of anomaly density for the MRS (**Figure 3.1**), differentiate between areas of low anomaly density representing background conditions in areas considered to be relatively unaffected by potential concentrated munitions use and areas of high anomaly density potentially representing MEC-contaminated HUAs, identify locations for low density area AGC grids to be used to confirm that MEC is not a significant hazard in background areas, and identify locations and sizes for high density area AGC grids to be used to determine the nature and extent of MEC contamination in potential target areas.

3.4.3.2.2 As shown in **Figure 3.1**, calculated across-site densities based on the analog transect data range from approximately 0 anomalies per acre (APA) to roughly 250 APA. A single high anomaly density area was identified. Based on the results of the transect survey the Project Team selected 5 grids (100 ft by 100 ft), totaling approximately 1.15 acres, to characterize the HD area. The LD area was characterized using roughly 1.84 acres of grids (8 grids). The grid placements are depicted on **Figure 3.1**.

3.4.3.3 AGC GRID SURVEYS AND ANOMALY SELECTION

3.4.3.3.1 AGC was collected using the MPV in three grids to identify subsurface anomalies that might be indicative of MEC. These three grids were specifically placed in areas of the MRS where the surface and subsurface are made up of soil, and not a'a lava, so that AGC could be performed. The method used to conduct AGC surveys is described in the approved Final UFP-QAPP (Parsons, 2021a). The anomaly selection criterion used for the MPV data is documented in the Target Selection Technical Memorandum (**Appendix A**). Anomalies were selected as described in the UFP-QAPP and Target Selection Technical Memorandum.

3.4.3.3.2 PDM8® DGM data was collected in a single AGC grid (Grid 3), to provide a baseline comparison between the two systems in the volcanic terrain/geology present at the site. The PDM8® data were processed and qualitatively evaluated against the AGC data collected with the MPV. The data were processed and evaluated to identify anomalies with responses above the target selection criteria.

3.4.3.3.3 Dynamic survey QC results are summarized in the project QC database (daily sensor testing and general dataset information) or in Geosoft databases and maps (**Appendix A** digital data deliverable). QC seed results were evaluated prior to submittal of the dig list along with other pertinent QC data prior to acceptance of the list. Dynamic AGC results had significantly lower anomaly counts (more than 1 order of magnitude lower) than the neighboring PDM8® transect results and for the coincident data collected in Grid 3. This compares well with the significantly lower anomaly densities also reported during the analog transect survey and indicates that the PDM8® results were more severely influenced by the volcanic terrain/geology.

3.4.3.4 CUED AGC SURVEYS

3.4.3.4.1 Cued AGC surveys were performed on all targeted anomalies identified during the dynamic AGC grid surveys, to classify anomaly sources as either targets of interest (e.g., MEC, seed items, MD with characteristics similar to MEC), or non-targets of interest. Initial cued survey results showed limited anomaly reduction of about 50%, due to responses associated with the terrain and geology. Due to the uncertainties regarding the cued AGC survey classification accuracy in the difficult site conditions, cued AGC classification results were not used to remove targeted anomalies from the dig list. All dynamic AGC targeted anomalies were referred for intrusive investigation.

3.4.3.4.2 Cued data QC results are summarized in the project QC database (daily sensor testing and general dataset information) or in Geosoft databases and maps (**Appendix A** digital data deliverable).

3.4.3.5 ANOMALY REAQUISITION AND INTRUSIVE INVESTIGATION

3.4.3.5.1 Intrusive investigation of anomalies identified in the grid-based data was used to determine the nature and extent (vertical and horizontal) of MEC contamination. Intrusive investigation results were recorded including the characteristics of sources (i.e., size, shape, metal composition) recovered from targeted anomalies. For all excavations, the intrusive team navigated to the location of each dynamic AGC anomaly selected for investigation. Once the location was positioned, a marker flag was placed at the location and a 1-m radius around the flag was resurveyed using analog detectors to confirm and refine the position of the selected anomaly.

3.4.3.5.2 Following reacquisition, anomalies were excavated with hand tools by qualified UXO technicians. The intrusive team began each excavation in the location of highest response and continued the excavation until the reacquired response had either been removed or characterized around the 1-m search radius. Reacquisition locations were evaluated according to the required accuracy for the survey performed. The results of the intrusive investigation were recorded on the project dig sheets. The results are discussed in Chapter 5.

3.4.3.6 ANALOG GRID SURVEYS AND INTRUSIVE INVESTIGATION

Unlike the three AGC surveyed grids discussed in **Subsection 3.4.3**, ten grids in the more difficult terrain characteristic of most of the Kanaio LTA MRS were surveyed using analog methods. Anomalies identified during these analog surveys were typically on the surface or partially obscured by eroding a'a lava gravel. No soil layer was present in these areas thus no excavation was required. All anomalies were assessed by qualified UXO technicians. If the source of an anomaly was not visible, rocks and gravel were moved, if possible, in an effort to resolve the anomaly. If the anomaly could not be resolved, the location was documented as a geologic response ("hot rock"). Intrusive investigation results were recorded including the characteristics of sources (i.e., size, shape, metal composition) recovered from targeted anomalies. The results of the intrusive investigation were recorded on the project dig sheets. The results are discussed in **Chapter 5**.

3.4.4 MUNITIONS AND EXPLOSIVES OF CONCERN SAFETY

3.4.4.1 MUNITION WITH THE GREATEST FRAGMENTAION DISTANCE

Based on historical data and previous investigations, the munition with the greatest fragmentation distance (MGFD) for the Kanaio LTA MRS is the Projectile, 105-mm, HE, M1 Series. The MGFD was presented in the DoD Explosives Safety Board (DDESB)-approved Explosives Site Plan (ESP) (Parsons, 2021b).

3.4.4.2 MINIMUM SEPARATION DISTANCE

The minimum separation distance (MSD) is a personnel protective distance based on the characteristics of the selected MGFD and Department of the Army Pamphlet 385-63 (Department of the Army, 2012). The specific MSDs for the Kanaio LTA MRS were presented in the DDESB-approved ESP (Parsons, 2021b) and the approved Final UFP-QAPP (Parsons, 2021a). MSDs for unintentional detonations were established for personnel based on the hazardous fragment distance (HFD) of 335 ft for the appropriate MGFD. MSDs for intentional detonations were also established for disposal operations, based on the maximum fragmentation distance, horizontal for the MGFD.

3.4.4.3 EXCLUSION ZONES

Exclusion zones (EZs) were established during the RI to protect the public and nonessential personnel from intentional and unintentional detonations. The size of the EZ was determined based on the calculated MSD for the known or assumed MGFD. These EZ distances were enforced during all intrusive operations at the Kanaio LTA MRS.

3.4.5 UXO/MPPEH MANAGEMENT AND DISPOSITION

One item discovered during intrusive operations was blown-in-place (BIP). Complete munitions debris disposal details are provided in **Appendix B**.

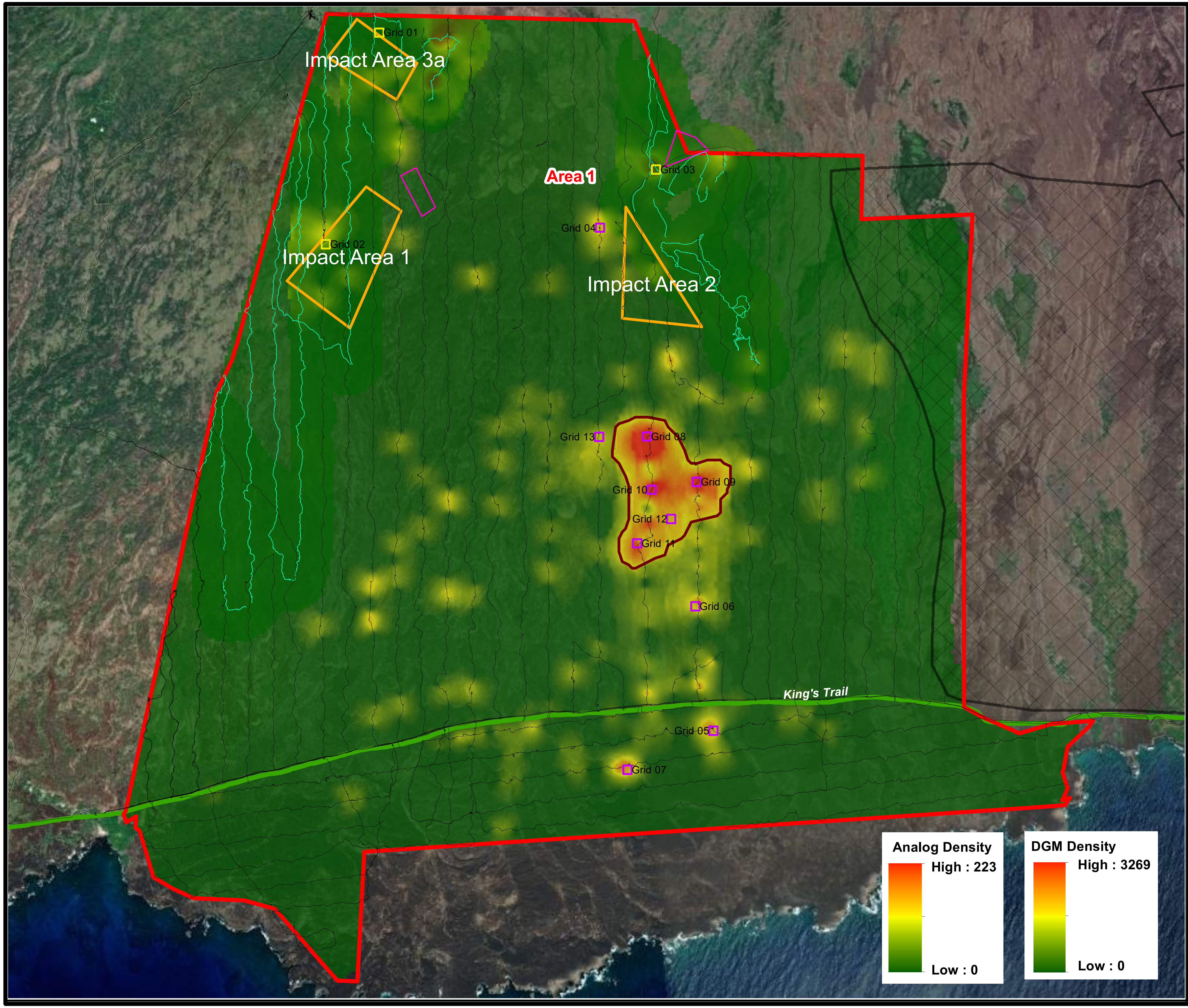


Figure 3.1

Kanaio LTA MRS
Analog and DGM Anomaly Density and Final Grid Locations

Maui, Hawaii

Legend

- ☐ Proposed AGC Grid Location
- ☐ Proposed Analog Grid Location
- — Kanaio Local Training Area MRS (Area 1 and Area D) Boundary
- — King's Trail
- — Impact Area
- — Transect (Analog)
- — Transect (DGM)
- ☐ Private Property (No ROE)
- ☐ Proposed High Use Area Boundary

300 150 0 300

Meters

PARSONS

U.S. ARMY CORPS
OF ENGINEERS
HUNTSVILLE CENTER

DESIGNED BY: BT

DRAWN BY: BT

CHECKED BY: DS

SUBMITTED BY: DS

Analog and DGM Anomaly Density

SCALE: As Shown

DATE: January 2022

FILE:

PROJECT NUMBER: 100087.0538.110208.02002

PAGE NUMBER: 63

4.0 Data Quality Assessment

4.1 DATA NEEDS

The preliminary CSM for the Kanaio LTA MRS indicated that MEC, in the form of UXO, were likely present in the MRS based on the historical MEC and MD findings of multiple clearances and investigations performed at the site periodically starting in 1981. The project objective for the RI at the Kanaio LTA MRS are to obtain data to sufficiently characterize the nature and extent of MEC present at the Kanaio LTA MRS, and to evaluate potential hazards or risks related to identified contamination. The data needs for this project were reviewed by the Project Team and include collecting adequate data to assess MEC at the Kanaio LTA MRS. The Data Quality Objectives (DQOs) associated with the data to be collected during the RI were developed by the SPP Team and included in the approved Final UFP-QAPP (Parsons, 2021a).

4.2 DATA QUALITY OBJECTIVES

4.2.0.1 DQOs are qualitative and quantitative statements that specify the quality and level of data required to support the decision-making processes for a project. The MEC DQOs developed for the project include the environmental problem, the related decisions that need to be made, the type and quantity of data, and level of data quality needed to ensure that those decisions are based on sound scientific data. The overall goal of this project is to obtain acceptance of an RI/FS, PP, and DD in accordance with CERCLA, as amended, and DoD, ARNG, and USACE regulations and guidance. The information collected to meet the DQOs will be sufficient to characterize the nature and extent of any MEC and/or MC and assess human health and ecological risks present at the MRS to facilitate development of the FS.

4.2.0.2 DQO elements are developed during project planning sessions using a systematic planning process (SPP). Examples of SPP include the Environmental Protection Agency (EPA)'s seven-step DQO process defined in EPA Guidance on Systematic Planning Using the Data Quality Objectives Process, EPA QA/G-4, EPA/240/B-06/001, February 2006; Intergovernmental Data Quality Task Force Uniform Federal Policy-Quality Assurance Project Plans Manual; and the USACE Technical Project Planning Process (TPP), EM 200-1-2, February 29, 2016. Worksheet #11 of the approved Final UFP-QAPP (Parsons, 2021a) describes the EPA seven-step process for the MEC and MC DQOs for the Kanaio LTA MRS. The status of the MEC DQOs following completion of the RI is summarized in **Sections 5.1.2** and **5.2.2**, respectively. The status of the geophysical measurement quality objectives (MQOs) is described in **Section 4.3**.

4.3 MEASUREMENT PERFORMANCE CRITERIA/MEASUREMENT QUALITY OBJECTIVES

4.3.1 MEC CHARACTERIZATION QUALITY CONTROL

The field operations for this project involved multiple elements, or "definable features of work." **Tables 4.1** and **4.2** summarize the measurement performance criteria (MPCs) and MQOs that were established for the definable features of work associated with the MEC-related tasks conducted during the RI. The quality of these procedures and the related results have been evaluated for compliance with DQOs through a review of overall Precision, Accuracy, Representativeness, Comparability, and Completeness (PARCC). Note that MPCs and MQOs are required to indicate that the relevant data are of adequate quality to support project decisions; however, not all definable features of work are related to project decisions and for this reason not all definable features of work have related MPCs. The full list of MPCs and MQOs evaluated for MEC is included in **Tables 4.1** and **4.2**, which include a pass/fail decision for each MPC and MQO. Failures noted in the table are described in more detail below.

4.3.1.1 GEOPHYSICAL INVESTIGATION QUALITY CONTROL

The following MPC/MQO failures were noted for the geophysical data collected during the RI. The root cause analyses (RCAs) are located in **Appendix D**:

UFP-QAPP, Worksheet 22, MQO Initial dynamic survey positioning accuracy (IVS): Derived positions of IVS target(s) are within 25cm of the ground truth locations. On February 16, 2021, the field team collected the initial IVS using the PDM8® sensor. It was determined during post processing of the initial IVS data that three out of seven passes over the medium industry standard object (ISO), and one out of seven passes over the small ISO did not meet the positioning accuracy MQO of being within 0.25 m of the actual IVS item location. All of these offsets are in the south to south-southwest direction, crossline and in the maximum downslope direction from the seed items. The GPS antenna is mounted with somewhat higher vertical offset from the sensor than the EM61-MK2, making the PDM8® more sensitive to tilt associated with slope. RCA-01 accepted, the field teams were made aware of the offset issue. The team checked the IVS construction and verified it was correct and straight. The team adjusted and actively monitored the GPS position to verify its correct orientation during data collection. Monitoring the GPS position allowed the data collector to minimize the tilting due to the slope. No offsets larger than the MQO of 0.25 m have been recorded on subsequent days.

Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP), Worksheet 22, Measurement Quality Objective (MQO): Dynamic Survey Performance: For Quality Control (QC) seeds: offset between selected anomaly location and seed item location is ≤ 40 cm. Coverage (advance geophysical classification [AGC]): ≥90% at 0.5m (project design cross-track measurement spacing); 98% ≤ 1m, not including documented obstacles. The peak MPV response recorded for blind QC seed item K-04 in Grid 1 was lower than the target selection threshold of 15 mV/A (millivolts per ampere) and was over 40cm from the closest data collection line path and as a result was not selected as a target. The peak MPV response recorded for blind QC seed item K-08 in Grid 3 was lower than the target selection threshold of 15 mV/A and was located next to a GPS data gap and was not selected as a target. The peak MPV response recorded for blind QC seed item K-10 in Grid 3 was lower than the target selection threshold of 15 mV/A was not selected as a target. Rugged terrain, uncleared vegetation, and the size, weight, and balance of the MPV made it difficult for the field team to attain complete coverage over the survey areas. This was exacerbated by erratic, non-linear drift in the inertial measurement unit (IMU) yaw values during the course of data collection which made it difficult for the field teams to observe and correct their gaps in real time. Headings for processed data were generated using RTK GPS paths, due to the potential errors in the IMU yaw value. Sufficient coverage for the Remedial Investigation was attained by additional data collection outside of each grid, even though each grid included numerous gaps. Volcanic soils with high ground response resulted in a higher target selection threshold, also reducing the detection potential of the MPV. Additional data will be collected over each of the untargeted seed items, to confirm the instrument response over these items. Anomalies with responses similar to the seeds will be added to the dig list.

Uniform Federal Policy – Quality Assurance Project Plan (UFP-QAPP), Worksheet 12, Measurement Quality Objective (MQO): Initial measurement of production area back-ground locations and background verification (five background measurements: one centered at the flag and one offset at least ½ sensor spacing in each cardinal direction): A target of interest (TOI) small industry standard object (ISO) at 30cm synthetically seeded in the ongoing background, and background-corrected using the initial background measurement results in polarizabilities with a library match of ≥0.9. Confirm inversion model supports classification. None of the background validation measurements at Kanaio Local Training Area met the UFP-QAPP objective of a library match of ≥0.9. Additional testing at progressively more shallow synthetic seed responses demonstrated that a limited number of background locations would pass validation if the seeded response used for the background validation was a small ISO (schedule 80) at 15 cm below ground surface. No backgrounds could be validated using a deeper response. Initial cued survey results showed that the majority of targeted anomalies had at least one fit identified as a TOI. Qualitative review of these fits indicates that most of these fits are likely geologic response, and not actually TOI. The subsurface at Kanaio Local Training Area is comprised entirely of recent mafic lava flows rich in iron. This geology can both mimic and mask subsurface metallic objects. Background validation requires sufficient signal to noise so that the synthetic seed response is large enough relative to the ground response that it is not significantly degraded by the ground response. The background validation results indicate that reliable classification of a small ISO (schedule 80) is likely limited to depths of 15 cm or less. Initial cued results may not reliably classify TOI with responses smaller than the response used for the background validation. Further, the limited ability of the initial classification approach to minimize the dig list suggests that the cued survey provides limited utility for the Remedial Investigation. Therefore, intrusive investigations will be based on the dynamic survey results. No anomalies will be removed from the dig list based on advanced geophysical classification results.

The information pertaining to geophysical QC, including the IVS reports, dig sheets, Microsoft Access Database, and raw geophysical data for the RI are included as attachments within **Appendix A**.

4.3.1.2 INTRUSIVE INVESTIGATION QUALITY CONTROL

Each anomaly selected for intrusive investigation was resolved. The intrusive team leader documented the source of the anomaly and verified that the anomaly had been adequately characterized. A final reading was taken with the PDM8® at the anomaly location to confirm that the area had been cleared. Any remaining response at an anomaly location was investigated unless the source was identified (i.e., fencepost). In addition to the post-intrusive checks by the intrusive team; the UXO QC Specialist (UXOQCS) checked at sufficient excavations to confirm that they were properly resolved and that the MPC for confirming removal (**Table 4.1**) had passed. A geophysicist reviewed the intrusive results and compared the intrusive teams' findings with the geophysical anomalies selected from the DGM data. The intrusive information collected for the Kanaio LTA MRS has been determined to be sufficient to determine the nature and extent of the MEC hazard in the MRS.

4.4 DEPARTURES FROM PLANNING DOCUMENTS

The Kanaio LTA MRS was investigated in accordance with the approved Final UFP-QAPP (Parsons, 2021a) with the following deviations:

Field Change Request (FCR)-1 made several changes to the transect survey design, these changes were a result of difficulties implementing the original transect survey design due to the roughness of the terrain causing issues in data reliability and safety concerns. Changes made to planning documents outlined FCR-1 are as follows:

- Several changes we made to the Final UFP-QAPP, Worksheet #11 – Section 11.1.5.1 A. specified: "DGM transect surveys utilizing a PDM8® sensor will be used to locate anomalies and delineate areas of high anomaly density (HD areas) from areas of low anomaly density (LD areas), as analyzed using VSP. FCR-1 was submitted requesting to change this sentence to "DGM transect surveys utilizing a PDM8® sensor and analog transect surveys will be used to locate anomalies…". Additionally in Section 11.1.5.1 A. the following decision rule was added "4) If transect paths are considered to be unsafe for DGM by the OESS and Parsons Field Team, they will be collected using analog transects unless analog transects are also considered to be unsafe.". Two changes to Table 11.3 were also made; footnote 1a) was amended to be "a) Transect width 0.6m (1.9685 feet) for DGM, 1m for analog" and footnote 2) was added "2) Analog transects will have larger sweep width and will meet the HD detection requirements using the same spacing as DGM transects."
- In the Final UFP-QAPP, Worksheet #12 - Table 12-1 two MPC were modified: "Survey coverage: maximum speed on transect (analog) || Accuracy/ Completeness || 98% ≤ 0.45 meter/second (approx. 1 mile/hr); 100% ≤ 0.5 meter/second || QC geophysicist/lead agency (or designee) oversight" was added to the MPC and "analog" was added to MPC #7.
- The Final UFP-QAPP Worksheet 17.5 DFW 4 – was changed to "Conduct DGM and Analog Transect Surveys". Section 17.5.2 was amended to read: "Where DGM cannot be performed due to safety considerations, as determined by the OESS and Parsons field team, analog transects will be collected along planned DGM transects. Analog transects will be collected using handheld GPS positioning and will follow the procedures described in SOP MEC-04 Analog Intrusive and Surface Sweep Ops. Intrusive investigations will not be performed on analog transects. Anomaly locations will be recorded either individually or by count per 50 m transect segment."
- The UFP-QAPP Worksheet 22 – Table 22-2 – "and analog" was added to MQO PC12 after PDM8®. Two additional MQO were added: "Maximum velocity (Analog) || Verified for each transect by reviewed the filtered survey track of each sensor || Project Geophysicist / Running QC Summary / QC Geophysicist || 98% ≤ 0.45 meter/second (~1 mile/hour); 100% ≤ 0.5 meter/second || RCA/CA", and "Ongoing positioning test (analog) || Beginning of each day || Field Team Leader / Running QC Summary / Project/QC Geophysicist or designee || QC or control point position within 10 m of actual position || RCA/CA"
- All of the changes proposed in FCR-1 were approved by the USACE and ARNG

Field Change Request (FCR)-2 made several changes to the grid investigation survey design, these changes were a result of difficulties implementing the original survey design due to the roughness of the terrain causing issues in data reliability and safety concerns in certain areas. Changes made to planning documents outlined in FCR-2 are as follows:

- Two changes were made to UFP-QAPP, Worksheet 11 – Section 11.1.5.1 B. The last two sentences were changed to read "All placed seeds should be detected in the grid DGM or "modified" analog detection surveys. DGM detection surveys covering the survey area (grids or transects) will be used to gather data so that a threshold-based selection process can be used to identify anomalies for intrusive investigation based on the processed DGM data or "modified" analog findings". The first paragraph fourth sentence of Section 11.1.5.1 C. was changed to read "All available and relevant lines of evidence for the delineation (e.g., HRR, historical photo interpretation, visual observations) will be considered, along with data collected during the RI from selected existing DGM/"modified" analog transects and grids that will be intrusively investigated".
- The UFP-QAPP, Worksheet 12 – Table 12.1 Sampling Design – Two measurement items, #12 and #13 were added addressing QC seeding of analog grids. New language under "Specification" for #12 reads "QC seeds will be placed at an average rate of 2 seeds per analog grid" with performance activity added to read "Lead agency verifies all QC seed failures are explained and corrective action implemented." For #13 under "Specification" reads "Blind quality assurance (QA) seeds will be placed at the site by USACE at the rate determined by USACE QA personnel" with performance activity added to read "Lead agency verifies all QA seed failures are explained and corrective action implemented."
- UFP-QAPP Worksheet 17 – 17.1. the last two sentences of the first paragraph were changed to read "The design for obtaining data described in the DQOs summarizes the technical approach for the investigation area including: QR, "modified" analog, DGM, and AGC surveys, intrusive investigation of anomalies, and collection of environmental soil samples (based on pre-specified conditions). If warranted, "step out" surveys (out-side the Kanaio LTA [Area 1] MRS) may be conducted if potential MEC contamination is identified at the boundary". The second bullet last sentence of paragraph 17.1.3 was also changed to read "If grid footprints are considered to be unsafe for DGM by the OESS and Parsons Field Team, data will be collected using analog methods (SOP MEC-04) unless analog procedures are also considered to be unsafe".

No other departures from planning documents occurred with regard to the RI performed at the Kanaio LTA MRS. Additional details in fieldwork variances are located in **Appendix E**.

Table 4.1 Measurement Performance Criteria for MEC-Related Tasks and Status Following Remedial Investigation

Measurement	Data Quality Indicator	Measurement Performance Criteria	Activity Used to Assess Performance	Status Following Remedial Investigation
Site Preparation				
1. Accessibility	Completeness	All areas inaccessible to investigation or inaccessible to use of proposed geophysical systems are identified in a geographic information system (GIS) or the Geophysical database.	Parsons will visually inspect the site and/or review the GIS/Geophysical database	Pass
Sampling Design				
2. Planned survey coverage (Preliminary MRS Characterization)	Representativeness/ Completeness	Planned, initial transect spacing will be sufficient to detect HUAs with nominal transect spacing of 300 ft outside of the expected high use area.	QC geophysicist reviews VSP output.	Pass
3. Detection threshold (transects & grids)	Sensitivity	A detection threshold of 10 times the site-specific background noise, per PDM8® standard procedure, will be used for the transect using the PDM8®. MPV target selection will be based on system response (5 times the site-specific background noise) and coherence anomaly. The thresholds are subject to change based on IVS results.	1) Review of sampling design 2) Initial verification at IVS 3) Background analysis prior to VSP analysis	Pass
4. Background data collections (AGC)	Representativeness/ Accuracy	Background locations will be selected such that background data will be representative of the various subsurface conditions expected to be encountered within each survey unit at the site	Data verification/data validation	Pass
5. Positioning requirement (locating transects and centers of sampling grids)	Accuracy	Actual positions must be within 10 meters of planned positions unless documented dangerous terrain, obstructions, and other unsafe site conditions require moving the planned grid.	Review of sampling design compared to actual survey location. (QC Geophysicist and lead agency oversight).	Pass
6. Positioning requirement (full coverage grid mapping and reacquisition)	Accuracy	Recorded measurement positions must be within 0.1m of actual positions.	Review of sampling design Initial verification at IVS	Pass
7. Survey coverage (transects – DGM and Analog)	Accuracy/ Completeness	100% of planned transects are sampled, excluding dangerous terrain, large obstructions, and other unsafe site conditions.	Actual course over ground is recorded and evaluated for each survey unit	Pass
8. Survey coverage (grids)	Accuracy/ Completeness	100% of specified acreage is surveyed.	Data validation	Pass
9. Survey coverage: Maximum speed on transect (analog)	Accuracy/ Completeness	98% <= 0.45 meter/second (approx. 1 mile/hr); 100% <= 0.5 meter/second.	QC geophysicist/lead agency (or designee) oversight.	Pass
10. QC seeding (DGM grids only)	Accuracy/ Completeness	During the high density (HD) Area Characterization phase only, contractors will place blind QC seeds at the rate of 1 seed/system/day.	Lead agency verifies all QC seed failures are explained and corrective action implemented	Pass
11. QC seeding (analog grids)	Accuracy/ Completeness	QC seeds will be placed at an average rate of 2 seeds per analog grid.	Lead agency verifies all QC seed failures are explained and corrective action implemented	Pass
12. QA seeding (analog grids)	Accuracy/ Completeness	Blind QA seeds will be placed at the site by USACE at the rate determined by USACE QA personnel.	Lead agency verifies all QA seed failures are explained and corrective action implemented	Pass
Anomaly Resolution				
11. Anomaly resolution (DGM and analog)	Completeness	All items within 0.5 m laterally and within the threshold depth must be recovered for each flag unless the source can be documented.	QC Geophysicist (or designee) verifies	Pass
12. Anomaly resolution (AGC)	Accuracy/ Representativeness	HD Area Characterization: Excavation of anomalies will be performed in representative grids where necessary to dill data gaps in the CSM. Inversion results correctly predict one of	Qualitative examination and documentation of recovered items	Pass

Measurement	Data Quality Indicator	Measurement Performance Criteria	Activity Used to Assess Performance	Status Following Remedial Investigation
		more physical properties (e.g., size, symmetry, or wall thickness) of the recovered items (specific tests and test objectives established during project planning).		
13. Anomaly classification (AGC)	Completeness/ Comparability	Library must include signatures for all items considered by the project team to be a target of interest (TOI), as listed in the CSM.	Verification of site-specific library	Pass
14. Anomaly classification (AGC)	Completeness	All detected anomalies classified as: 1. TOI; 2. Non-TOI; 3. Inconclusive	Data verification	N/A
15. Anomaly classification (AGC)	Completeness	100% of predicted non-TOI that are intrusively investigated are confirmed to be non-TOI.	Visual inspection of recovered items from classification validation	N/A
Non-Impacted Area Confirmation				
16. Non-Impacted Area Confirmation	Representativeness/ Completeness	Well-developed CSM, confirmed by RI results, showing no evidence of munitions use.	Data Usability assessment (DUA)	Pass

Table 4.2 Measurement Quality Objectives for MEC-Related Tasks and Status Following Remedial Investigation

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response/Corrective Action	Status Following Remedial Investigation
Site Preparation				
Construct IVS: Verify as-built IVS against design plan (Digital sensors)	Once, following IVS construction	Small ISO seed buried at 15cm medium ISO seed buried at 30cm	RCA/CA; Make necessary changes to seeded items and re-verify	Pass
Initial Instrument Function Test (PDM8®)	Once following assembly	PDM8®: All IVS seed items detected with response greater than target selection threshold	RCA/CA: Make necessary adjustments, and re-verify	Pass RCA 01 applied to initial IVS constructed
Initial Instrument Function Test (Analog)	Once upon arrival at the project site	Audible response consistent with expected change in tone in presence of standard object	RCA/CA: Make necessary adjustments, and re-verify	Pass
Initial detection survey positioning accuracy (IVS) (Digital)	Once prior to start of data acquisition	Derived positions of IVS target(s) are within 25cm of the ground truth locations	RCA/CA: Make necessary adjustments, and re-verify	Pass
Initial detection survey Check for interference surrounding seed response (IVS) (All sensors)	Once prior to start of data acquisition	All seeds placed in locations that are free of detected anomalies within a radius of ≥1.5m	RCA/CA; and re-verify MQO	Pass
Preliminary Characterization (To delineate HD and LD areas)				
Ongoing instrument function test (DGM)	Beginning and end of each day and each time instrument is turned on	PDM8®: All IVS seed items detected with response greater than target selection threshold	RCA/CA: Make necessary repairs and reverify	Pass
Ongoing instrument function test (Analog)	Beginning and end of each day and each time instrument is turned on	Audible response consistent with expected change in tone in presence of standard object	RCA/CA	Pass
Ongoing detection survey positioning precision (IVS) (Digital)	Beginning and end of each day	Derived positions of IVS target(s) or target over test item placed at known location within 10m of the ground truth location	RCA/CA	Pass
In-line measurement spacing (Digital)	Verified for each transect using UX-Land sample separation gx for fiducial, Robotic Total Station (RTS), or RTK GPS positioned data	98% ≤ 0.25m between successive measurements; 100% ≤1.0m	RCA/CA Coverage gaps are filled or adequately explained	Pass
Coverage – Transect mapping (All sensors)	Verified with target radius using VSP 'Post-survey probability of traversal' tool	Probability of traversal is 100% (excluding site-specific access limitations, e.g., obstacles, unsafe terrain, ROE refusal)	RCA/CA: Coverage gaps are filled or adequately explained	Pass
Geodetic Equipment Function Test	Daily (RTK GPS) Each time equipment is moved (RTS)	Measured position of control point within 10cm of ground truth	RCA/CA; document questionable information in database	Pass
HD Area Characterization – Detection Survey				
Geodetic Accuracy (Confirm Valid Position)	Evaluated for each measurement with RTK GPS or RTS positioning	GPS status flag indicates RTK fix (RTK GPS) RTS passes Geodetic Function Test (RTS)	RCA/CA; document questionable information in database	Pass
Ongoing Instrument Function Test (DGM)	Beginning and end of each day and each time instrument is turned on	PDM8®: All IVS seed items detected with response greater than target selection threshold	RCA/CA: Make necessary repairs and re-verify	Pass
Ongoing detection survey positioning precision (IVS) (Digital)	Beginning and end of each day	Derived positions of IVS targets(s) or target over test item placed at known location within 0.25 m of the ground truth location.	RCA/CA	Pass
Ongoing Instrument Function Test (Analog)	Beginning and end of each day and each time instrument is turned on	Audible response consistent with expected change in tone in presence of standard object	RCA/CA: Make necessary repairs and re-verify	Pass
In-line measurement spacing (Digital, all detection phases)	Verified using UX-Land sample separation gx for fiducial, RTS, or RTK GPS positioned data.	98% ≤ 0.25m between successive measurements; 100% ≤1.0m	RCA/CA Coverage gaps are filled or adequately explained (e.g., unsafe terrain)	Pass

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response/Corrective Action	Status Following Remedial Investigation
HD Area Characterization – Detection Survey (continued)				
Coverage (Digital using electronic positioning, all phases)	Verified using UX-Land crossline spacing gx for fiducial, RTS, or RTK GPS positioned data.	≥90% at project design cross-track measurement spacing; 98% ≤ 0.6m, not including documented obstacles.	RCA/CA: Collect additional data to increase coverage percentage to meet acceptance criterion CA assumption: Gaps require fill-in lines to achieve re-quired coverage or collected data includes enough area to meet intended grid size	Pass
Coverage – Full coverage (Digital, using line and fiducial positioning, all phases)	Verified for each transect/grid	Visual inspection and photos of survey lanes/lines established using: tapes and rope lanes; OR tapes and marking paint; OR sub-meter accuracy track-plot (filtered) of each operator's progress through assigned survey lanes	RCA/CA	Pass
Confirm adequate spacing between units (PDM8®, all phases)	Evaluated at start of each day (or grid)	Minimum separation of 50m	RCA/CA: Recollect all coincident measurements	Pass
Detection survey performance (Digital)	Average one to three blind QC seed per instrument per day. Seeds to be placed throughout expected detection depth range	For QC seeds: offset between selected anomaly location and seed item location is ≤ 55 cm for digital positioning systems or ≤ 50 cm + ½ line spacing for fiducially positioned data.	RCA/CA: Verify instrument is functioning correctly; if so, reduce threshold, or determine if seed is buried too deep. If instrument is not functioning correctly, recollect data.	Initially failed as seeds weren't directly covered; after additional data were collected in gaps, Pass (see **Subsection 4.3.1.1**).
Geodetic Equipment Function Test	Daily	Measured position of control point within 10cm of ground truth	RCA/CA; document questionable information in database	Pass
Geodetic Accuracy (Confirm Valid Position)	Evaluated for each measurement with RTK GPS	GPS status flag indicates RTK fix (RTK GPS)	RCA/CA; document questionable information in database	Pass
Initial measurement of production area background locations and background verification (five background measurements: one centered at the flag and one offset at least ½ sensor spacing in each cardinal direction) (AGC)	Once per background location	A TOI small ISO at 30cm synthetically seeded in the ongoing background, and background-corrected using the initial background measurement results in polarizabilities with a library match of ≥0.9	RCA/CA: reject BG location and find alternative	No background locations were able to pass with a small ISO synthetically seeded at 30cm. At least one location per grid and the IVS passed when a small ISO at 20cm below ground surface was synthetically seeded.
Ongoing production area background measurements (AGC)	Background data collected a minimum of every two hours during production	BG data from a verified location collected within two hours of all cued data points	RCA/CA: Document environmental changes; Project Geophysicist must approve before proceeding.	Pass
Ongoing production area background measurements Confirm measurements are valid (AGC)	Evaluated for each background measurement over verified background locations	Background measurements are verified to be consistent.	RCA/CA: BG measurement rejected and removed from active BG measurements	Pass
Ongoing derived target position precision (IVS) (AGC)	Beginning and end of each day as part of IVS testing	All IVS items fit locations within 0.25m of average derived fit locations	RCA/CA	Pass
Ongoing Instrument Function Test (Instrument response amplitudes) (AGC)	Beginning and end of each day and each time instrument is turned on	Response (mean static spike minus mean static background) within 20% of predicted response for all Tx/Rx combinations	RCA/CA: Make necessary repairs and re-verify	Pass, unable to process all function test data for one AM test..
Transmit current levels (AGC)	Evaluated for each sensor measurement	Current must be ≥ 3.5 A	RCA/CA: stop data acquisition activities until condition corrected	Pass
Confirm adequate spacing between units	Evaluated at start of each day (or grid)	Minimum separation of 25m	RCA/CA: Recollect data	Pass
Confirm inversion model supports classification (AGC, 1 of 3)	Evaluated for all models derived from a measurement (i.e., single item and multi-item models)	Derived model response must fit the observed data with a fit coherence ≥ 0.8	Follow procedure in SOP or RCA/CA	Pass – all fit coherence ≤ 0.8 included in dig list.

Measurement Quality Objective	Frequency	Acceptance Criteria	Failure Response/Corrective Action	Status Following Remedial Investigation
Confirm inversion model supports classification (AGC, 2 of 3)	Evaluated for derived target	Fit location estimate of item ≤ 0.4m from center of sensor	RCA/CA	This was not evaluated – cued results and fit locations were not utilized for intrusive investigations.
Confirm inversion model supports classification (AGC, 3 of 3)	Evaluated for all seeds	100% of predicted seed positions ≤ 0.25m radially from known position (x, y).	RCA/CA	Pass
Confirm reacquisition GPS precision (AGC)	Daily	Benchmark positions repeatable to within 10cm	RCA/CA	Pass
Classification performance (AGC)	Evaluated for all seeds	100% of QC seeds classified as TOI	RCA/CA	Pass
HD Area Characterization – Intrusive Investigation				
Documenting recovered sources (All sensors)	Daily	All metallic debris collected is documented for the following attributes: Designation as UXO, MD, range related debris (RRD) or non-munitions-related debris (NMRD); UXO and MD described by type, weight, depth. Photos displaying all MD recovered (individual MD photos not necessary), and photos showing all surfaces of each MEC are recorded.	RCA/CA; document questionable information in database	Pass
Confirm anomaly resolution (DGM)	Evaluated for all intrusive results	Verification of anomaly footprint after excavation by secondary personnel, using original instrument (PDM8®), confirms anomaly is resolved below anomaly identification threshold AND Reported excavation findings match expectations	RCA/CA	Pass

5.0 Remedial Investigation Results

RI field activities were conducted at the Kanaio LTA MRS between 15 February 2021 and 04 May 2021. This chapter presents the results of the MEC and MC investigations at the MRS and describes the estimated extent of contamination.

5.1 MUNITIONS AND EXPLOSIVES OF CONCERN CHARACTERIZATION RESULTS

As described in **Chapter 3**, MEC characterization at the Kanaio LTA MRS included conducting a combination of modified analog transect and grid surveys in addition to dynamic and cued AGC grid surveys followed by intrusive investigation of subsurface anomalies within grids wherever possible. This subchapter describes the results of the activities and investigations. Daily field reports are located in **Appendix F**.

5.1.1 MEC INVESTIGATION RESULTS

5.1.1.1 As described in **Subsection 3.4.3.2**, the transect surveys led to the differentiation between areas of low anomaly density representing background conditions in areas considered to be relatively unaffected by concentrated munitions use and areas of high anomaly density potentially representing MEC-contaminated target areas. A total of 371 MD items were also recovered during the transect surveys. VSP analysis of the collected transect data calculated the probability of traversal of a theoretical target area in the areas surveyed to be 100% within accessible portions of the MRS. Based on the results of the transect survey the Project Team selected 5 grids (100 ft by 100 ft), totaling approximately 1.15 acres, to characterize the HD area and approximately 1.84 acres (8 grids) to characterize the LD area.

5.1.1.2 During the modified analog portion of the intrusive investigation 10 total grids (5 HD and 5 LD) were swept for surface and subsurface anomalies using analog equipment as described in FCR-02 (**Appendix E**). The results of the intrusive investigation are presented in **Tables 5.1** and **5.2.**

5.1.1.3 Grid-based AGC data were collected to identify anomalies for intrusive investigation. This intrusive investigation was completed as described in the UFP-QAPP. The results of the intrusive investigation are presented in **Table 5.3**. A total of 99 targets were intrusively investigated in 3 LD grids totaling 0.69 acres at the Kanaio LTA MRS. Two of the 100 detected anomalies were consolidated into one dig due to their proximity.

5.1.1.4 The preliminary CSM for the Kanaio LTA MRS (**Table 10.1** of the approved Final UFP-QAPP [Parsons, 2021a]) contained a list of munitions known or suspected to be present at the MRS. One MEC item (81-mm HD mortar from Grid 12) was recovered and confirmed at the MRS during the RI fieldwork. The CSM was updated and is discussed in detail in **Subsection 2.6**. No MD items not previously included in the preliminary CSM were identified during the RI.

Table 5.1 Modified Analog Results for HD Grids

Type	Number Recovered	Percent (%)
MEC	1	0.27%
MD	357	94.7%
Seeds	19	5.03%

Note: Anomaly resolution percentages presented for categories of intrusive findings represent actual results and cannot necessarily be assumed to extrapolate for subsequent remaining anomalies.

Table 5.2 Modified Analog Results for LD Grids

Type	Number Recovered	Percent (%)
MEC	0	0
MD	95	79.2%
Seeds	25	20.8%

Notes: Anomaly resolution percentages presented for categories of intrusive findings represent actual results and cannot necessarily be assumed to extrapolate for subsequent remaining anomalies. 30 inert US Rocket 3.5” Practice M29 Series were found in transit to Grid 4, this finding is included in the total count of MD recovered sitewide but is not included in Table 5.2.

Table 5.3 Intrusive Results for LD Grids

Type	Number Recovered	Percent (%)
MEC	0	0
MD	1	1.69%
OD	36	61.01%
Other (seeds, duplicate anomaly, hot soil, etc.)	22	37.28%

Note: Anomaly resolution percentages presented for categories of intrusive findings represent actual results and cannot necessarily be assumed to extrapolate for subsequent remaining anomalies. OD = other debris.

5.1.2 STATUS OF MUNITIONS AND EXPLOSIVES OF CONCERN DATA QUALITY OBJECTIVES

5.1.2.1 The overall project objective for MEC was to obtain data to sufficiently characterize the nature and extent of MEC contamination at the Kanaio LTA MRS. To this end, specific DQOs were established. The MEC DQOs for this RI are described in the approved Final UFP-QAPP (Parsons, 2021a). This section addresses the status of the MEC DQOs upon completion of the RI at the Kanaio LTA MRS.

5.1.2.2 MQO failures occurred during the course of the MEC RI, with impacts and corrective actions described by RCAs and the Data Usability Assessments. Corrective actions were completed to ensure that MPCs and the MEC DQOs were still achieved. The inability to complete DGM/AGC surveys over large portions of the site due to the presence of steep, unstable lava flows also led to FCR-01 that changed much of the planned DGM/AGC coverage to analog surveys. Additional MPCs and MQOs were developed for the analog surveys as documented in FCR-01, to ensure that MEC DQOs would still be achieved. Cued AGC surveys were completed on all dynamic AGC anomalies, but given the inability to resolve MQO failures for the cued survey in the short timeframe of the RI field effort, and to ensure that the MPCs and MEC DQOs were still achieved, cued classification results were not utilized for dig list development and all targeted dynamic AGC anomalies were intrusively investigated.

5.1.2.3 The MEC DQOs were achieved by completing the following actions:

- Conducted both DGM surveys using the PDM8®, and analog surveys over transects spaced at approximately 600-ft intervals within the expected HUA within Area 1 and 300-ft intervals in all other areas;
- Collected 1.15 acres of modified analog data in HD grids, 1.15 acres of modified analog data in LD grids, and 0.69 acres of AGC data in LD grids;
- Recovered 854 MD items and 1 MEC item during analog transect surveys and intrusive investigation, including the 30 MD items discovered in transit to Grid 4;
- Confirmed through evaluation of the geophysical data that applicable MQOs were achieved; and
- Confirmed that applicable MQOs had been achieved for 556 intrusive results (377 in HD grids/179 in LD grids).

5.1.2.4 Based on the summary above and the information presented elsewhere in this report, the data obtained during this RI are considered sufficient to characterize the nature and extent of MEC contamination at the Kanaio LTA MRS and the MEC DQOs for this RI are determined to have been achieved.

5.2 MUNITIONS CONSTITUENT CHARACTERIZATION RESULTS

As described in **Subchapter 3.3**, previous investigations determined that throughout most of the Kanaio LTA MRS insufficient soil was present to collect MC samples. Where soil was present (generally outside the RI/FS project area), a total of eight individual locations were sampled during the SI for selected metals (lead, antimony, copper, and zinc) and explosives. Although a formal risk assessment was not conducted as part of the SI, the SI Report concluded “Based on the analytical results, MC does not pose a risk to human health or the environment.” (Na Ali`i, 2018). Based on the SI conclusions and known absence of soil within the impact area (the subject of this RI), MC sampling during this RI was limited to areas where low-order detonation munitions were located, suspected contamination sources (e.g., a cache of DMM), and conducting BIP activities; if sufficient soil was present to collect a sample. During the RI, a single BIP (intact 81-mm HE mortar from Grid 12) was conducted and a stockpile of US Rocket Practice M29 Series rockets (MD) were found; however, in both cases no sampleable soil was present.

5.3 EXTENT OF MUNITIONS AND EXPLOSIVES OF CONCERN AND MUNITIONS CONSTITUENT CONTAMINATION

5.3.1 EXTENT OF MUNITIONS AND EXPLOSIVES OF CONCERN CONTAMINATION

5.3.1.1 As described in Subchapters 3.4.3 and 5.1.1, 36 acres of the 1983-acre investigation area of the MRS were identified as a HD area and 1947 acres were identified as LD areas. One UXO item was recovered in one of the HD grids (Grid 12) during the RI. MD was recovered from all 5 grids (Grids 8, 9, 10, 11, and 12) within the HD area and 6 grids (Grids 3, 4, 5, 6, 7 and Grid 13) within the LD area.

5.3.1.2 No MD or MEC was recovered in 2 LD grids (Grids 1 and 2). MD was recovered to a maximum depth of approximately 34 cm bgs (~13.4 inches). The balance of the MD recovered was either surface level or just below the surface with 92.5 percent recovered at less than 15 cm bgs (~6 inches). These results suggest that any potential MEC would likely be present on the surface or at very shallow depths throughout the MRS (most dependent on location and associated subsurface profile). The depth estimates are supported by the reported geologic conditions at the MRS, which are characterized primarily by a’a lava. It is not expected that munitions would reside below the loose rock layer on top of the a’a and in the lava itself.

5.3.2 EXTENT OF MUNITIONS CONSTITUENT CONTAMINATION

As described in **Subchapter 5.2**, MC contamination (i.e., COPCs) was not identified within the MRS. Insufficient soil was present to sample in both areas meeting the sampling criteria (BIP and DMM stockpile).

6.0 Contaminant Fate and Transport

Understanding the fate of the various MEC and MC contaminants present in or released to the environment is important to evaluate the potential hazards or risk posed by those contaminants to human health and the environment. For example, MEC may be present on the ground surface or be buried in the subsurface; however, it is possible for natural processes to result in the movement, relocation, or unearthing of the MEC, thereby increasing the chance of its subsequent exposure to human receptors. Furthermore, MC may remain inside intact munitions. The following paragraphs discuss potential migration processes for and the potential migration routes of MEC and MC at the Kanaio LTA MRS.

6.1 FATE AND TRANSPORT PROCESSES FOR MUNITIONS AND EXPLOSIVES OF CONCERN

6.1.1 The primary natural process that can result in the migration or exposure of MEC at the MRS is erosion. Natural erosion over time of soil by the wind or by water (precipitation runoff) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the sizes of munitions present, this process can also result in the movement of MEC from its original position to another location (typically somewhere downgradient of the wash).

6.1.2 The Kanaio LTA MRS is characterized by additional, fairly unique conditions that may affect fate and transport of any residual munitions present. The majority of the MRS is void of a soil profile and characterized by a'a lava in various stages of erosion. The potential for an MEC item to reside below the maximum detected MD depth of 34 cm bgs may exist due to historical impact (and non-detonation) within a lava tube, void space, or crevasse. In general, UXO present as a result of these conditions would not be available for exposure to current or future receptors based on typical site activities. Construction activities that may be undertaken associated with potential development of the Forestry and Wildlife Management Area would require UXO construction support. Otherwise, any MEC find in general would follow the procedures of notification of the local Sheriff's Department who would engage local EOD or bomb squad for emergency support as warranted.

6.2 FATE AND TRANSPORT FOR MUNITIONS CONSTITUENTS

6.2.1 Contaminant release and migration is evaluated for potential MC contamination, if present, because of the risk posed to receptors from exposure to contaminated media and the migration of chemicals through environmental media. At the Kanaio LTA MRS, no MC contamination has been identified due to the absence of sampleable soil. However, the presence of MEC may result in a release of MC to a site, and migration of MC may occur because of releases by normal detonation, low-order detonations, demolition, or where deterioration of the MEC item exposes MC to climate. MC may include the filler, secondary explosives, propellants of the munitions, or components of the munition's cases.

6.2.2 If a release of MC is documented, the fate and transport of MC contaminants present in or released to the environment must be evaluated to support the overall evaluation of human health and/or ecological risks. As described in **Section 5.2.1**, no MC were identified since no sampleable soil was present at the locations that met the sampling criteria specified in the approved UFP-QAPP. For this reason, the fate and transport of MC was not evaluated for the Kanaio LTA MRS.

7.0 Baseline Risk Assessment

7.1 INTRODUCTION

7.1.1 The purpose of a baseline risk assessment is to evaluate the potential current and future adverse health effects resulting from hazards or hazardous substances present at an MRS. The risk assessment evaluates the magnitude of the potential baseline hazard/risk at the MRS and identifies the sources of the greatest risk. The baseline risk assessment does not take into account actions to control or mitigate releases. Results of the risk assessments are used to justify no further action or to aid in the development, evaluation, and selection of appropriate response alternatives.

7.1.2 Risk assessments are MRS-specific evaluations, which consider current and future land use and activities, and may vary in detail and extent to which qualitative and quantitative inputs are used. Generally, the risk assessment process follows a phased approach, starting with generic assumptions, moving toward a more complex MRS-specific evaluation as necessary. The complexity of the risk assessment depends on the particular circumstances of the MRS.

7.2 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT

7.2.1 An MEC Risk Management Methodology (RMM) hazard assessment was conducted to evaluate potential explosive risk from MEC at the Kanaio LTA MRS. The assessment was conducted using risk matrices and methods from the *Final Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites* (USACE, 2016) in accordance with the memorandum titled "*Trial Period Extension for Risk Management Methodology (RMM) at Formerly Used Defense Sites (FUDS) Military Munitions Response Projects*" (Department of the Army, 2017). The RMM was established as interim guidance by USACE on January 3, 2017, and was approved most recently for continued trial use in 2020 (Department of the Army, 2020), and is currently the Army's recommended method for evaluating MEC hazards. The methodology and matrices are used to determine if unacceptable risk exists for MEC. The methodology also supports the development of RAOs to identify and evaluate remedial action alternatives in the FS.

7.2.2 The hazard assessment for MEC is based on the likelihood of a receptor encountering MEC, the likelihood of an unintentional detonation for a given encounter, and the severity of an unintentional detonation. The RMM uses four matrices to determine the baseline MEC risk. The existing (i.e., baseline) conditions at the Kanaio LTA MRS using the risk matrices are presented in **Appendix G** and discussed below.

Matrix 1: The Likelihood of Encounter. This matrix relates the site characterization data for amount of MEC potentially present (data from RI, previous investigations, and historical reports) to site use (based on the CSM), to determine the likelihood of encountering MEC. To facilitate discussion of Matrix 1 in the text, corresponding categories were assigned to each row of Matrix 1:

Category I:

- MEC is visible on the surface and detected in the subsurface.

Category II:

- The area is identified as a HUA where MEC is known or suspected (e.g., MD indicative of MEC is identified) to be present in surface and subsurface.

Category III:

- MEC presence based on physical evidence (e.g., MD indicative of MEC), although the area is not an HUA.
- The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 1.0/acre at 95% confidence).

Category IV:

- MEC presence is based on isolated historical discoveries (e.g., EOD report), or
- A DERP response action has been conducted to physically remove surface MEC.
- The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 0.5/acre at 95% confidence).

Category V:

- MEC presence is suspected based on historical evidence of munitions use only.
- A DERP response action has been conducted to physically remove surface and subsurface MEC (unlimited use/unrestricted exposure [UU/UE] not achieved).
- The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 0.25/acre at 95% confidence).

Category VI:

- Investigation of the MRS did not identify evidence of MEC presence.
- A DERP response action has been conducted that will achieve UU/UE.

Matrix 2: The Severity of an Incident. This matrix assesses the outcome of Matrix 1 as related to the severity of an unintentional detonation.

Matrix 3: The Likelihood of Detonation. This matrix relates the sensitivity of the MEC to the likelihood for energy to be imparted on an item during an encounter by specific land users, as defined by the CSM.

Matrix 4: Acceptable and Unacceptable Site Conditions. Matrix 4 combines the results of the previous matrices to differentiate between “acceptable” and “unacceptable” site conditions.

7.2.1.3 Multiple conditions exist within the MRS, such that unique baseline risks can be established for multiple hazard scenarios that are present within the MRS. Therefore, the RMM was applied to the identified LUA, HUA, and King’s Trail within the MRS. The HUA and LUA were evaluated separately due to differing MEC distribution between the areas. The King’s Trail was also evaluated separately because of different land use and accessibility assumptions associated with the King’s Trail. Thus, a separate set of RMM Matrices were created for each area. No NEU areas were delineated based on the results of this RI. Based on the RI data, the potential exists for receptors to be exposed to unacceptable explosive hazards at the HUA, LUA, and King’s Trail of the Kanaio MRS. The baseline risk assessment for the LUA, HUA, and King’s Trail of the Kanaio LTA MRS is presented in **Appendix G**.

7.2.1.4 In accordance with the risk methodology, where unacceptable risks are present, further munitions response is recommended; where an acceptable risk is present, no further munitions response related action is recommended. This risk assessment determination for the RI along with stakeholder inputs will be used for development of remedial alternatives in a FS. The Risk Management Methodology evaluations in **Appendix G** provide the baseline for the assessment of response alternatives for the MEC contaminated portions of the MRS in an FS. At the request of project stakeholders, the superseded Munitions and Explosives of Concern Hazard Assessment (MECHA) was also completed and is included in **Appendix G**.

7.3 MUNITIONS CONSTITUENT RISK ASSESSMENT

Based on the results of the RI described in **Subchapter 5.2**, by default no COPCs or COPECs were identified within the Kanaio LTA MRS due to the lack of sampleable soil in the impact areas in locations identified for sampling in accordance with the UFP-QAPP. Combined with the results of the limited soil sampling conducted during the SI and the absence of soil precluding MC sampling during this RI, no MC contamination was identified and the soil exposure pathway is considered incomplete. Therefore, no risk assessment for MC was conducted.

8.0 Summary of Remedial Investigation Results

8.1 REMEDIAL INVESTIGATION RESULTS SUMMARY

The purpose of this RI is to define the horizontal and vertical extent of MEC and MC contamination to support the identification of unacceptable risks within the Kanaio LTA. **Sections 8.1.1** and **8.1.2** below summarize the nature and extent of MEC and MC at the Kanaio LTA MRS. As previously noted, no MC contamination was identified; therefore, no risk assessment for MC was conducted.

8.1.1 MUNITIONS AND EXPLOSIVES OF CONCERN

8.1.1.1 NATURE AND EXTENT OF CONTAMINATION

8.1.1.1.1 Dynamic AGC and analog surveys followed by intrusive investigation of anomalies were completed utilizing transects and then focused grids placed throughout accessible portions of the site. Transect data were collected and used to identify geophysical anomalies and document the horizontal distribution of anomalies. The VSP modeled anomaly density results were then used to differentiate between HD and LD areas within the MRS. The HD and LD areas were further categorized based on geophysical and intrusive grid data for the purpose of identifying geophysical anomalies and documenting their horizontal distribution. The combined anomaly density information and intrusive results was then used to differentiate between HUAs, LUAs and NEU areas within the MRS.

8.1.1.1.2 One MEC item was discovered at the Kanaio LTA MRS during the RI (81-mm HE mortar in Grid 12). Historical munitions confirmed to be used via MD and MEC discovery on site include grenades (40-mm), rockets (2.5-inch, LAW), mortars (81-mm and 4.2-inch), and projectiles (90-mm, 105-mm, and 155-mm) of various configurations. The RI successfully confirmed the presence and location of a single 36-acre HUA at the MRS; however, unacceptable explosives risks remain in the 1947-acre LUA based on historical distribution of munitions finds within the Kanaio LTA MRS. No NEU areas were identified during the RI.

8.1.1.2 RISK ASSESSMENT

MEC Risk Management Methodology was applied to the MRS. Based on the presence of surface (historical) MEC, the current land use and accessibility of the project site, there is an unacceptable risk for human receptors to be exposed to explosive hazards within the Kanaio LTA MRS.

8.1.2 MUNITIONS CONSTITUENTS

8.1.2.1 NATURE AND EXTENT OF CONTAMINATION

As described in **Subchapter 3.3**, previous investigations determined that throughout most of the Kanaio LTA MRS insufficient soil was present to collect MC samples. Where soil was present (generally outside the RI/FS project area), a total of eight individual locations were sampled for selected metals (lead, antimony, copper, and zinc) and explosives. Although a formal risk assessment was not conducted as part of the SI, the SI Report concluded "Based on the analytical results, MC does not pose a risk to human health or the environment." (Na Ali`i, 2018). Based on the SI conclusions and known absence of soil within the impact area (the subject of this RI), MC sampling during this RI was limited to areas where low-order detonation munitions were located, suspected contamination sources (e.g., a cache of DMM), and conducting BIP activities; if sufficient soil was present to collect a sample. During the RI, a single BIP (intact 81-mm HE mortar from Grid 12) was conducted and a stockpile of US Rocket Practice M29 Series rockets (MD) was found; however, in both cases no sampleable soil was present.

8.1.2.2 RISK ASSESSMENT

The absence of soil precluded MC sampling during this RI. Combined with the results of the limited soil sampling conducted during the SI and absence of surface soil to provide a complete exposure pathway throughout most of the site, no MC contamination was identified within the project area. Therefore, no risk assessment for MC was conducted.

8.2 CONCLUSIONS

This section provides the RI conclusions and recommendations for MEC and MC. The results of this RI and the assessment of MEC hazards indicate that the MEC contamination identified at the Kanaio LTA MRS poses an unacceptable risk from explosive hazards to current and future receptors. Based on the SI findings and lack of soil present in potential sampling areas identified during the RI, no MC contamination was identified and the soil exposure pathway is considered incomplete. Therefore, no risk assessment for MC was conducted.

8.2.1 RECOMMENDATIONS FOR FS

8.2.1.1 The presence of MEC hazards negates the potential acceptability of the "no-action" response. It is recommended that a risk management decision to address unacceptable explosive risks from MEC be carried forward to the FS phase to develop and evaluate appropriate remedial alternatives for presentation to decision-makers and to support remedy selection for explosive hazards. Alternatives will be developed that protect human health by eliminating, reducing, and/or managing explosive risks posed through each exposure pathway.

8.2.1.2 The collected MEC data and associated characterization described in this RI report are considered sufficient to fully characterize the Kanaio LTA MRS, to identify and evaluate any associated potential MEC hazards, and to fully support the recommended FS. The next step after an FS would be to prepare a PP to convey this finding to the public, followed by a DD to formally document the remediation plan at the MRS.

9.0 Identification and Screening of Remedial Technologies

This chapter identifies the remedial technologies available to address the MEC risk at the Kanaio LTA MRS and screens these technologies to establish which are technically implementable at the site. The process used for developing and screening technologies includes establishing a Remedial Action Objective (RAO) and developing general response objectives that describe areas or volumes of media to which response actions may be applied and that can be used for screening the technologies. Once these steps are completed, potential contamination treatment and removal technologies are identified and assessed for technical implementability. The identification of treatment and removal technologies includes consideration of the types of response actions selected for other sites with similar contamination. The following sections describe the RAO for the Kanaio LTA MRS, outline the general response actions to be considered, and summarize the available remedial technologies for MEC.

9.1 REMEDIAL ACTION OBJECTIVES

9.1.1 INTRODUCTION

9.1.1.1 RAOs are developed to address the goals of reducing risk to ensure protection of human health, safety, and the environment (U.S Environmental Protection Agency [USEPA], 1988). RAOs are intended to be as specific as possible without limiting the range of alternatives that can be developed or to prescribe a particular alternative. They are identified for the hazardous substances in each specific medium to which receptors can become exposed (e.g., MEC in soil or lead in groundwater). Regulations often require RAOs achieve certain mandated criteria (e.g., drinking water maximum contaminant levels). They specify contaminant(s) and media of concern; exposure route(s) and receptor(s); and remediation goal(s) for each exposure route. Regulations often require that RAOs achieve certain mandated criteria. RAOs specify:

Explosive safety hazards and chemicals of concern;

ARARs;

Exposure pathways;

Receptors and potential receptors; and

Preliminary remediation goals (PRGs) for each exposure pathway that was identified during the RI.

9.1.1.2 The typical method for developing RAOs at hazardous waste sites involves considering the nature and extent of contamination, current and future receptors, the exposure pathways, and current and future land use. Based on this information, the appropriate cleanup levels can be established. Site-specific RAOs can be found in **Table 9.2**.

9.1.2 EXPLOSIVE SAFETY HAZARDS AND CONTAMINANTS OF CONCERN

9.1.2.1 EXPLOSIVE SAFETY HAZARDS

The results of the RI, previous field investigations, and the known prior munitions use were used to evaluate the explosive safety hazards at the Kanaio LTA MRS. The results of the RMM assessment for the Kanaio LTA MRS indicate the overall risk from explosive hazards is unacceptable for the entire MRS under current and future conditions.

9.1.2.2 CHEMICALS OF CONCERN

No human health chemicals of concern (HHCOCs) or chemicals of ecological concern (COECs) have been identified and there are no complete exposure pathways for human or environmental receptors. Therefore, MC was not considered for risk mitigation.

9.1.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND "TO BE CONSIDERED" INFORMATION

9.1.3.1 Under Section 121 (d)(2)(A) of CERCLA, remedial actions must meet a level and standard of control that attain standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate" under the circumstances of the release. These requirements are derived from federal and state laws and are known as ARARs. Federal, state, or local permits are not necessary for removal or remedial actions implemented under a CERCLA remedial action, but ARARs must be met.

9.1.3.2 In addition to legally binding laws and regulations, many federal and state environmental public health programs also develop criteria, advisories, guidance, and proposed standards that are not legally binding, but which may provide useful information or recommended procedures. These TBC requirements are not promulgated, and thus, are not potential ARARs. State requirements identified in a timely manner that are more stringent than corresponding federal requirements may be applicable or relevant and appropriate. The USEPA classifies ARARs as chemical-, action-, and location-specific to provide guidance for identifying and complying with ARARs (USEPA, 1988). All ARARs must meet the following criteria:

Are limited to promulgated requirements,

Are environmental or facility siting laws,

Are substantive requirements, and

Pertain to the circumstances at the MRS.

9.1.3.3 ARARs are grouped into the following three categories:

Chemical-Specific ARARs: These are usually health- or risk-based numerical values or methodologies. Applying these numerical values establishes the acceptable amount or concentration of a chemical that may exist in a medium or that may be discharged to the environment.

Action-Specific ARARs: These are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous waste.

Location-Specific ARARs: These include restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they occur in special locations.

9.1.3.4 Identification of potential ARARs was conducted as part of this RI/FS as presented in **Section 2.8** and **Table 2.3**. The ARARs were selected as applicable or relevant and appropriate to the MRS (as CERCLA applies to the MMRP) and will be evaluated for the proposed alternatives.

9.1.4 RECEPTORS AND POTENTIAL RECEPTORS

Human receptors are categorized by their ability to access a site combined with activities that potentially allow for contact (i.e., interaction) with MEC. Receptors at the Kanaio LTA MRS include recreational users and site workers. Ecological receptors are not likely, except in the rarest of circumstances, to act on MEC in a manner forcible enough to initiate an unintentional detonation. For this reason, MEC does not pose an appreciable threat to soil, biota, plants, or animals. Therefore, ecological receptors are not considered further in the development of the MEC-related RAOs.

9.1.5 EXPOSURE PATHWAYS

Based on the presence of MEC and the general level of site accessibility, the existence of complete MEC exposure pathways in soil is confirmed at the Kanaio LTA MRS. A summary of the exposure pathway for receptors present is presented in **Table 9.1**.

Table 9.1 Summary of Exposure Pathways

Medium	Hazard	Receptors	Exposure Pathways
a'a lava	MEC on surface and in subsurface	Current recreational users (King's Trail hikers) and periodic site workers (DLNR). Potential future receptors include hunters, DLNR Forestry and Wildlife Management Area personnel, and construction workers (fences)	*Surface*: Presence at site; direct contact

9.1.6 PRELIMINARY REMEDIATION GOALS

9.1.6.1 PRGs are both site- and contaminant-specific and define the conditions considered by stakeholders to be protective of human health and the environment. PRGs provide a design target for the analysis of and selection of remedial alternatives. For this reason, PRGs are screening tools rather than the final remediation target or cleanup level and they are designed to be conservative. As with the CSMs, PRGs may be reevaluated and refined throughout the RI/FS process as new information becomes available. The preliminary goal of the RI/FS for the Kanaio LTA MRS was to determine the nature and extent of munitions contamination; and the ultimate goal for the Kanaio LTA MRS is to manage any risk from MEC that may be present.

9.1.6.2 Consequently, the preliminary remediation goal for MEC is based on limiting interaction between any residual MEC and any receptors accessing the site. Based on the project goals, the PRG for MEC is defined as "no unacceptable risks resulting from human exposure to MEC." This PRG will require remedial alternatives to minimize unintentional human exposure to surface or subsurface MEC and will be evaluated using the RMM, as described in the study paper titled, "*Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for MRSs*" (USACE, 2016).

9.1.7 REMEDIAL ACTION OBJECTIVE

9.1.7.1 The RAO addresses the goals for reducing the MEC hazards to ensure protection of human health, safety, and the environment. Based on the known current conditions and the explosive safety hazards described in **Chapter 2**, a site-specific RAO was developed to address MEC (**Table 9.2**). This RAO is based on the format recommended in the study paper titled, "*Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for MRSs*" (USACE, 2016).

9.1.7.2 There is no MC contamination present within the MRS based on the SI finding and absence of sampleable soil in areas identified for potential sampling during this RI. Based on the results of the RI, the RAO developed for the MRS is as follows:

9.1.7.3 To reduce the MEC risk due to presence of LAW rockets, 3.5-inch rockets, 40-mm HE grenades, 105-mm projectiles, 106-mm HEAT projectiles, 4.2-inch mortars, 81-mm WP mortars, and 81-mm HE mortars within the Kanaio LTA MRS on the surface and in the subsurface to the depth of contamination (confirmed depth up to 34 cm bgs) to address likelihood of exposure to trespassers and recreational users (hikers) via direct contact, through a source removal, an implementation of land use controls, access restrictions, or a combination thereof, such that an acceptable condition (as defined by RMM Matrix 4) is achieved.

9.1.7.4 This RAO was used to evaluate the effectiveness of the remedial alternatives (**Chapters 10 and 11**). All remedial alternatives developed must achieve the selected RAO when implemented.

Table 9.2 Remedial Action Objectives

Medium	Soil, a'a lava
Contaminant	MEC (UXO): Surface to depth based on RI intrusive data to be primarily less than 17 cm (6.7 inches) bgs in Kanaio LTA MRS. Historically MEC was identified at or immediately below the surface. 99.7% of MD and MEC was recovered from 17 cm or less bgs. The maximum depth of MD was 34 cm (~13.4 inches) bgs.
Receptors	Site workers, trespassers, and recreational users (hikers/hunters).
Exposure Pathways	Presence at site; direct contact (e.g., recreational users).
RAO	To reduce the risk due to presence of LAW rockets, 3.5-inch rockets, 40-mm HE grenades, 105-mm rounds, 106-mm HEAT rounds, 4.2-inch mortars, 81-mm WP mortars, and 81-mm HE mortars within the Kanaio LTA MRS on the surface and in the subsurface to the depth of contamination (depths up to 34 cm bgs confirmed in RI) to address likelihood of exposure to site workers, trespassers, and recreational users (hikers/hunters) via direct contact, through a source removal, an implementation of land use controls, access restrictions, or a combination thereof, such that an acceptable condition (as defined by RMM Matrix 4) is achieved.

9.2 GENERAL RESPONSE ACTIONS

This section summarizes the General Response Actions (GRAs) that are relevant for munitions actions under the Technical Guidance for Military Munitions Response Actions, EM 200-1-15 (USACE, 2018). GRAs are those actions that will achieve the RAO and may include remedial actions for detection and removal/recovery of MEC and remedial actions for disposal (demolition) of MEC, land use restrictions such as LUCs, or combinations of these actions. Under CERCLA, evaluation of a "No Action" alternative is also required to provide a baseline for the other remedial technologies and alternatives. No action refers to a remedy where no active remediation or enforceable land use restrictions such as LUCs are implemented. The DERP manual (DoD, 2012) requires the DoD component to include at least three alternatives including No Action, an action to remediate to UU/UE, and an action to remediate to a protective condition that requires land use restrictions (i.e., LUCs or exposure controls). The following GRAs have been identified and are considered for the MRS:

LUCs – LUCs are designed to prevent or limit exposure of receptors to explosive hazards from military munitions. LUCs can include physical, legal, educational, and administrative mechanisms used to mitigate the explosive hazards associated with the MEC present on the site. Physical measures (engineering controls such as fencing, barriers, or gates) were not considered due to the large site footprint and future planned use as a wildlife management area. Institutional controls (ICs) (permits or restrictions on excavation) and educational controls (warning signs, pamphlets), were accepted and retained for further consideration.

MEC Detection/MEC Removal – The GRA to accomplish physical removal of MEC requires various detection technologies to locate explosively hazardous items (e.g., MEC) in the environment. Detection is generally used in conjunction with removal and demolition to meet the RAO but can also be used to identify areas for LUCs. MEC detection technologies include surface detection, subsurface analog survey, and subsurface digital survey. Detection process options examined include instrument–aided surface sweep (for surface detection), analog magnetometers and electromagnetic detectors (for subsurface analog surveys), and digital magnetometers and electromagnetic instruments, and AGC sensors (for subsurface digital surveys). The GRA of MEC treatment and removal was focused only on in-situ excavation that requires manual excavation by UXO technicians.

MEC Treatment and Disposal – The GRA for MEC treatment and disposal that was considered was only on-site treatment. Process options that were evaluated were blow -in-place or consolidated detonation for destroying MEC found in place using donor explosives or moving MEC to a central disposal area and detonating with donor explosives, respectively. MD that is generated is then certified as material documented as safe (MDAS) and disposed offsite.

9.3 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

9.3.1 BACKGROUND

9.3.1.1 Pursuant to the Technical Guidance on for Military Munitions Response Actions (USACE, 2018), planning for a munitions removal action requires that a strategy be developed to efficiently and effectively meet project needs. This FS defines the goals of the strategy and RAO of the action as well as the means (i.e., processes and technologies) to accomplish the RAO. An initial list of remedial technologies was developed based on Version 4.0 of the Remediation Technologies Screening Matrix and Reference Guide produced by the Federal Remediation Technologies Roundtable (FRTR) (FRTR, 2007). The FRTR is a consortium of government agencies that have worked to build a more collaborative atmosphere among federal agencies involved in hazardous waste site remediation.

9.3.1.2 This section identifies the potentially applicable technologies for MEC in soil at the Kaniao LTA MRS. Overviews of the various technologies can be found in **Section 9.3.2**. The remedial technologies were screened to eliminate those technologies that cannot be technically implemented at the site. Landowners may also permit or prohibit the use of the proposed remedial technologies on their property. This technology screening is distinct from the alternative screening that may be conducted later in this report once alternatives have been developed. The results of the screening evaluations are described in **Section 9.3.3** and summarized in **Table 9.3**.

9.3.2 POTENTIALLY APPLICABLE TECHNOLOGIES

9.3.2.1 LAND USE CONTROLS

9.3.2.1.1 The three types of LUCs defined by DERP include physical, legal, and administrative controls. The DERP Manual (DoD, 2012) gives the following descriptions of the LUCs types:

> Physical mechanisms encompass a variety of engineered remedies to contain or reduce contamination and physical barriers to limit access to property;
>
> Legal mechanisms include restrictive covenants, negative easements, equitable servitudes, and deed notices; and
>
> Administrative mechanisms include notices, adopted local land use plans and ordinances, construction permitting, or other land use management systems to ensure compliance with the use restrictions.

9.3.2.1.2 LUCs can be implemented either alone or in conjunction with other remedial actions. The administrative feasibility of implementing LUCs depends on site-specific circumstances, including whether a site is under the direct operational control of the DoD or was transferred to non-federal ownership, as well as on the ability, willingness, and commitment of local authorities to implement institutional controls. Inspections and monitoring are typically required to document the long-term effectiveness of institutional controls.

9.3.2.1.3 Physical mechanisms can prevent or limit uncontrolled access to the contaminated area. In the case of MEC, such restrictions prevent access to both surface and subsurface hazards by potential receptors. Physical mechanisms include the installation of fencing or some type of physical barrier over the surface of the affected area to reduce or eliminate the potential for receptor interaction with subsurface MEC. Fencing can be used in conjunction with administrative methods, such as signs, to enhance the awareness of site receptors regarding the potential hazards.

9.3.2.1.4 Legal mechanisms can limit contact with MEC by preventing or otherwise controlling the way receptors might be exposed. Use restrictions and regulatory controls dictate the type of development that will occur on a site and the methods in which that development occurs. For example, using a deed notice or restrictive covenant to designate the land use in an area as commercial/industrial only would prevent future residential or recreational land uses at the site. Other common activity restrictions for a contaminated area include total prohibitions on intrusive activities or implementing a “no parking” restriction.

9.3.2.1.5 Administrative mechanisms involve increasing potential receptors’ awareness of the hazards at a site. Available processes include installing signage and distributing educational materials. Placing signs around a contaminated area can help to warn potential receptors of the associated hazards so they can choose to avoid them entirely by not entering the affected area or make them less likely to interact with potential hazards (e.g., suspicious items that might be MEC) if they do enter the area. Signs can also be used in conjunction with physical mechanisms, such as fencing. Similar to signs, educational materials warn potential receptors of the associated hazards so they can choose to avoid them entirely by not entering the affected area or make them less likely to interact with potential hazards.

9.3.2.2 MEC DETECTION TECHNOLOGIES

9.3.2.2.1 A number of effective technologies exist for detection of MEC, with some supported by subsets of systems for transport, positioning and navigation, and data processing and analysis. Detection and location technologies for MEC primarily depend on the ability of geophysical instruments to distinguish the physical characteristics of MEC from those of the surrounding environment. Information on the capabilities of existing technologies have been balanced against site-specific conditions throughout the MRS to screen out approaches that are not suitable. This section evaluates geophysical and positioning technologies for MEC detection using summary information for each method from the USACE Technical Guidance for Military Munitions Response Actions, Engineering Manual 200-1-15 (USACE, 2018).

9.3.2.2.2 Detection of MEC on the surface or in the subsurface can be accomplished using analog methods, digital methods, or AGC methods. However, according to the DoD-USEPA Joint UXO Management Principles, ‘To the maximum extent practicable, the permanent record shall include sensor data that is digitally-recorded and geo-referenced”. Digital methods refer to DGM in which detector signals are digitally recorded with geo-referencing information to create a permanent record of the survey. AGC also provides digitally-recorded, geo-referenced data, while also allowing for the discrimination of TOI from non-TOI prior to intrusive investigation. In the munitions response industry, analog methods refer to the use of handheld detector technologies operated by UXO technicians to identify anomalies (detect and count, detect and dig). Analog results are not digitally recorded and are generally not geo-referenced except for grid boundaries and MEC items recovered. However, if needed, analog detection can be run in tandem with hand-held GPS technology to geo-reference the path of the operator and anomaly locations as they are discovered. This method is more labor and time intensive than traditional analog and is not as accurate as DGM or AGC methods but can be utilized in areas where geo-referenced anomaly data is necessary but are inaccessible to DGM or AGC equipment. Anomalies are still detected and then retrieved real time, but by combining with the hand-held GPS a spatial representation of anomaly density and placement can still be placed on a site map.

9.3.2.2.3 For AGC surveys, geophysicists use advanced electromagnetic induction sensors (such as MM2x2, MPV, APEX, and UltraTEM) to collect data which geophysicists can use to estimate the depth, size, wall thickness, and shape of each buried item. AGC is the process of using these data to make a more informed decision as to whether a buried metal item is a potentially hazardous munition or is metal clutter that can be left in the ground. AGC is used to focus a munitions response on excavating only those geophysical anomalies identified as potential munitions, resulting in a more efficient, more rigorous, better understood, and better documented munitions response *(Interstate Technology & Regulatory Council, Geophysical Classification for Munitions Response Technical Fact Sheet* [ITRC, October 2014]). AGC can be performed in one of three ways: 1) using the AGC equipment for mapping (dynamic mode) and for performing informed source selection to select anomalies, 2) using DGM or dynamic AGC for mapping and using cued AGC to determine if the anomalies are munitions (cued mode), 3) single pass mode where a dynamic AGC survey is collected with sufficient resolution to provide full anomaly classification to determine if the anomalies are munitions.

9.3.2.2.4 When MEC is located on the ground surface analog methods are appropriate, such as a detector-aided visual search by UXO technicians. When MEC is present in the subsurface DGM or AGC are usually the most appropriate; however, analog methods may be necessary under certain conditions. The decision to use analog, DGM, AGC, or a combination of one or more is based on the project requirements, depth, and size of the suspected MEC, and the environmental characteristics present within the project area (i.e., topography, vegetation, and man-made features).

9.3.2.2.5 With regard to environmental characteristics, detector and positioning technologies and the specific equipment used have inherent advantages and disadvantages based on their design and operational characteristics. Detector technologies commonly used for terrestrial applications in the munitions response industry include magnetometry and electromagnetic induction. Common positioning technologies/methods include GPS, relative coordinates (wheel counter mode /odometer, line and fiducial), and laser-based technologies such as

RTS and simultaneous localization and mapping. Positioning technologies are impacted primarily by obstacles (trees, structures), canopy (tree cover), and topography.

9.3.2.3 MEC REMOVAL TECHNOLOGIES

9.3.2.3.1 MEC removal is typically conducted using excavation to the depth of anomaly detection (i.e., the removal team continues digging until the anomaly source is located and removed) or excavation to a fixed removal depth. During excavation to a fixed depth, the removal team will stop digging at that depth whether or not the anomaly is resolved. This approach is typically used when the maximum potential intrusive depth for site receptors is established so removal will not need to proceed deeper than the fixed depth, or where the maximum potential depth of MEC was established.

9.3.2.3.2 Excavation technologies include manual and mechanical methods (e.g., mini-excavators, backhoes). Manual excavation is considered the industry standard for MEC recovery and can safely achieve good results. Mechanical excavation methods can be used if site conditions or the anticipated depth of MEC might make manual excavation challenging and if the site is reasonably accessible with heavy equipment. Using mechanical excavators to remove MEC would necessitate the use of "up-armored" excavators to protect the operator in the event of an unintentional detonation and might require remote control equipment if large MEC items were present. Mechanical excavation methods can also be used in conjunction with mechanical sifting equipment to process quantities of soil containing large amounts of MEC or metal debris. Excavation and sifting are typically costly and results in large disturbances to the affected land and can only be performed at sites that are reasonably accessible with heavy equipment.

9.3.2.4 MEC DISPOSAL TECHNOLOGIES

The disposal of MEC items recovered during removal operations includes the process option of using (BIP) procedures, or if the MEC items are deemed acceptable-to-move, performing consolidated demolition shots at the end of a project or on an as-needed basis.

9.3.3 TECHNOLOGY EVALUATION

9.3.3.1 LAND USE CONTROLS

Given the lack of use of the Kanaio LTA MRS, the large physical area it takes up, and the roughness of terrain, physical mechanisms such as physical barriers (i.e., fences, paved or gravel ground cover) would not likely be implementable since it would be difficult and dangerous to implement and maintain. Legal use restrictions such as the requirement for UXO construction support for any intrusive work on site are retained for consideration. Administrative mechanisms (i.e., warning signs and educational materials) are also retained for consideration.

9.3.3.2 MEC DETECTION TECHNOLOGIES

Four detection technologies were evaluated: analog geophysical surveys, DGM surveys, dynamic AGC surveys, and DGM surveys with cued AGC. Only two are retained for consideration: analog geophysical surveys and Dynamic AGC surveys. Both of these technologies are implementable, having been used directly at the Kanaio MRS. Due to the unique site composition and unusually rough terrain, the majority of the Kanaio LTA MRS is likely to require the use of analog instruments as the primary detection sensor. However, since digitally-recorded and geo-referenced geophysical data are preferred by DoD and USEPA, Dynamic AGC surveys would be implemented wherever AGC was physically practical. The detection technology of dynamic AGC with limited cued AGC was evaluated but not retained for consideration. The extremely rugged terrain at the site prevents dynamic AGC from being implemented over the lava covered parts of the Kanaio LTA MRS. Cued AGC is also limited by rugged terrain. Roughly half of the dynamic AGC target list were incorrectly classified as TOI after cued AGC demonstrating limited classification capabilities for cued AGC at Kanaio LTA when utilized during the RI..

9.3.3.3 MEC REMOVAL TECHNOLOGIES

Manual excavation, mechanical excavation, and mechanical excavation and sifting technologies were all evaluated in the screening process, all three methods are well-established but only manual excavation would be implementable at the site due to the site characteristics as the majority of the MRS is composed of a'a lava. The extremely rough terrain covered by loose rock and rubble makes it impossible to traverse with heavy equipment, and the lack of soil makes sifting impossible. For these reasons, only manual excavation removal methods were retained for consideration.

9.3.3.4 MEC DISPOSAL TECHNOLOGIES

The disposal of MEC items recovered during removal operations was also evaluated. This includes the process option of using (BIP) procedures, or if the MEC items are deemed acceptable-to-move, performing consolidated demolition shots at the end of a project or on an as-needed basis. These methods were both found to be implementable, and therefore retained for consideration

9.3.3.5 CONCLUSION

Screening level evaluation of remedial technologies were evaluated for implementability in **Table 9.3**. Relative cost information for technology screening represents the approximate technology cost only (implementation and operation), not the overall remedial cost to achieve a cleanup objective. All identified technologies retained for consideration are deemed physically and administratively implementable, and practical. The development and screening of alternatives is presented and evaluated in **Chapter 10**.

Table 9.3 Technology Screening and Evaluation

General Response Action	Remedial Technology	Process Options	Advantages	Disadvantages	Screening Evaluation	
					Implementable?	Retained for Consideration?
Land Use Controls	Physical Mechanisms	Security Fence – prevents or limits uncontrolled access to the contaminated area.	Prevents access to both surface and subsurface hazards Proven and routinely used for small sites	Terrain may make installation difficult Would require maintenance Precludes current use May restrict wildlife movement Inaesthetic	NO Landowner acceptance of fence installation and associated access restrictions highly unlikely as this would preclude potential future land use. Size of site would require extensive fencing to install and maintain.	NO – screened out *Not readily implementable*
		Paved or Gravel Cover – installation of a physical barrier over the surface of the affected area using materials such as concrete, paving, or gravel.	Prevents access to both surface and subsurface hazards	Dangerous to implement on lava field Impractical for larger areas Very invasive and greatly change the environmental quality of the site, affects site drainage	NO Landowner acceptance of cover installation highly unlikely as this is very invasive and impractical for an area of this size.	NO – screened out *Not readily implementable*
		Earth Cover – installation of a physical barrier over the surface of the affected area using an earth material.	Prevents access to both surface and subsurface hazards	Dangerous to implement on lava field Impractical for larger areas	NO Landowner acceptance of cover installation highly unlikely as this is very invasive and impractical for an area of this size.	NO – screened out *Not readily implementable*
	Legal Mechanisms	Prohibit Specific Land Uses/Deed Notice – restrictions and regulatory controls dictating the type of development that will occur on a site and the methods in which that development occurs.	Proven and routinely used Limits or prevents contact with MEC	Can at times be difficult to enforce Landowner must be willing If U.S. Government does not own the property, the federal government would not be entity imposing/enforcing any deed/environmental covenant restrictions.	YES Readily implementable	YES
	Administrative Mechanisms	Organizational Permits – recommends that HI DLNR (the landowner) requires UXO support for any intrusive work done on site.	Ensures intrusively done at the site is done safely.	Only reaches those requesting to perform work at the site.	YES Readily implementable	YES
		Warning Signs – used to delineate the hazardous area clearly and act as a visual reminder. Placed along the perimeter of the MRS with extra signs placed at access points.	Proven and routinely used Increases awareness of MEC hazards and provides info on what to do if munitions are found	Only reaches those receiving and reading the materials – landowners, visitors at trailheads, etc.	YES Readily implementable	YES
		Educational Materials – production and distribution of educational materials to inform receptors about the nature of the MEC present at the site.	Proven and routinely used Increases awareness of MEC hazards and provides info on what to do if munitions are found	Only reaches those receiving and reading the materials – landowners, visitors at trailheads, hunting permit applicants, etc.	YES Readily Implementable	YES
MEC Detection	Detection & Classification (options to precede and/or couple with MEC Removal options below)	Analog Geophysical Survey – UXO technicians operate handheld analog metal detectors over specified areas to identify potential surface and subsurface MEC.	Proven and routinely used May be used along ditches, in rough terrain, and closer to structures	Brush and understory vegetation may need clearing Effectiveness dependent on the skill and experience of the instrument operator Less effective than DGM. More MEC would remain in the ground. No record of anomaly locations is available for review Large number of potential digs produced	YES Readily Implementable; much of the terrain at each MRS is likely to require the use of analog instruments as the primary detection sensor, but digitally-recorded and geo-referenced geophysical data are preferred by DoD and USEPA (1).	YES

General Response Action	Remedial Technology	Process Options	Advantages	Disadvantages	Screening Evaluation	
					Implementable?	Retained for Consideration?
				Difficult to use on slopes, ditches, and rough terrain		
		DGM Survey – digital metal detectors are operated over specified areas while combined with location technology such as high-resolution GPS, Robotic Total Station, or fiducial lines on grids.	Proven and routinely used Locations of anomalies and background response are recorded Anomaly selection can be tuned to site specific munitions	Brush and understory vegetation may need clearing Less effective near ferrous geology, surface metal, or structures including utilities Difficult to use on slopes, ditches, and rough terrain and cannot be used across majority of site	NO Is physically impractical across the majority of the terrain at the Kanaio LTA, results were significantly more impacted by terrain/geology than dynamic AGC at site.	NO – screened out *Not readily implementable*
		DGM Survey/Advanced Geophysical Classification – DGM survey as above plus the use of an advanced sensor to evaluate anomalies identified in the initial (dynamic) DGM survey. Anomaly dig list is reduced by comparison of data with known responses of munitions.	Proven and routinely used Tested at Kanaio Locations of anomalies and background response are recorded Anomaly selection can be tuned to site specific targets Decreased number of digs	Brush and understory vegetation may need clearing Less effective near ferrous geology, surface metal or structures including utilities Difficult to use on slopes, ditches, and rough terrain and cannot be used across majority of site Leaves munitions debris in the ground	NO Is physically impractical across the majority of the terrain at the Kanaio LTA, cued survey provided no advantage over dynamic AGC at site.	NO – screened out *Not readily implementable*
		Dynamic AGC Survey/Cued AGC selection – AGC sensors are operated over specified areas while combined with location technology such as high-resolution GPS, Robotic Total Station, or fiducial lines on grids.	Proven and routinely used Locations of anomalies and background response are recorded Tested at Kanaio LTA Anomaly selection can be tuned to site specific targets Decreased number of digs	Brush and understory vegetation may need clearing Less effective near ferrous geology, surface metal, or structures including utilities Difficult to use on slopes, ditches, and rough terrain and cannot be used across majority of site Leaves munitions debris in the ground	NO Cannot be physically implemented across the majority of site.	NO – screened out *Not readily implementable*
MEC Removal	Surface Clearance	Surface Clearance – anomalies are removed from surface by UXO technicians while maintaining exclusion zones (EZ) to protect the public and non-essential personnel.	Proven and routinely used Good safety record Soil disturbance minimal	Requires specially trained personnel Safety risk to workers due to potential unintentional detonations EZ must be maintained, potentially required evacuations of non-essential personnel.	YES Readily Implementable; best for areas with no anticipated intrusive activities.	YES
	Excavation	Manual Excavation – anomalies are dug by UXO technicians while maintaining exclusion zones to protect the public and non-essential personnel.	Proven and routinely used Good safety record Soil disturbance limited to anomaly locations only	Requires specially trained personnel Safety risk to workers due to potential unintentional detonations EZ must be maintained, potentially requiring evacuations of non-essential personnel.	YES Readily Implementable; best for individual anomalies outside disposal features.	YES

General Response Action	Remedial Technology	Process Options	Advantages	Disadvantages	Screening Evaluation	
					Implementable?	Retained for Consideration?
		Mechanical Excavation – typically used to reach deeper anomaly sources. A small backhoe or excavator is used. Needed only if depths of clearance and MEC occurrence require it.	Proven and routinely used All MEC is removed to depth of investigation. Good safety record Requires specially trained personnel	Safety risk to workers due to potential unintentional detonations May require armoring of the excavating equipment to protect the operator EZ must be maintained, potentially requiring evacuations of non-essential personnel.	NO Terrain is too rough to traverse with heavy equipment.	NO – screened out *Not readily implementable*
		Mechanical Excavation and Sifting – excavate all soil within a designated area and process it through a sifter to removal all MEC.	Proven and routinely used All MEC is removed to depth of investigation Good safety record	Requires specially trained personnel Safety risk to workers due to potential unintentional detonations EZ must be maintained, potentially requiring evacuations of non-essential personnel. All soil must be removed to depth of investigation Greater environmental impact due to vegetation and soil removal Not likely to be accepted by landowner	NO Site composition (a'a lava fields) not conducive to sifting.	NO – screened out *Not readily implementable*
MEC Disposal	Demolition	BIP or Consolidated Shots – UXO technicians bring donor explosives to detonate the MEC, typically using engineering controls such as sandbags.	Proven and routinely used Hazard is eliminated quickly (in a few days) Good safety record Relatively inexpensive	Requires specially trained personnel Safety risk to workers due to potential unintentional detonations Blast may cause disturbance to the public EZ must be maintained, potentially requiring evacuations of non-essential personnel.	YES Readily implementable, although proximity to inhabited structures may require evacuations. Public roads may need to be shut down temporarily.	YES

(1) USEPA Munitions Response Guidelines, USEPA Office of Solid Waste and Emergency Response (OSWER), OSWER Directive 9200.1-101, Federal Facilities Restoration and Reuse Office, Interim Final, July 27, 2010.

Shading indicates whether the process option passes or fails the screening criteria as follows:

PASSES	FAILS

10.0 Development of Remedial Alternatives

This chapter describes the development of remedial alternatives for the Kanaio LTA MRS using the technology process options retained during the detailed screening process in **Chapter 9**. The remedial alternatives are developed to meet the RAOs for the MRS; therefore, alternatives have been developed by contaminant and exposure medium (i.e., for MEC in soil). Each remedial alternative comprises an individual technology or a combination of technologies. This chapter lists and briefly describes each of the developed remedial alternatives.

10.1 DEVELOPMENT OF ALTERNATIVES

10.1.1 The USEPA has established guidelines for the types of remedial alternatives that should be developed during the detailed analysis stage; they are listed in the NCP (40 CFR 300.430(a)(1)) and are summarized as follows:

- Use treatment to address the principal threats posed by a site, wherever practicable.
- Use engineering controls for low, long-term threats or where treatment is impracticable.
- Use a combination of methods, as appropriate, to achieve protection of human health and the environment.
- Use institutional controls to supplement engineering controls to prevent or limit exposure to hazardous substances, pollutants, or contaminants. The use of institutional controls shall not substitute for active response measures as the sole remedy unless such active measures are determined not to be practicable.
- Consider using innovative technologies.

10.1.2 NCP guidance further states that “the development and evaluation of alternatives shall reflect the scope and complexity of the remedial action under consideration” (40 CFR 300.430(e)). Land use is also a consideration in developing alternatives.

10.2 RATIONAL FOR ALTERNATIVE DEVELOPMENT

10.2.1 OVERVIEW

10.2.1.1 Remedial alternatives were developed based on the CSM, the RAO for the MRS (**Table 9.2**), the general response actions, and available detection, removal, and disposal technologies and process options for MEC, the remedial technologies retained after the technology evaluation (**Table 9.3**) were assembled into the following remedial action alternatives:

Alternative 1 – No Action

Alternative 2 – Public Education and Warning Signs (LUCs)

Alternative 3 – Surface MEC Removal and LUCs

Alternative 4 – Focused Surface and Subsurface MEC Removal and LUCs

Alternative 5 – Complete Surface and Subsurface MEC Removal (UU/UE)

10.2.1.2 Five-year reviews, as outlined in Section 121(c) of CERCLA, as amended by the Superfund Amendments and Reauthorization Act, and Section 300.430 (f) (ii) of the NCP, are required for sites where hazardous substances, pollutants, or contaminants remain above levels that allow UU/UE following implementation of the remedy. Five-year reviews are not considered part of a remedy. As referenced in subchapter 2.5, DLNR has indicated possible near-term development of portions of the MRS in support of a Forestry and Wildlife Management Area to include boundary fence construction, access road installation/construction, hunter kiosks, and placement of game “water units”. UXO Construction Support can be requested by HDOH/DLNR for development actions within the MRS where the risk of potential encounter with UXO remains before or following application of selected response actions. The request must be submitted with sufficient advance notification to ARNG to allow coordination and secure funding.

10.2.2 USING THE ARMY RISK MANAGEMENT METHOD TO EVALUATE ALTERNATIVES

10.2.2.1 A baseline risk assessment was conducted to evaluate potential explosive risk from MEC at the Kanaio LTA MRS. The assessment was conducted using risk matrices and methods from the *Final Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites* (USACE, 2016) in accordance with the memorandum titled "*Trial Period Extension for Risk Management Methodology (RMM) at Formerly Used Defense Sites (FUDS) Military Munitions Response Projects*" (Department of the Army, 2017). The RMM was established as interim guidance by USACE on January 3, 2017, and was approved most recently for continued trial use in 2020 (Department of the Army, 2020), and is currently the Army's recommended method for evaluating MEC hazards. The methodology and matrices are used to determine if unacceptable risk exists for MEC. The methodology also supports the development of RAOs to identify and evaluate remedial action alternatives in the Feasibility Study. The results of the RMM assessment for the Kanaio LTA MRS indicate the overall risk from explosive hazards is unacceptable for the MRS under current and future conditions (**Appendix G**).

10.2.2.2 The RMM (USACE, 2017) uses three matrices (Matrices 1 through 3) to support the risk evaluation for a range of risk scenarios. To complete the baseline assessment for explosive risk, input factors for the three matrices are reviewed and suitable categories are selected based on the baseline site conditions and assumptions for the proposed alternatives. The matrices are related to the three critical risk elements and are:

Likelihood of Encounter (Matrix 1), which is based on the input factors:

- *Amount of MEC* (i.e., how much MEC is there at the site?)
- *Access Conditions (frequency of use)* (i.e., how likely are human receptors to access the site based on access conditions and frequency of use?)

Severity of Incident (Matrix 2), which is based on the input factors:

- *Likelihood of encounter* (see first bullet above)
- *Severity Associated with Detonation of Specific Munitions* (i.e., if someone encounters MEC and it detonates, how many people might be injured and how seriously?)

Likelihood of Detonation (Matrix 3), which is based on the input factors:

- *Sensitivity/Susceptibility to Detonation* (i.e., how sensitive is the fuzing of the MEC?)
- *Likelihood to Impart Energy on an Item* (i.e., if MEC is encountered, what is the likelihood that energy will be imparted based on the known activities that take place at the site?)

10.2.2.3 A fourth matrix (Matrix 4) combines the results of the other matrices to differentiate acceptable versus unacceptable conditions regarding risk from explosive hazards:

Acceptable and Unacceptable Site Conditions (Matrix 4), which is based on the:

- Outputs of Matrix 1 – Likelihood of Encounter and Matrix 2 – Severity of Incident
- Likelihood of Detonation (i.e., output of Matrix 3)

10.2.2.4 Whether a remedial alternative achieves the established RAO is demonstrated by whether the alternative leads to an acceptable risk condition as defined by RMM Matrix 4, that is, whether the alternative changes unacceptable baseline risk conditions to acceptable risk conditions. This is achieved by assessing how each remedial alternative mitigates risk.

Risk is mitigated by remedial alternatives that reduce the "Likelihood of Encounter". This can be accomplished by reducing the "Amount of MEC" via detection and removal, or by modifying the "Access Conditions (frequency of use)" via implementation of LUCs, or by a combination of the two.

Risk is mitigated by remedial alternatives that address the "Likelihood to Impart Energy on an Item." This can be accomplished via implementation of LUCs.

10.2.2.5 The RMM and its application to this site are described in more detail in **Appendix G**.

10.2.3 RISK MANAGEMENT METHOD EVALUATION OF ALTERNATIVES

The RMM was used to determine if implementation of various remedial alternatives developed for the Kanaio LTA MRS would result in an acceptable site condition. The evaluation was conducted for both current land use and a future unrestricted use scenario for each of the following alternatives:

Alternative 1 – No Action

Alternative 2 – Public Education and Warning Signs (LUCs)

Alternative 3 – Surface MEC Removal and LUCs

Alternative 4 – Focused Surface and Subsurface MEC Removal and LUCs

Alternative 5 – Complete Surface and Subsurface MEC Removal (UU/UE)

10.2.3.1 ALTERNATIVE 1 – NO ACTION

The risks associated with **Alternative 1 – No Action**, are the baseline risks established in the RI (Section 7). Because Alternative 1 does not involve implementing any remedial actions, it would not permanently reduce or eliminate the MEC risk, and it would not change the site conditions from "Unacceptable" to "Acceptable".

10.2.3.2 ALTERNATIVE 2 – PUBLIC EDUCATION AND WARNING SIGNS (LUCS)

10.2.3.2.1 The baseline risks associated with **Alternative 2 – Land Use Controls**, are established in the RI. The implementation of public education and warning signs would serve to limit human interaction with surface and subsurface UXO at the MRS by increasing the awareness of MEC hazards. The LUCs implemented under Alternative 2 would change the RMM evaluation of the site conditions from "Unacceptable" to "Acceptable" at the Kanaio MRS. This is based on the "Likelihood to Impart Energy on an Item" changing from "Modest" to "Inconsequential" (**Table I.1**).

10.2.3.2.2 Implementing LUCs within the MRS would not change the amount of MEC or the access conditions therefore no changes were made in *Matrix 1: Likelihood of an Encounter*. Likewise, implementing LUCs would not significantly change the severity of an unplanned detonation, resulting in no changes to *Matrix 2: Severity of Incident*. Implementing LUCs as described would change human behavior thereby decreasing the "Likelihood to Impart Energy on an Item" in *Matrix 3: Likelihood of Detonation* from "Modest" to "Inconsequential." Based on the results from Matrices 1 through 3 the overall site risk conditions for the Kanaio LTA MRS under current and anticipated future conditions would change from "Unacceptable" to "Acceptable" as shown in *Matrix 4: Acceptable and Unacceptable Site Conditions*.

10.2.3.3 ALTERNATIVE 3 – COMPLETE SURFACE MEC REMOVAL AND LUCS

10.2.3.3.1 The baseline risks associated with **Alternative 3 – Complete Surface MEC Removal and LUCs**, are established in the RI. The implementation of a complete surface MEC removal and LUCs would serve to reduce risks by removing surface MEC throughout the MRS and would limit human interaction with surface and subsurface UXO at the MRS by increasing the awareness of potential hazards. The actions implemented under Alternative 3 would change the RMM evaluation of the site conditions from "Unacceptable" to "Acceptable" at the Kanaio LTA MRS. This is based on the "Amount of MEC" changing in the HUA from "Category II" to "Category IV" and in the LUA from "Category III" to "Category IV" in addition to the "Likelihood to Impart Energy on an Item" changing from "Modest" to "Inconsequential" (**Table I.2**).

10.2.3.3.2 Implementing a complete surface MEC removal within the MRS would reduce the amount of MEC in the HUA from "Category II" to "Category IV" and in the LUA from "Category III" to "Category IV" in *Matrix 1: Likelihood of an Encounter* therefore changing the "Likelihood of Encounter" from "Occasional" to "Unlikely" for the HUA and from "Seldom" to "Unlikely" for the LUA. The category for the King's Trail would remain the same because a DERP response action has been conducted to physically remove surface MEC. Implementing Alternative 3 would not change the severity of an unplanned detonation, resulting in changes to *Matrix 2: Severity of Incident* only due to reducing the likelihood of encounter via source removal (Matrix 1). Implementing LUCs (public education and warning signs) would change human behavior thereby changing the “Likelihood to Impart Energy on an Item” in *Matrix 3: Likelihood of Detonation* from “Modest” to “Inconsequential.” Based on the results from Matrices 1 through 3 the overall site risk conditions for the Kanaio LTA MRS under current and anticipated future conditions would change from “Unacceptable” to “Acceptable” as shown in *Matrix 4: Acceptable and Unacceptable Site Conditions*.

10.2.3.4 ALTERNATIVE 4 – FOCUSED SURFACE AND SUBSURFACE MEC REMOVAL AND LUCS

10.2.3.4.1 The baseline risks associated with **Alternative 4 – Focused Surface and Subsurface MEC Removal and LUCs,** are established in the RI. The implementation of a focused surface and subsurface MEC removal would serve to reduce risk by removing targeted surface and subsurface MEC at the HUA and King’s Trail. The MEC removal implemented under Alternative 4 would change the RMM evaluation of the site conditions from “Unacceptable” to “Acceptable” at the Kanaio LTA MRS. This is based on the “Amount of MEC” changing from “Category IV” to “Category VI (Least)” (**Table I.3**).

10.2.3.4.2 Implementing a focused surface and subsurface MEC removal within the MRS would reduce the amount of MEC in the HUA from “Category II” to “Category VI (Least)” and in the King’s Trail from “Category IV” to “Category VI (least)” in *Matrix 1: Likelihood of an Encounter* therefore changing the “Likelihood of Encounter” from “Occasional” to “Unlikely” for the HUA and “Occasional” to “Unlikely” for the King’s Trail.” Alternative 4 would not reduce the amount of MEC in the LUA in Matrix 1: *Likelihood of an Encounter* therefore the “Likelihood of Encounter” remains as “Seldom.” Implementing Alternative 4 would not change the severity of an unplanned detonation, resulting in changes to *Matrix 2: Severity of Incident* only due to reducing the likelihood of encounter via source removal (Matrix 1). Implementing LUCs (public education and warning signs) would change human behavior thereby changing the “Likelihood to Impart Energy on an Item” in *Matrix 3: Likelihood of Detonation* from “Modest” to “Inconsequential.” Based on the results from Matrices 1 through 3 the overall site risk conditions for the Kanaio LTA MRS under current and anticipated future conditions would change from “Unacceptable” to “Acceptable” as shown in *Matrix 4: Acceptable and Unacceptable Site Conditions*.

10.2.3.5 ALTERNATIVE 5 – COMPLETE SURFACE AND SUBSURFACE MEC REMOVAL (UU/UE)

10.2.3.5.1 The baseline risks associated with **Alternative 5 – Complete Surface and Subsurface MEC Removal (UU/UE)**, are established in the RI. The implementation of a complete surface and subsurface MEC removal would serve to reduce risk by removing all surface and subsurface MEC throughout the MRS. The MEC removal implemented under Alternative 5 would change the RMM evaluation of the site conditions from “Unacceptable” to “Acceptable” at the Kanaio LTA MRS. This is based on the “Amount of MEC” changing from “Category IV” to “Category VI (Least)” (**Table I.4**).

10.2.3.5.2 Implementing a complete surface and subsurface MEC removal within the MRS would reduce the amount of MEC in the HUA from “Category II” to “Category VI (Least)”, the LUA from “Category III” to “Category VI (Least)”, and King’s Trails from “Category IV” to “Category VI (Least)” in *Matrix 1: Likelihood of an Encounter* therefore changing the “Likelihood of Encounter” from “Occasional” to “Unlikely” for the HUA and King’s Trail and from “Seldom” to “Unlikely” for the LUA. Implementing these remedial actions would not change the severity of an unplanned detonation, resulting in changes to *Matrix 2: Severity of Incident* only due to reducing the likelihood of encounter via source removal (Matrix 1). Implementing Alternative 5 would not result in any changes human behavior, therefore the “Likelihood to Impart Energy on an Item” in *Matrix 3: Likelihood of Detonation* would not change. Based on the results from Matrices 1 through 3 the overall site risk conditions for the Kanaio LTA MRS under current and anticipated future conditions would change from “Unacceptable” to “Acceptable” as shown in *Matrix 4: Acceptable and Unacceptable Site Conditions*.

10.3 ALTERNATIVE DESCRIPTIONS

10.3.1 ALTERNATIVE 1 – NO ACTION

The NCP requires that a No Action alternative be evaluated to provide a baseline for comparison to other alternatives. This alternative provides no actions to protect human health or the environment at the MRS. This alternative, if implemented, would involve continued use of the MRS in its current condition. As this is required per the NCP, no preliminary screening is necessary, and this alternative is retained for the detailed analysis of alternatives in **Chapter 11**.

10.3.2 ALTERNATIVE 2 – PUBLIC EDUCATION AND WARNING SIGNS (LUCS)

10.3.2.1 Alternative 2 would not remove any MEC from the MRS. Rather, it would focus on modifying human behavior through the requirement for UXO support for any future intrusive activities at the MRS and public education and warning signs. To educate the receptors of potential explosive hazards, educational pamphlets would be developed and distributed to local residents, posted on community boards, and given to anyone who applies for a hunting permit. Warning signs would be installed at MRS access points along the Piilani highway (Hawaii state route HI-37) to the north of the Kanaio LTA and the King's Trail (also referred to locally as Hoapili Trail or the King's Highway) in the south section of the Kanaio LTA MRS. The specific pamphlet language, distribution points and mailings, and public meeting frequency and location will be developed in close collaboration with DLNR, HDOH, and ARNG as part of the subsequent Response/Removal Action phase of the project. The warning sign numbers, locations and text will similarly be addressed. LUC cost estimates developed herein are based on estimates from other similar projects for planning/budgeting purposes and will be further evaluated for sufficiency as part of the next project phase during preparation of the Response/Removal Action Work Plan. By increasing awareness of the explosive hazards and of the proper reporting procedures to use if a suspected MEC item is observed, receptor behavior would be modified.

10.3.2.2 The signs would stress the importance of the "3Rs" — Recognize, Retreat, and Report. Any MEC that is found during current and future activities should be left undisturbed and should be reported to the appropriate authorities, per the "3Rs." The focus of educational pamphlets should be the prevention of handling of suspected MEC and the reporting of suspected MEC. The signs would reinforce the link between appropriate access and safety. Annual maintenance would be necessary for the signs. This alternative does not achieve UU/UE. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of potential human receptors. In the event an MEC item is identified by DLNR, procedurally the local Sheriff would need to be contacted. The Sheriff's office will engage the local active military Explosives Ordnance Disposal (EOD) unit for emergency response. Any such responses should be conveyed by DLNR to ARNG for consideration of ongoing effectiveness of the LUCs and in support of 5-year review evaluations. The components of this alternative are summarized in **Table 10.1**.

Table 10.1 Summary of Alternative 2

Alternative 2	Important Actions
Restrictions on Digging	Would recommend that HI DLNR (the landowner) require UXO support for any future intrusive activities on site. For example, during the installation of warning signs or in support of potential development of the MRS as a Forestry and Wildlife Management Area.
Public Education	Development and distribution of an educational pamphlet including relevant information on the potential presence of MEC within the MRS and the necessary safety precautions to be taken within those areas. Annual printing and distribution of educational pamphlets:

Alternative 2	Important Actions
	5,000 distributed to local residents, placed at community boards (such as libraries, community centers, and high traffic public locations), and give to anyone who applies for a hunting permit.
Warning Signs	Installation of warning signs along the edge of the MRS, Piilani highway to the north and King's Trail to the south, to include relevant information on the potential presence of MEC within the MRS and the necessary safety precautions to be taken within those areas. Initial installation and annual maintenance warning signs: 25 warning signs initially installed along the edge of the MRS, Piilani Highway to the north and King's Trail to the south 5 replacement signs installed annually as part of sign maintenance

10.3.3 ALTERNATIVE 3 – COMPLETE SURFACE MEC REMOVAL AND LUCS

10.3.3.1 Alternative 3 would use instrument-aided surface sweeps to identify and remove potential MEC exposed or at the ground surface in the MRS. LUCs consisting of educational controls (public education) and warning signs would be required to mitigate the potential for human exposure to remaining subsurface MEC in the MRS. This alternative does not achieve UU/UE.

10.3.3.2 MEC detection would be the first step in surface MEC removal, which would be accomplished with an instrument-aided surface sweep. UXO-qualified personnel would systematically walk the MRS and mark, identify, and record the locations of all MEC found on the surface for removal or subsequent disposal. UXO-qualified personnel would systematically search sweep lanes within a pre-established grid network using the magnetometer to identify anomalies. The grid-network would be established for 100% coverage of the 1983-acre MRS. If the instrument indicates a response but the source item is not found on or just below the ground surface, the UXO Technician would move on without extensive digging into the subsurface.

10.3.3.3 MEC removal on the ground surface would be performed by UXO-qualified personnel investigating visually detected anomalies. If the MEC is partially exposed, or protruding above the surface in any areas that are comprised of soil rather than a'a lava rock, limited digging with hand tools would be conducted where until the item could be verified as MEC or MD. It is anticipated that removal activities under Alternative 3 would not disturb the environment since only MEC on or just below the ground surface (1-2 inches in loose soil) would be investigated. An exclusion zone must be maintained while digging anomalies.

10.3.3.4 Demolition would be performed on all MEC. Any MEC would be evaluated by the UXO-qualified personnel to determine whether it is acceptable to move or if it would be BIP. MEC considered acceptable to move would be transported to an appropriate location for demolition. If a MEC item were not acceptable to move, then BIP would be unavoidable and evacuations within the EZ would be necessary. All notifications and procedures for demolition operations would be conducted in accordance with the procedures established in the Remedial Action Work Plan. Holes created by the detonation would be backfilled, as appropriate. Items that are acceptable to move would be consolidated for destruction with items that are unacceptable to move, using a consolidated shot for demolition of the explosively hazardous item. All MD would be collected for off-site disposal for smelting and recycling. NMRD recovered during the removal action would be transported off site for disposal or recycling as non-hazard municipal waste. MC sampling for explosives would be limited to post-BIP sampling if sufficient soil is available for sampling.

10.3.3.5 LUCs are included in this alternative because MEC would potentially remain in the subsurface in the MRS. Educational controls (public education) and warning signs would be necessary to reduce the likelihood of human interaction with MEC. LUCs would be the same as described in Alternative 2. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of potential human receptors. The components of this alternative are summarized in **Table 10.2**.

Table 10.2 Summary of Alternative 3

Alternative 3	Important Actions
Surface Clearance	Surveying, vegetation clearance (only where necessary), visual surface clearance and removal of MEC with analog magnetometers, and disposal of any MEC and MD. Cost assumptions include: • Kanaio LTA Area 1 and Area D LUA: 100% of this area requires surface clearance – 1983 acres. Details are provided in **Appendix J** for the cost assumptions.
LUCs	Development and distribution of an educational pamphlet including relevant information on the potential presence of MEC within the MRS and the necessary safety precautions to be taken within those areas. Annual printing and distribution of educational pamphlets: • 5,000 distributed to local residents, placed at community boards (such as libraries, community centers, and high traffic public locations), and give to anyone who applies for a hunting permit. Installation of warning signs along the edge of the MRS Piilani highway to the north and King's Trail to the south to include relevant information on the potential presence of MEC within the MRS and the necessary safety precautions to be taken within those areas. Initial installation and annual maintenance warning signs: • 25 warning signs initially installed along the edge of the MRS, Piilani Highway to the north and King's Trail to the south • 5 replacement signs installed annually as part of sign maintenance

10.3.4 ALTERNATIVE 4 – FOCUSED SURFACE AND SUBSURFACE MEC REMOVAL AND LUCS

10.3.4.1 Alternative 4 would use instrument-aided surface sweeps within a 126-acre "focus" area that includes the 36-acre HUA which is where the majority of the MD and single MEC item (81-mm HE mortar from Grid 12) were identified during the RI (**Figures 3.1 and 10.1**) as well as where the majority of SI findings were located. While it was determined to be low anomaly density, the King's Trail is the highest traffic area onsite; therefore, a 50-foot swath (25 feet on each side of the centerline of the trail) will be collected the entire length of the trail within the MRS. The entirety of the 126-acre "focus" area falls within the a'a lava field which, as previously described, has minimal to no soil profile. Following field-delineation of the 126-acre "focus" area (derived based on RI findings plus buffer area) and establishing a subgrid network for progress tracking purposes, analog sweeps would be conducted to investigate 100% of the surface and subsurface (if present, to maximum instrument detect depths or until rock is encountered). Note that rock is exposed at most areas of the surface, so subsurface work will not be needed in most of the "focus" area. LUCs consisting of educational controls (public education) and warning signs would be implemented to mitigate the potential for human exposure to remaining potential MEC hazards within the balance of the MRS. This alternative does not achieve UU/UE for the entire MRS.

10.3.4.2 Instrumented-aided sweeps would be conducted over the "focus" area. UXO-qualified personnel would systematically walk the pre-established subgrid network and would mark, identify, and record the locations of all MEC found on the surface or subsurface. The operator would systematically search sweep lanes within subgrids using the hand-held detector to identify anomalies. The subgrid network would be established for 100% coverage of the 126-acre "focus" area of the MRS. No Vegetation clearance is expected to be needed in the "focus" area.

10.3.4.3 QA seeding is assumed to be conducted in tandem with the survey and completed by the government. A Garrett AT Max, or similar instrument, would be used to investigate. Analog detectors can detect the munitions of interest at the recovery depths specified in the RAO. Analog detection will be verified using QC and validation seeds.

10.3.4.4 MEC removal would be performed by manually using hand tools to excavate the subsurface until each anomaly is fully investigated.

10.3.4.5 Demolition would be performed on all MEC. Any MEC would be evaluated by the UXO-qualified personnel to determine whether it is acceptable to move or if it would be BIP. If needed, MEC considered acceptable to move would be transported to an appropriate location for demolition. If an MEC item was not acceptable to move, then BIP would be unavoidable and evacuations within the EZ would be necessary. All notifications and procedures for demolition operations would be conducted in accordance with the procedures established in the Remedial Action Work Plan (RAWP). Depressions/craters created by the detonation would be backfilled and restored, as appropriate. Hazardous MEC determined to be acceptable to move could be stockpiled and consolidated for demolition with other MEC items that are unacceptable to move, where practicable. All MD would be collected for off-site disposal for smelting and recycling. NMRD recovered during the removal action would be transported off site for disposal or recycling as non-hazard municipal waste. MC sampling for explosives would be limited to post-BIP sampling following demolition actions in areas where soil is present.

10.3.4.6 LUCs are included in this alternative because MEC would potentially remain on the surface or in the subsurface outside the “focus” area. Educational controls (public education) and warning signs would be used to reduce the likelihood of human interaction with MEC. LUCs would be the same as described in Alternative 2. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of potential human receptors. The components of this alternative are summarized in **Table 10.3**.

Table 10.3 Summary of Alternative 4

Alternative 4	Important Actions
Focused Surface and Subsurface Clearance	Surface and subsurface removal of MEC, utilizing analog equipment. Cost assumptions include: • Surface and Subsurface removal over 100% of the 126-acre “focus” area. Details are provided in **Appendix J** for the cost assumptions.
LUCs	Development and distribution of an educational pamphlet including relevant information on the potential presence of MEC within the MRS and the necessary safety precautions to be taken within those areas. Annual printing and distribution of educational pamphlets: • 5,000 distributed to local residents, placed at community boards (such as libraries, community centers, and high traffic public locations), and give to anyone who applies for a hunting permit. Installation of warning signs along the edge of the MRS, Piilani highway to the north and King’s Trail to the south, to include relevant information on the potential presence of MEC within the MRS and the necessary safety precautions to be taken within those areas. Initial installation and annual maintenance warning signs: • 25 warning signs initially installed along the edge of the MRS Piilani highway to the north and King’s Trail to the south • 5 replacement signs installed annually as part of sign maintenance

10.3.5 ALTERNATIVE 5 – COMPLETE SURFACE AND SUBSURFACE CLEARANCE (UU/UE)

10.3.4.1 Alternative 5 would accomplish MEC detection using dynamic AGC methods where accessible, and analog methods elsewhere, followed by MEC removal though intrusive investigation of geophysical anomalies over all of the MRS.

10.3.4.2 Preparatory Activities consist of vegetation clearance. Vegetation and trees up to 4-inch diameter would need to be removed prior to collection of dynamic AGC data to within 6 inches of the ground surface. Areas of thick groundcover would be removed to provide visibility for the safety of the UXO-qualified personnel. Surface clearance and anomaly reduction prior to dynamic AGC would be completed using analog detectors.

10.3.4.3 MEC Detection would be accomplished with the goal of achieving 100% coverage of the accessible areas of the MRS with AGC MPV, UltraTEM Screener, or APEX sensors. Use of AGC would allow accurate data collection, resulting in a digital, georeferenced map of anomalies in accessible portions of the MRS. Where an isolated target anomaly is present, the coordinates would be located, and the anomaly would be “reacquired” to precisely pinpoint its location with a pin flag for subsequent removal. AGC detection will be verified using QA/QC and validation targets. QA seeding is assumed to be completed by the government. A Garrett AT Max, or similar instrument, would be used to investigate inaccessible areas that could not be mapped with the AGC sensor (i.e., most of the MRS). Analog detectors can detect the munitions of interest at the recovery depths specified in the RAO. Analog detection will be verified using QC and validation seeds.

10.3.4.4 MEC removal following AGC would be performed by manually using shovels to excavate the soil until the maximum equipment detection depth is attained. Once that depth has been reached, the excavation bottom and sides would be surveyed with analog detectors to verify that all detected MEC contamination has been removed. During this time, all nonessential personnel would be evacuated beyond the required EZs. Excavation areas would be backfilled and re-graded using the native soil verified as free of MEC and MD. MEC removal for the portion of the MRS using analog methods would be performed by manually using hand tools to excavate the subsurface until each anomaly is fully investigated.

10.3.4.5 MEC Demolition would be performed on all MEC items. Any MEC would be evaluated by the UXO-qualified personnel to determine whether it is acceptable to move or if it would be BIP. If needed, MEC considered acceptable to move would be transported to an appropriate location for demolition. If a MEC item is not acceptable to move, then BIP is unavoidable and evacuations within the EZ would be necessary. All notifications and procedures for demolition operations will be conducted in accordance with the procedures established in the Remedial Action Work Plan. Holes created by the detonation would be backfilled as appropriate. Items that are acceptable to move will be consolidated for destruction with items that are unacceptable to move, using a consolidated shot for demolition of the explosively hazardous item. All MD would be collected for off-site disposal for smelting and recycling. NMRD found during the remedial action would be transported off-site for disposal or recycling as non-hazard municipal waste. MC sampling for explosives will be limited to post-BIP sampling when of use a demolition area is completed in areas where soil is present.

10.3.4.6 UU/UE Conditions will be assessed. The depths that MEC is detected and removed and whether 100% coverage was attained will be evaluated post-removal to verify that UU/UE is achieved. UU/UE would also require that ROE is granted or renewed for 100% of the area. If UU/UE is not achieved, LUCs as described in Alternative 2 would be implemented. The components of this alternative are summarized in **Table 10.4**.

Table 10.4 Summary of Alternative 5

Alternative 5	Important Actions
Complete Surface and Subsurface Clearance	Vegetation clearance, surface and subsurface removal of MEC, utilizing analog, DGM, and AGC detection methods, and disposal of any MEC and MD. Cost assumptions include: • Surface and Subsurface removal over 100% of the 1983-acre MRS. Details are provided in **Appendix J** for the cost assumptions.

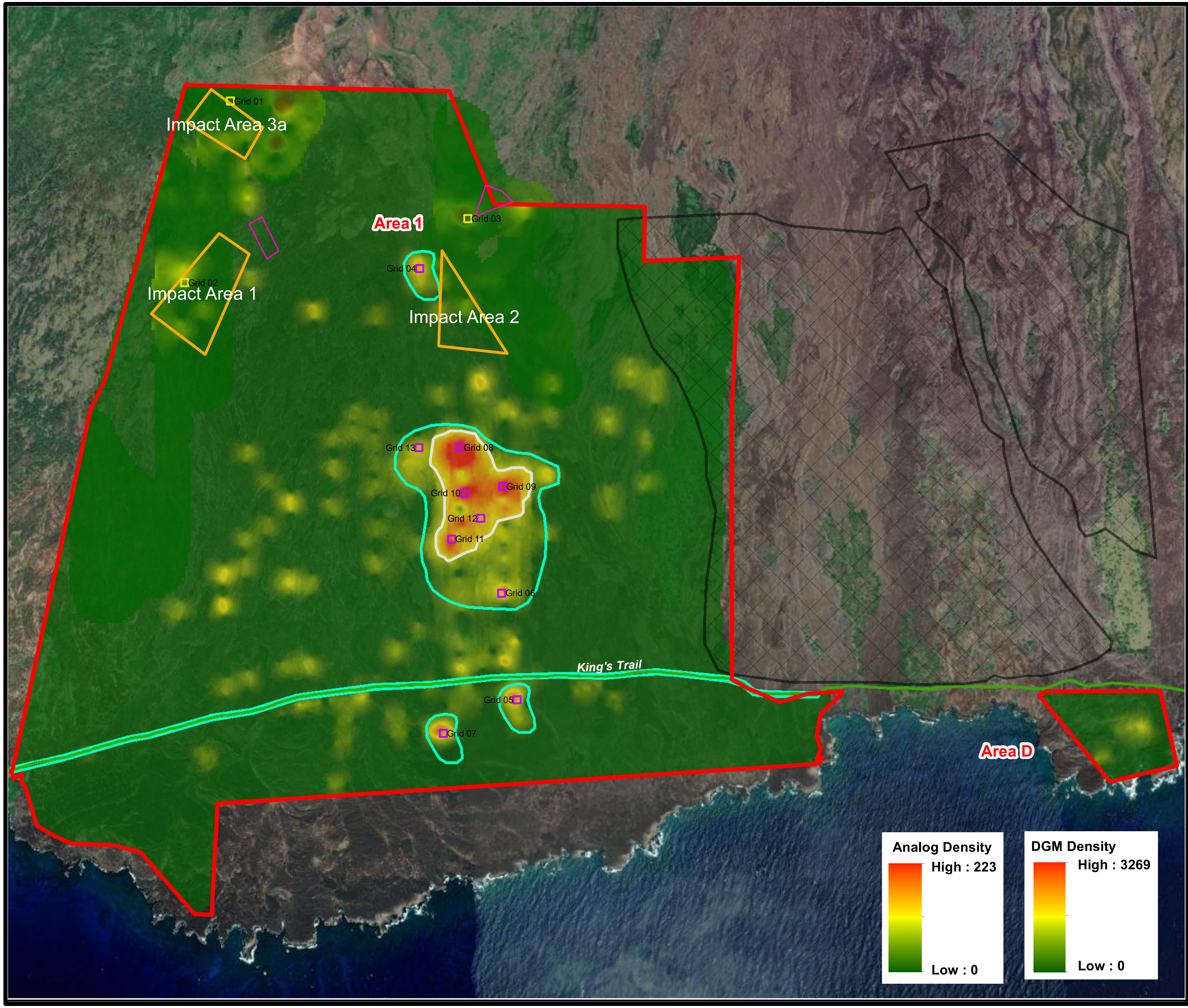


Figure 10.1

Kanaio Local Training Area Munitions Response Site ("Area 1") and Area of Interest ("Area D")

Proposed Focused Removal Area

Maui, Hawaii

Legend

- 🟨 Proposed AGC Grid Location
- 🟪 Proposed Analog Grid Location
- Kanaio Local Training Area MRS (Area 1 and Area D) Boundary
- King's Trail
- Impact Area
- ☐ Private Property (No ROE)
- ☐ Proposed High Use Area Boundary
- ☐ Proposed Focused Removal Area

300 150 0 300
Meters

PARSONS

U.S. ARMY CORPS
OF ENGINEERS
HUNTSVILLE CENTER

DESIGNED BY: BT
DRAWN BY: BT
CHECKED BY: DS
SUBMITTED BY: DS

Proposed Focused Removal Area

SCALE: As Shown
DATE: January 2022
FILE:
PROJECT NUMBER: 100087.0538.110208.02004
PAGE NUMBER: 63

11.0 Detailed Analysis of Remedial Alternatives

11.1 INTRODUCTION

11.1.1 The purpose of the detailed analysis is to evaluate and compare each of the alternatives that were developed in the previous chapter (**Subchapter 10.2**). This analysis will help to identify the most permanent solution consistent with current and future land use (see **Subchapter 2.5**) as determined by the criteria specified in the NCP (40 CFR 300.430).

11.1.2 Section 300.430(e) of the NCP lists nine CERCLA criteria against which each remedial alternative must be assessed. The acceptability or performance of each alternative against the criteria is evaluated individually so that relative strengths and weaknesses can be identified. The criteria are as follows:

1) Overall protection of Human Health and the Environment
2) Compliance with ARARs
3) Long-term effectiveness and permanence
4) Reduction of toxicity, mobility, or volume through treatment (TMV)
5) Short-term effectiveness
6) Implementability
7) Cost
8) State acceptance
9) Community acceptance

11.1.3 The NCP [Section 300.430(f)] states that the first two criteria, protection of human health and the environment and compliance with ARARs, are “threshold criteria” that must be met by the selected remedial action unless a waiver is granted under Section 121(d)(4) of CERCLA. The next five criteria are “primary balancing criteria,” and the tradeoffs within this group must be balanced. The preferred alternative will be the alternative that is protective of human health and the environment, is ARAR-compliant, and provides the best combination of primary balancing attributes. The final two criteria, state and community acceptance, are “modifying criteria,” which are based on the degree of acceptance from the local public and from state agencies regarding the implementation of alternatives and are evaluated following the 30-day public comment period on the PP and during DD preparation. The following sections describe each of the evaluation criteria and the evaluation process used for performing the analysis.

11.2 EVALUATION CRITERIA

11.2.1 THRESHOLD CRITERIA

Threshold criteria are requirements that each alternative must meet or have specifically waived to be eligible for selection. There are two threshold criteria: Overall Protection of Human Health and the Environment and Compliance with ARARs, as described below.

11.2.1.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The selected alternative must adequately protect human health and the environment from unacceptable risks posed by MEC. The threshold criterion will be met if the unacceptable risks associated with the human exposures to MEC are eliminated, reduced, or controlled through treatment, engineering, or LUCs, and if the remedial action is protective of the environment. The RMM was used to evaluate whether risks are acceptable or unacceptable for each remedial alternative.

11.2.1.2 COMPLIANCE WITH ARARS

Compliance with ARARs is a threshold criterion that must be met by the proposed remedial alternative. The remedial alternative will meet this criterion if all ARARs are met by the alternative. ARARs identified for the remedial actions at the Kanaio LTA MRS consist of RCRA Subpart X which would apply to all consolidated munition destruction events as part of Alternatives 3 through 5. For those ARARs that are not met, a determination will be made as to whether a waiver is appropriate. It should be noted that the ARARs presented in this FS are preliminary. Final ARARs and compliance determinations will be made in the DD.

11.2.2 BALANCING CRITERIA

Primary balancing criteria are those that form the basis for comparison among alternatives that meet the threshold criteria. The five primary balancing criteria are Long-term Effectiveness and Permanence, Reduction of TMV through Treatment, Short-term Effectiveness, Implementability, and Cost, as described below. Remedies are required to be permanent (e.g., removal of MEC) to the maximum extent practicable and to be cost effective. The five balancing criteria are weighed against each other to determine which remedies meet these criteria. The NCP explains that in general, preferential weight is given to alternatives that offer advantages in terms of the reduction of TMV through treatment, and that achieve long-term effectiveness and permanence. However, the NCP also recognizes that some contamination problems will not be suitable for treatment and permanent remedies. The balancing process considers that preference and weighs the proportionality of costs to effectiveness to select one or more remedies that are cost effective. The final risk management decision made for the site is one that determines which cost-effective remedy offers the best balance of all criteria to achieve permanence to the maximum extent practicable.

11.2.2.1 LONG-TERM EFFECTIVENESS AND PERMANENCE

The long-term effectiveness and permanence criterion evaluates the degree to which an alternative permanently reduces or eliminates the potential for MEC risks. This criterion also evaluates the magnitude of residual risk with the alternative in place, and the adequacy and reliability of controls, such as containment systems and ICs, necessary to manage residual risk.

11.2.2.2 REDUCTION OF TMV THROUGH TREATMENT

This criterion addresses the statutory preference for selecting remedies that employ treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of the hazardous substances. The following factors are considered:

The amount of hazardous materials that will be destroyed or treated;

The degree of expected reduction in toxicity, mobility, or volume;

The degree to which the treatment will be irreversible;

The type and quantity of treatment residuals that will remain following treatment;

Treatment processes the remedial alternatives employ and the materials they will treat; and

Degree to which treatment reduces the inherent hazards posed by the principal threats at the MRS.

For munitions response projects, excavation followed by explosive demolition of MEC is considered to reduce the TMV through treatment.

11.2.2.3 SHORT-TERM EFFECTIVENESS

The short-term effectiveness criterion addresses the potential consequences and risks of an alternative during the implementation phase. The following factors will be addressed:

Protection of the community during the remedial action, such as protection from intentional and unintentional detonations, transportation of contaminated materials, and air-quality impacts from on-site disposal or treatment;

Potential impacts on workers during the remedial action and the effectiveness and reliability of any protective measures;

Environmental impacts of the remedial action and the effectiveness and reliability of mitigating measures; and

Time required to achieve the remedial response objectives.

11.2.2.4 IMPLEMENTABILITY

The implementability criterion evaluates the difficulty of implementing a specific cleanup action alternative both technically and administratively. Technical implementability refers to the ability to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is complete. It also includes operation, maintenance, replacement, and monitoring of technical components of an 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.

11.2.2.5 COST

11.2.2.5.1 The cost criterion evaluates the financial cost to implement the alternative. This includes direct, indirect, and long-term operation and maintenance costs (30-year estimate). For the purposes of evaluating and comparing alternatives as specified in the RI/FS Guidance (USEPA, 1988), a period of 30 years is used for estimating operations and maintenance (O&M) costs. Direct costs are those costs associated with the implementation of the alternative. Indirect costs are those costs associated with administration, oversight, and contingencies. For periodic costs, such as five-year reviews and O&M, the estimate is based on a project life of 30 years.

11.2.2.5.2 Cost estimates presented are order-of-magnitude level estimates. Based on a variety of information, including productivity estimates (based on site conditions), cost estimating guides, and prior experience at the Site. The actual costs will depend on true labor rates, actual weather conditions, final project scope, and other variable factors. A present value analysis is used to evaluate costs (capital and O&M) which occur over different periods. The total present value (TPV) is the amount needed to be set aside at the initial point in time (base year) to assure that funds will be available in the future as they are needed. The discount rate of 7 percent per the USEPA guidance, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, (USEPA, 2000) was used to estimate TPV.

11.2.2.5.3 Remedial action alternative cost estimates for the detailed analysis are intended to provide a measure of total resource costs over time (i.e., “life cycle costs”) associated with any given alternative. As such, these estimates generally are based on more detailed information and should achieve a greater level of accuracy than screening-level estimates. The detailed analysis level accuracy range of –30 to +50 percent means that, for an estimate of $100,000, the actual cost of an alternative is expected to be between $70,000 and $150,000 (USEPA, 2000).

11.2.3 MODIFYING CRITERIA

Community and State acceptance of the remedy can play a role in weighing the balance between remedies that are cost effective and meet other criteria. The SPP process and public involvement activities help to provide an understanding of these criteria even though the PP has not yet been issued. The community and State acceptance criteria are based on the degree of assumed acceptance from the local public and from State agencies regarding the implementation of alternatives. These criteria cannot be fully evaluated and assessed until comments on the FS and the PP are received.

11.3 INDIVIDUAL ANALYSIS OF ALTERNATIVES

The alternatives developed in **Chapter 10** that were retained for detailed analysis are listed below (only the “No Action” alternative and those alternatives which were evaluated as “acceptable” following implementation of the remedy as summarized in **Subchapter 10.4**):

Alternative 1 – No Action

Alternative 2 – Public Education and Warning Signs (LUCs)

Alternative 3 – Complete Surface MEC Removal and LUCs

Alternative 4 – Focused Surface and Subsurface MEC Removal and LUCs

Alternative 5 – Complete Surface and Subsurface MEC Removal (UU/UE)

The following sections provide a detailed analysis of these alternatives according to the nine NCP criteria. If an alternative does not meet the threshold criteria it will not be retained for further analysis and will be removed from consideration as an alternative. The final two criteria, state and community acceptance will be evaluated after the PP.

11.3.1 ALTERNATIVE 1 – NO ACTION

A description of this alternative is provided in **Subchapter 10.3.1**.

11.3.1.1 ASSESSMENT OF THRESHOLD CRITERIA

This alternative assumes no action would be taken to address the RAO. This alternative is provided as a baseline for comparison to the other remedial alternatives, as required under CERCLA and the NCP. Alternative 1 does not reduce risk due to the presence of surface and subsurface MEC, since no remedial activities would be implemented to mitigate those risks at the Kanaio LTA MRS. Because no actions would be implemented under Alternative 1, RCRA, Subpart X is not triggered. This alternative is not protective of human health and the environment and does not meet the criterion. As such, this alternative has been removed from consideration for applicability for this MRS but is retained for comparison of alternatives as required.

11.3.2 ALTERNATIVE 2 – PUBLIC EDUCATION AND WARNING SIGNS (LUCS)

A description of this alternative is provided in **Subchapter 10.3.2**.

11.3.2.1 ASSESSMENT OF THRESHOLD CRITERIA

Alternative 2 would use LUCs to reduce and manage MEC risk at the Kanaio LTA MRS. Potential hazards associated with direct contact and contact through intrusive activities. This alternative is protective of human health and the environment and meets the criterion. The risk for the MEC contaminated area would be revised to “acceptable” after implementation of this alternative (**Appendix I**). Because no MEC removal or demolition actions would be implemented under Alternative 2, RCRA, Subpart X is not triggered.

11.3.2.2 ASSESSMENT OF BALANCING CRITERIA

11.3.2.2.1 Successful implementation of the remedial actions under Alternative 2 would be effective at reducing risk over the long-term due to the increase in awareness of potential hazards through warning signs and public education even though MEC may remain on the ground surface and in the subsurface at the MRS. The long-term effectiveness would be ensured through continued annual implementation of LUCs in the form of public education of any potential remaining hazards on-site and maintenance of warning signs. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of any potential human receptors.

11.3.2.2.2 No treatment is employed as part of the Alternative 2. This alternative would not reduce the toxicity, mobility, or volume of MEC remaining in the surface and subsurface of the MRS, therefore this alternative would not satisfy the statutory preference for employing treatment as a principal element.

11.3.2.2.3 Implementation of Alternative 2 would result in short-term hazards to workers involved with the installation of warning signs because of the increased likelihood of MEC exposure. However, these hazards would be managed using industry standard safety procedures (e.g., using qualified UXO personnel, enforcement of safe separation distances, engineering controls, etc.), which would also minimize any associated potential risks to the surrounding community. This alternative would not cause any adverse short-term effects on the environment. The estimated timeframe for implementing Alternative 2 is 2 weeks. Maintenance of warning signs and distribution of public education materials will continue to be implemented annually.

11.3.2.2.4 All technologies and methods involved in implementing Alternative 2 are well established and would be technically and administratively implementable. The services and materials required to implement the work are readily available: (1) Handheld analog detectors can easily be obtained to support the installation of warning signs; and (2) UXO-qualified personnel who are specially trained for EOD work and who would support and conduct any remedial actions. Conversely, Alternative 2 is dependent on landowner participation, ROEs must be granted or renewed for the work to occur. Although equipment and personnel required to complete Alternative 2 are readily available, if implementation of the alternative throughout the MRS is limited by ROE, the overall effectiveness would decrease.

11.3.3.2.5 The TPV cost of implementing Alternative 2 at the Kanaio LTA MRS is estimated as $639,694 (**Table J.1** and **Appendix J**). Alternative 2 would not achieve UU/UE and Five-Year Reviews would be required.

11.3.3 ALTERNATIVE 3 – COMPLETE SURFACE MEC REMOVAL AND LUCS

A description of this alternative is provided in **Subchapter 10.3.3.**

11.3.3.1 ASSESSMENT OF THRESHOLD CRITERIA

11.3.3.1.1 The remedial actions included in Alternative 3 would remove all surface MEC at the Kanaio LTA MRS and LUCs would be used to manage the remaining risk from MEC in the subsurface. This alternative is protective of human health and the environment and meets the criterion. The risk for the MEC contaminated area would be revised to “acceptable”, after implementation of this alternative (**Appendix I**).

11.3.3.1.2 Investigation-derived waste material produced would be subject to the action-specific ARAR, RCRA (Subpart X). All materials resulting from MEC disposal activities would be inspected, certified as MDAS, transported under chain of custody control, and disposed by smelting.

11.3.3.2 ASSESSMENT OF BALANCING CRITERIA

11.3.3.2.1 Successful implementation of the remedial actions under Alternative 3 would be effective at reducing risk over the long-term due to the removal of surface MEC throughout the MRS and the increase in awareness of potential hazards through warning signs and public education. Implementing Alternative 3 may result in some MEC remaining in the subsurface and in locations where removal was not able to be implemented (e.g., where ROE is not obtained). The long-term effectiveness would be ensured through continued annual implementation of LUCs in the form of public awareness measures of any potential remaining hazards on-site and maintenance of warning signs. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of potential human receptors.

11.3.3.2.2 Alternative 3 would result in complete removal of MEC in the surface of the MRS as defined in **Table 10.2**. Alternative 3 includes the intentional removal and/or treatment of MEC (demolition), thus satisfying the statutory preference for employing treatment as a principal element.

11.3.3.2.3 Implementation of Alternative 3 would result in short-term hazards to workers involved with the surface MEC removal activities or the installation of warning signs because of the increased likelihood of MEC exposure. Evacuation of non-essential personnel would be necessary for some locations during MEC removal. However, these hazards would be managed using industry standard safety procedures (e.g., using qualified UXO personnel, enforcement of safe separation distances, engineering controls, etc.), which would also minimize any associated potential risks to the surrounding community. This alternative would not cause any adverse short-term effects on the environment. The estimated timeframe for implementing the removal action portion of Alternative 3 is 54 weeks. Maintenance of warning signs and distribution of public education materials will continue to be implemented annually.

11.3.3.2.4 All technologies and methods involved in implementing Alternative 3 are well established and would be technically and administratively implementable. The services and materials required to implement the work are readily available: (1) Handheld analog detectors can easily be obtained to support the MEC removal effort; and (2) UXO-qualified personnel who are specially trained for EOD work and who would support and conduct any MEC removal would be readily available. Conversely, Alternative 3 is dependent on landowner participation, ROEs must be granted or renewed for the work to occur. Although equipment and personnel required to complete Alternative 3 are readily available, if implementation of the alternative throughout the MRS is limited by ROE, the overall effectiveness would decrease.

11.3.3.2.5 The TPV cost of implementing Alternative 3 at the Kanaio LTA MRS is estimated as $15,128,084 (**Table J.1** and **Appendix J**). Alternative 3 would not achieve UU/UE and Five-Year Reviews would be required.

11.3.4 ALTERNATIVE 4 – FOCUSED SURFACE AND SUBSURFACE MEC REMOVAL

A description of this alternative is provided in **Subchapter 10.3.4**.

11.3.4.1 ASSESSMENT OF THRESHOLD CRITERIA

11.3.4.1.1 The remedial actions associated with Alternative 4 would remove surface and subsurface MEC within the 126-acre “focused” area of the Kanaio LTA MRS and LUCs would be used to manage the remaining risk from MEC in the remaining portion of the MRS. This alternative is protective of human health and the environment and meets the criterion. The risk for the MRS subarea would be revised to “acceptable”, after implementation of this alternative (**Appendix I**).

11.3.4.1.2 Investigation-derived waste material produced would be subject to the action-specific ARAR, RCRA (Subpart X). All materials resulting from MEC disposal activities would be inspected, certified as MDAS, transported under chain of custody control, and disposed by smelting.

11.3.4.2 ASSESSMENT OF BALANCING CRITERIA

11.3.4.2.1 Successful implementation of the remedial actions under Alternative 4 would be effective at reducing risk over the long-term through both surface and subsurface removal of potential MEC within the 126-acre “focused” area. The depth of potential MEC within the MRS is presented in **Table 10.3**. The maximum depth of anticipated explosive hazards lies within the maximum anticipated receptor depth. Implementing Alternative 4 may result in some MEC remaining in areas outside the “focused” area where no MEC removal would be implemented. The long-term effectiveness would be ensured through the annual implementation of LUCs in the form of public education of any potential remaining hazards on-site and the installation and maintenance of warning signs. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of potential human receptors.

11.3.4.2.2 Alternative 4 would result in complete removal of MEC in the “focused” surface and subsurface area of the MRS as defined in **Table 10.3**. Alternative 4 includes the intentional removal and/or treatment of MEC (demolition), thus satisfying the statutory preference for employing treatment as a principal element.

11.3.4.2.3 Implementation of Alternative 4 would result in short-term hazards to workers involved with the surface and subsurface MEC removal activities because of the increased likelihood of MEC exposure. Evacuation of non-essential personnel would be necessary for some locations during MEC removal. However, these hazards would be managed using industry standard safety procedures (e.g., using qualified UXO personnel, enforcement of safe separation distances, engineering controls, etc.), which would also minimize any associated potential risks to the surrounding community. Alternative 4 would cause minimal short-term effects on the environment. After removal of MEC from the excavation location, the native soil will be replaced and the area restored, as appropriate. The estimated timeframe for implementing the removal action portion of Alternative 4 is 18 weeks.

11.3.4.2.4 All technologies and methods involved in implementing Alternative 4 are well established and would be technically and administratively implementable. The services and materials required to implement the work are readily available: handheld analog detectors can easily be obtained to support the MEC removal effort; and UXO-qualified personnel who are specially trained for EOD work and who would conduct any MEC removal would be readily available. Conversely, Alternative 4 is dependent on landowner participation, ROEs must be granted or renewed for the work to occur; however, the entire 126-acre “focused” area is within the jurisdiction of the HI DLNR. Equipment and personnel required to complete Alternative 4 are readily available.

11.3.4.2.5 The TPV cost of implementing Alternative 4 at the Kanaio LTA MRS is estimated as $3,344,876 (**Table J.1** and **Appendix J**). As Alternative 4 does not achieve UU/UE, Five-Year Reviews would be required. Cost for five-year reviews is included.

11.3.5 ALTERNATIVE 5 – COMPLETE SURFACE AND SUBSURFACE MEC REMOVAL (UU/UE)

A description of this alternative is provided in **Subchapter 10.3.5**.

11.3.5.1 ASSESSMENT OF THRESHOLD CRITERIA

11.3.5.1.1 The remedial actions associated with Alternative 5 would serve to eliminate human interaction with MEC by removing all surface and subsurface MEC throughout the Kanaio LTA MRS. Alternative 5 would attain UU/UE and would be protective of receptors to the maximum depth of anticipated munitions such that there are no unacceptable risks resulting from exposure to MEC. This alternative is protective of human health and the environment and meets the criterion. The risk for the MEC contaminated area would be revised to “acceptable”, after implementation of this alternative (**Appendix I**).

11.3.5.1.2 Investigation-derived waste material produced would be subject to the action-specific ARAR, RCRA (Subpart X). All materials resulting from MEC disposal activities would be inspected, certified as MDAS, transported under chain of custody control, and disposed by smelting.

11.3.5.2 ASSESSMENT OF BALANCING CRITERIA

11.3.5.2.1 Successful implementation of the remedial actions under Alternative 5 would be effective at reducing risk over the long-term through removal of all surface and subsurface MEC. The depth of MEC at the MRS is presented in **Table 10.4**. The maximum depth of anticipated explosive hazards lies within the maximum anticipated receptor depth. Implementing Alternative 5 may result in some MEC remaining in areas where ROE is refused. The depths that MEC is detected and removed and whether 100% coverage was attained will be evaluated post-removal to verify that UU/UE is achieved. In the event that UU/UE is not achieved LUCs as described in Alternative 2 would be implemented. In that case, the long-term effectiveness would be ensured through the annual implementation of LUCs in the form of public education of any potential remaining hazards on-site and the installation and maintenance of warning signs. Five-Year Reviews would be conducted to ensure that the LUCs remain protective of potential human receptors.

11.3.5.2.2 Alternative 5 would result in complete removal of MEC in the surface and subsurface of the MRS as defined in **Table 10.4**. Alternative 5 includes the intentional removal and/or treatment of MEC (demolition), thus satisfying the statutory preference for employing treatment as a principal element.

11.3.5.2.3 Implementation of Alternative 5 would result in short-term hazards to workers involved with the surface and subsurface MEC removal activities because of the increased likelihood of MEC exposure. Evacuation of non-essential personnel would be necessary for some locations during MEC removal. However, these hazards would be managed using industry standard safety procedures (e.g., using qualified UXO personnel, enforcement of safe separation distances, engineering controls, etc.), which would also minimize any associated potential risks to the surrounding community. Alternative 5 would cause minimal short-term effects on the environment. This alternative would require vegetation clearing due to the low ground clearance (typically 6 inches) required for the DGM/AGC equipment that would be used. Soil disturbance would occur where TOI are investigated by manual excavation. After removal of MEC from the excavation location, the native soil will be replaced and the area restored, as appropriate. The estimated timeframe for implementing the removal action portion of Alternative 5 is 75 weeks.

11.3.5.2.4 All technologies and methods involved in implementing Alternative 5 are well established and would be technically and administratively implementable. The services and materials required to implement the work are readily available: (1) DGM instruments such as the PDM8® or equivalent are standard for this type of work and easily obtainable; (2) AGC instruments such as the MPV, UltraTEM, or equivalent are standard for this type of work and a DoD Advanced Geophysical Classification Accreditation Program (DAGCAP)-certified contractor would be used; (3) Similarly, handheld analog detectors can easily be obtained to support the MEC removal effort; and (4) UXO-qualified personnel who are specially trained for EOD work and who would support the DGM/AGC and conduct any MEC removal would be readily available. Conversely, Alternative 5 is dependent on landowner participation, ROEs must be granted or renewed for the work to occur. Although equipment and personnel required to complete Alternative 5 are readily available, if implementation of the alternatives throughout the MRS is limited by ROE, the overall effectiveness would decrease.

11.3.5.2.5 The TPV cost of implementing Alternative 5 at the Kanaio LTA MRS is estimated as $23,256,301 (**Table J.1** and **Appendix J**). In the event that Alternative 5 does not achieve UU/UE, Five-Year Reviews would be required. Cost for five-year reviews is not included.

11.4 FIVE-YEAR REVIEWS

While not a specific component of the remedies described in the previous subchapters, five-year reviews would also be required for any remedial alternative under which hazardous substances, pollutants or contaminants remain above levels allowing UU/UE following remedy implementation. These reviews, as outlined in Section 121 of CERCLA, as amended by the Superfund Amendments and Reauthorization Act, and Section 300.430(f)(ii) of the NCP, are conducted to determine if the remedial alternative continues to minimize human health risks and continues to be protective of human health, safety, and the environment. Five-year reviews would be required for Alternatives 2, 3, and 4 and are included in the cost estimates discussed in **Appendix J** and summarized in **Table J.1**.

11.5 COMPARATIVE ANALYSIS OF ALTERNATIVES

The detailed analysis performed in **Section 11.3** discussed the degree of compliance to the evaluation criteria for each remedial alternative. This section provides a comparative analysis of each remedial alternative (in relation to one another) with respect to each of the NCP evaluation criteria (**Subchapter 11.2**). The purpose of this evaluation is to identify the relative advantages and disadvantages of each alternative. **Table J.1** summarizes the alternative costs by their component elements. **Table 11.1** summarizes the results of the comparative analysis.

11.5.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Remedial Alternatives 2, 3, 4, and 5 would all be protective of human health and the environment by addressing the exposure of receptors to MEC such that there are no unacceptable risks remaining at the Kanaio LTA MRS. Alternative 1 (No Action), which does not include any remedial technologies is only included in the FS to provide a baseline for comparison. Remedial alternatives are either protective or not and, therefore, no comparison of overall protectiveness is possible between alternatives.

11.5.2 COMPLIANCE WITH ARARS

All remedial alternatives identified to address MEC risk at the Kanaio LTA MRS comply with ARARs where applicable. There are no chemical-specific or location-specific ARARs identified for any alternatives. Action-Specific ARARs HRS 128D, HERL Part 1 and HAR 11 451, SCP are applicable to all alternatives. Alternatives 3, 4, and 5 will include MEC disposal if MEC is encountered and will comply with RCRA Subpart X.

11.5.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

No actions would be taken under Alternative 1 to address the explosive hazards associated with residual surface and subsurface MEC at the MRS. Alternative 1 would not provide long-term effectiveness and permanence. Notably, there are different degrees of long-term effectiveness and permanence associated with Alternatives 2, 3, 4, and 5. Alternatives 3 through 5 are more effective over the long-term and more permanent than Alternative 2 because they involve some measure of MEC removal. Of the alternatives, Alternative 5 is the most effective because the MEC removal is complete resulting in UU/UE.

11.5.4 REDUCTION OF TMV THROUGH TREATMENT

Alternative 1 takes no actions, it does not provide any reduction of the toxicity, mobility, or volume of MEC. Alternative 2 does not implement any treatment technologies, therefore does not provide any reduction of the toxicity, mobility, or volume of MEC. Alternatives 3 through 5 achieve reduction in TMV of wastes because they all involve some measure of MEC removal/disposal. Of these alternatives, Alternative 5 achieves the greatest reduction in TMV of wastes because the associated MEC removal/disposal includes both surface and subsurface MEC. The MEC removal associated with Alternative 3 only focuses on potential MEC located on the surface; therefore, the reduction achieved with Alternative 3 is not as great as with Alternative 4 or 5. The MEC removal associated with Alternative 4 only focuses on potential MEC located in a portion of the MRS; therefore, the reduction achieved with Alternatives 4 is not as great as with Alternative 5.

11.5.5 SHORT-TERM EFFECTIVENESS

Alternative 1 would take no action and there are no adverse short-term effects, additionally Alternative 1 would not take any time to implement. Implementation of Alternatives 2 through 5 would result in short-term hazards to workers involved with the MEC removal activities or the installation of warning signs because of the increased likelihood of MEC exposure. Of Alternatives 2, 3, 4, and 5, Alternatives 3 through 5 would present the greatest short-term hazards to workers because the associated MEC removal actions. In all cases, hazards to workers during implementation of the alternatives would be managed using industry standard safety procedures (e.g., using qualified UXO personnel, enforcement of safe separation distances, engineering controls, etc.), which would also minimize any associated potential risks to the surrounding community. Alternatives 2 through 5 would not cause any adverse short-term effects on the environment. The estimated timeframe for implementing the remedial actions of Alternative 2 is 2 weeks, Alternative 3 is 54 weeks, Alternative 4 is 18 weeks, and Alternative 5 is 75 weeks. Maintenance of warning signs and distribution of public educational materials will continue to be implemented annually.

11.5.6 IMPLEMENTABILITY

There are no implementability limitations associated with Alternative 1. Alternatives 2, 3, 4, and 5 are all technically and administratively feasible but require (1) specialized personnel and equipment to implement MEC removal and (2) the development of detailed work plans. Additionally, ROE is required to perform any remedial action and implementation of these alternatives is dependent on landowner participation.

11.5.7 COST

Since no action would be implemented under Alternative 1, there are no costs associated with this alternative. The TPV of implementing Alternative 2 would be $639,694. The TPV of implementing Alternative 3 would be $15,128,084. The TPV of implementing Alternative 4 would be $3,344,876. The TPV of implementing Alternative 5 would be $23,256,301. Alternative 5 has the highest costs. Alternative 5 is more expensive than Alternatives 3 and 4 because it requires a complete removal of potential MEC, both surface and subsurface, while Alternative 3 only involves a surface MEC removal and Alternative 4 only involves a portion of the MRS. Alternative 2 is the least expensive of the three acceptable remedial alternatives as it does not involve a MEC removal action, only LUCs. Both Alternatives 2, 3, and 4 would require follow-on costs (i.e., O&M, periodic, or Five-Year Reviews). **Table J.1** summarizes costs for all alternatives, and **Appendix J** provides additional cost information.

11.5.8 STATE ACCEPTANCE

Hawaii State acceptance cannot be evaluated and assessed until comments on the FS and PP are received.

11.5.9 COMMUNITY ACCEPTANCE

Community acceptance cannot be evaluated fully until input is received on the FS (this document) and a PP is prepared and submitted for public comment.

11.6 CONCLUSIONS

The remedial alternatives identified to address MEC risk at the Kanaio LTA MRS were evaluated against the NCP evaluation criteria. The comparative analysis of alternatives was conducted using the current CSM for the Kanaio LTA MRS, which is based on the present state of knowledge concerning contamination and both current and reasonably anticipated future land use. This FS evaluates various alternatives but does not select an alternative for future response actions. The selection of an alternative must be made by the stakeholders following review of this FS. The preferred alternative will be identified in a subsequent document, the PP, which will be prepared and submitted separately for public comment. A DD will then be issued to present the selected remedy for the Kanaio LTA MRS.

Table 11.1 Comparison of Remedial Alternatives

CERCLA Evaluation Criteria	Alternative 1 No Action	Alternative 2 LUCs	Alternative 3 Surface MEC Removal with LUCs	Alternative 4 Focused Surface and Subsurface MEC Removal and LUCS	Alternative 5 Complete Surface and Subsurface MEC Removal
Protective of Human Health and the Environment	No	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable	Yes Change in Decision Logic to Assess Risk (Unacceptable to Acceptable)
Complies with Applicable or Relevant and Appropriate Requirements	No	Yes	Yes	Yes	Yes
Effective and Permanent	No	Medium	High	High	Highest
Reduces Toxicity, Mobility, or Volume through Treatment	None (no treatment)	None (no treatment)	Reduction in volume of MEC on ground surface	Reduction in volume of MEC on ground surface and in subsurface in 126-acre “focused” area	Reduction in volume of MEC on ground surface and in subsurface
Short-Term Effectiveness	No short-term hazards to workers and surrounding area	Some short-term hazards to workers and surrounding area	Significant short-term hazards to workers and surrounding area	Greatest short-term hazards to workers and surrounding area	Greatest short-term hazards to workers and surrounding area
Implementable	Readily Implementable	Readily Implementable	Readily Implementable	Readily Implementable	Readily Implementable
State Acceptance		To be determined during preparation of the Proposed Plan			
Community Acceptance		To be determined during preparation of the Proposed Plan			
Cost (1)	$0	$639,694	$15,128,084	$3,344,876	$23,256,301

(1) Costs shown are based on alternative implementation duration estimates with recurring costs based on 30-year planning horizons specified in the RI/FS Guidance (USEPA, 1988) for the purposes of evaluating and comparing alternatives with a 20% contingency reported as a TPV. The TPV is based on a discount rate of 7 percent. Details of the cost estimates and the development of the TPVs are provided in **Appendix J.**

12.0 References

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Appendix I
Risk Management Methodology Alternatives Matrices

The Risk Management Methodology (RMM) Matrices for the Kanaio LTA MRS.

Table I.1 Risk Management Methodology: Alternative 2, Public Education and Warning Signs (LUCs), Kanaio LTA MRS

Matrix 1: Likelihood of Encounter

Likelihood of Encounter (*Amount of MEC versus Access Conditions*)		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	**Category I (Most)**	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	Occasional	Seldom
	Category III	Likely	Occasional	Seldom	Unlikely
	Category IV	Occasional	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Rationale: *Implementing LUCs as described would not change the amount of MEC or the access conditions.*

HUA Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
King's Trail Baseline Conditions: 🟪
HUA Conditions After Remedial Response: 🟦
LUA Conditions After Remedial Response: 🟨
King's Trail Conditions After Remedial Response: 🟪
Result of Implementing Remedial Alternative ➡

Matrix 2: Severity of Incident

Severity of Explosive Incident (*Severity vs. Likelihood of Encounter*)		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	**Catastrophic/Critical**	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Rationale: *Implementing LUCs as described would not change the severity of an unplanned detonation (see Matrix 1).*

HUA and King's Trail Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
HUA and King's Trail Conditions After Remedial Response: 🟦
LUA Conditions After Remedial Response: 🟨
Result of Implementing Remedial Alternative ➡

Matrix 3: Likelihood of Detonation

Likelihood of Detonation (*Sensitivity vs. Likelihood to Impart Energy*)		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	**High**	1	1	3
	Moderate	1	2 ➡	3
	Low	1	3	3
	Not Sensitive	2	3	3

Rationale: *Implementing LUCs as described would affect human behavior, decreasing the likelihood to impart energy on an item.*

HUA, LUA, and King's Trail Baseline Conditions: 🟦
HUA, LUA, and King's Trail Conditions After Remedial Response: 🟦
Result of Implementing Remedial Alternative ➡

Matrix 4: Acceptable and Unacceptable Site Conditions

	Acceptable and Unacceptable Site Conditions	Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	**1**	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable** ↓	Acceptable	Acceptable
	3	**Unacceptable**	**Acceptable**	Acceptable	Acceptable

CONCLUSION: *Implementing Alternative 2 would change the site risk conditions from the baseline under current and anticipated future conditions.*

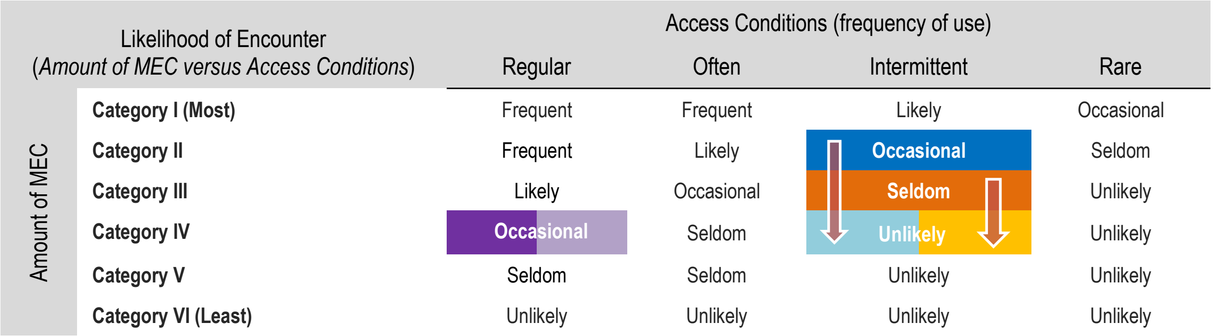
HUA, LUA, and King's Trail Baseline Conditions: 🟦

HUA, LUA, and King's Trail Conditions After Remedial Response: 🟦

Result of Implementing Remedial Alternative ➡

Table I.2 Risk Management Methodology: Alternative 3, Complete Surface MEC Removal and LUCs, Kanaio LTA MRS

Matrix 1: Likelihood of Encounter

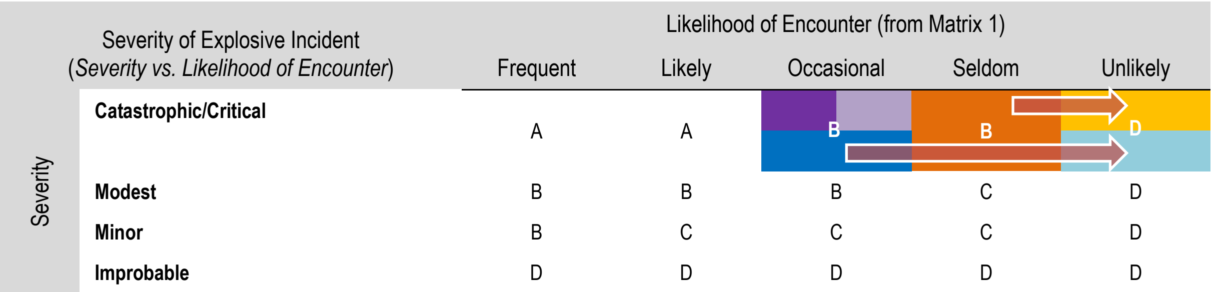


Likelihood of Encounter (*Amount of MEC versus Access Conditions*)		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	**Category I (Most)**	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	**Occasional**	Seldom
	Category III	Likely	Occasional	**Seldom**	Unlikely
	Category IV	**Occasional**	Seldom	**Unlikely**	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	Unlikely	Unlikely	Unlikely	Unlikely

Rationale: *The surface MEC removal would reduce the amount of MEC via source removal.*

HUA Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
King's Trail Baseline Conditions: 🟪
HUA Conditions After Remedial Response: 🟦
LUA Conditions After Remedial Response: 🟨
King's Trail Conditions After Remedial Response: 🟪
Result of Implementing Remedial Alternative ➡

Matrix 2: Severity of Incident

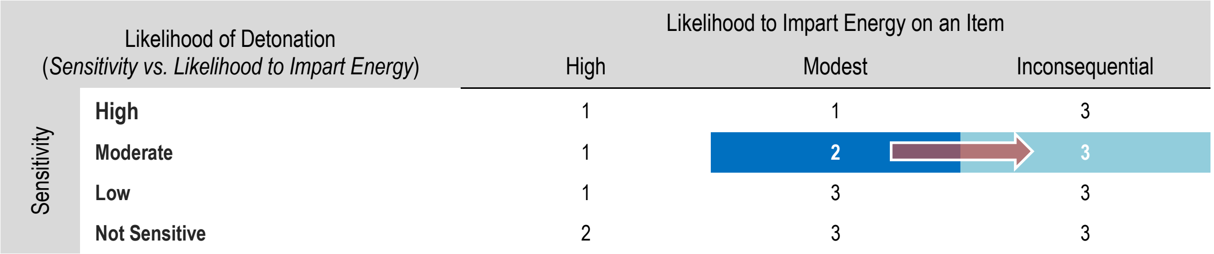


Severity of Explosive Incident (*Severity vs. Likelihood of Encounter*)		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	**Catastrophic/Critical**	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Rationale: *The surface MEC removal would reduce the likelihood of encounter via source removal (see Matrix 1).*

HUA Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
King's Trail Baseline Conditions: 🟪
HUA Conditions After Remedial Response: 🟦
LUA Conditions After Remedial Response: 🟨
King's Trail Conditions After Remedial Response: 🟪
Result of Implementing Remedial Alternative ➡

Matrix 3: Likelihood of Detonation

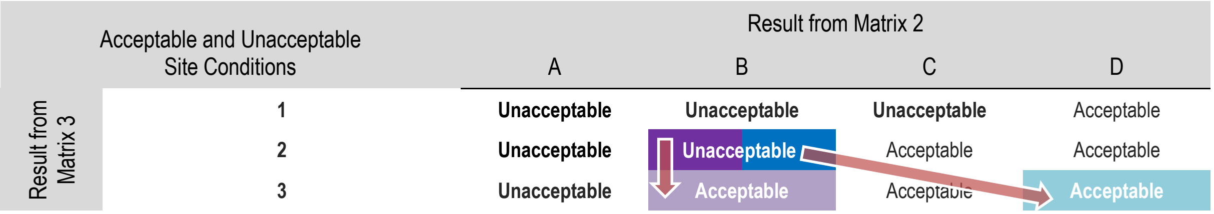


Likelihood of Detonation (*Sensitivity vs. Likelihood to Impart Energy*)		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	**High**	1	1	3
	Moderate	1	**2**	**3**
	Low	1	3	3
	Not Sensitive	2	3	3

Rationale: *Implementing LUCs as described would affect human behavior, decreasing the likelihood to impart energy on an item.*

HUA, LUA, and King's Trail Baseline Conditions: 🟦
HUA, LUA, and King's Trail Conditions After Remedial Response: 🟦
Result of Implementing Remedial Alternative ➡

Matrix 4: Acceptable and Unacceptable Site Conditions



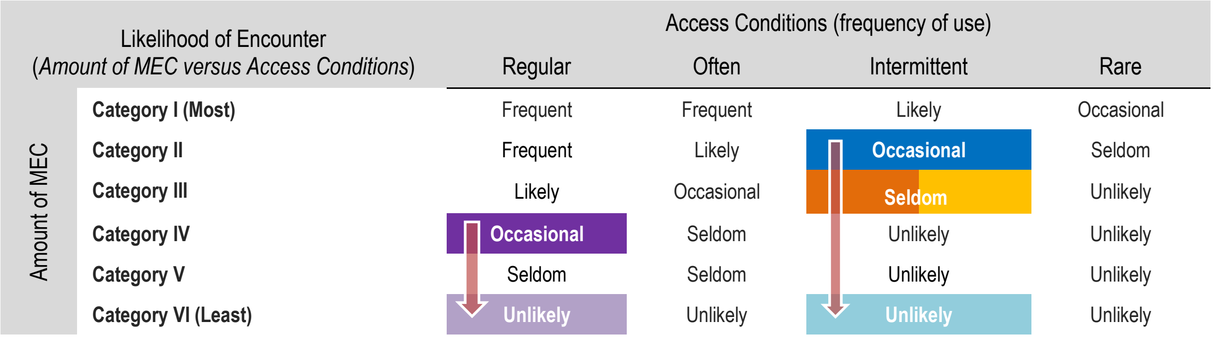
	Acceptable and Unacceptable Site Conditions	Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	**1**	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable**	Acceptable	Acceptable
	3	**Unacceptable**	**Acceptable**	Acceptable	**Acceptable**

CONCLUSION: *Implementing Alternative 3 would change the site risk conditions from the baseline under current and anticipated future conditions.*

HUA and LUA Baseline Conditions: 🟦
King's Trail Baseline Conditions: 🟪
HUA and LUA Conditions After Remedial Response: 🟦
King's Trail Conditions After Remedial Response: 🟪
Result of Implementing Remedial Alternative ➡

Table I.3 Risk Management Methodology: Alternative 4, Focused Surface and Sub-surface MEC Removal and LUCs, Kanaio LTA MRS

Matrix 1: Likelihood of Encounter

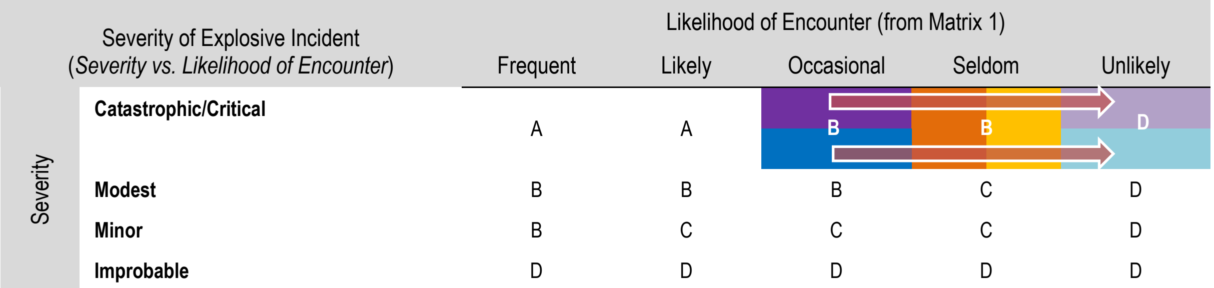


	Likelihood of Encounter (*Amount of MEC versus Access Conditions*)	Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	**Category I (Most)**	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	**Occasional**	Seldom
	Category III	Likely	Occasional	**Seldom**	Unlikely
	Category IV	**Occasional**	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	**Unlikely**	Unlikely	**Unlikely**	Unlikely

Rationale: *The focused surface and subsurface MEC removal of the HUA and King's Trail would reduce the amount of MEC via source removal. Implementing LUCs as described would not change the amount of MEC or the access conditions.*

HUA Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
King's Trail Baseline Conditions: 🟪
HUA Conditions After Remedial Response: ▨
LUA Conditions After Remedial Response: 🟨
King's Trail Conditions After Remedial Response: ▨
Result of Implementing Remedial Alternative →

Matrix 2: Severity of Incident

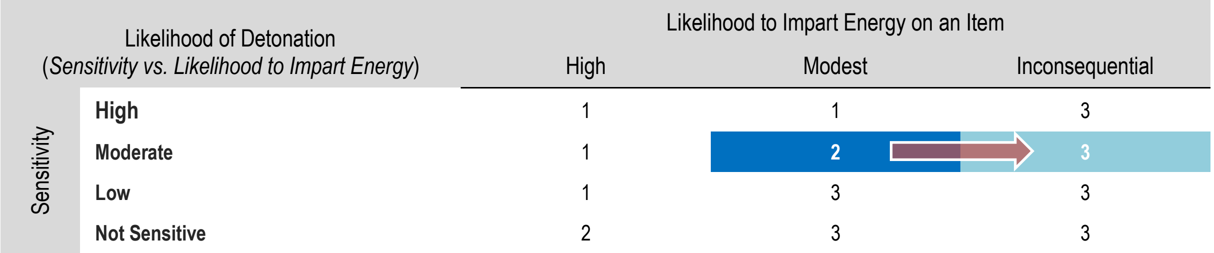


	Severity of Explosive Incident (*Severity vs. Likelihood of Encounter*)	Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	**Catastrophic/Critical**	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Rationale: *The focused surface and subsurface MEC removal of the HUA and King's Trail would reduce the likelihood of encounter via source removal (see Matrix 1). Implementing LUCs as described would not change the severity of an unplanned detonation (see Matrix 1).*

HUA Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
King's Trail Baseline Conditions: 🟪
HUA Conditions After Remedial Response: ▨
LUA Conditions After Remedial Response: 🟨
King's Trail Conditions After Remedial Response: ▨
Result of Implementing Remedial Alternative →

Matrix 3: Likelihood of Detonation

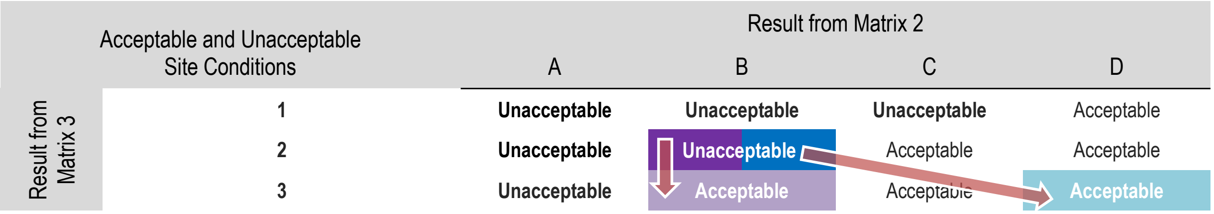


	Likelihood of Detonation (*Sensitivity vs. Likelihood to Impart Energy*)	Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	**High**	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2	3	3

Rationale: *Implementing LUCs as described would affect human behavior, decreasing the likelihood to impart energy on an item.*

HUA, LUA, and King's Trail Baseline Conditions: 🟦
HUA, LUA, and King's Trail Conditions After Remedial Response: ▨
Result of Implementing Remedial Alternative →

Matrix 4: Acceptable and Unacceptable Site Conditions



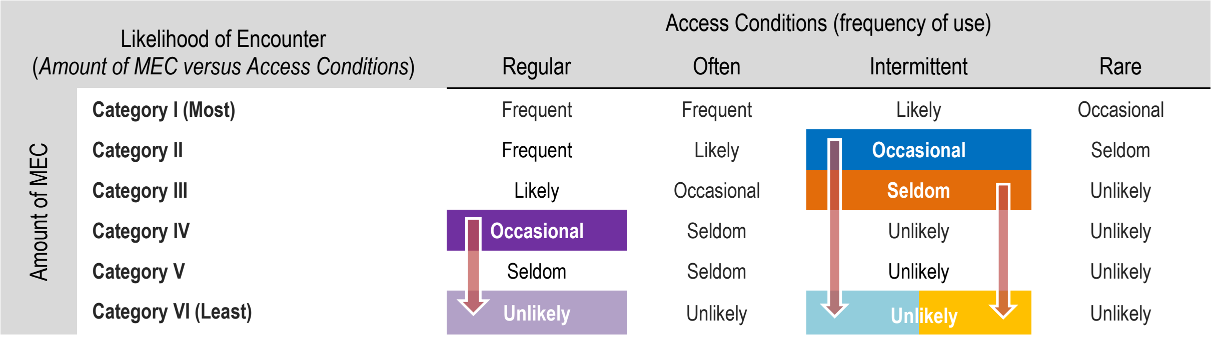
Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	1	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable**	Acceptable	Acceptable
	3	**Unacceptable**	**Acceptable**	Acceptable	**Acceptable**

CONCLUSION: *Implementing Alternative 4 would change the site risk conditions from the baseline under current and anticipated future conditions.*

HUA and King's Trail Baseline Conditions:	🟦	HUA Conditions After Remedial Response:	🟦	Result of Implementing Remedial Alternative	➡
LUA Baseline Conditions:	🟪	LUA and King's Trail Conditions After Remedial Response:	🟪		

Table I.4 Risk Management Methodology: Alternative 5, Complete Surface and Subsurface MEC Removal (UU/UE), Kanaio LTA MRS

Matrix 1: Likelihood of Encounter

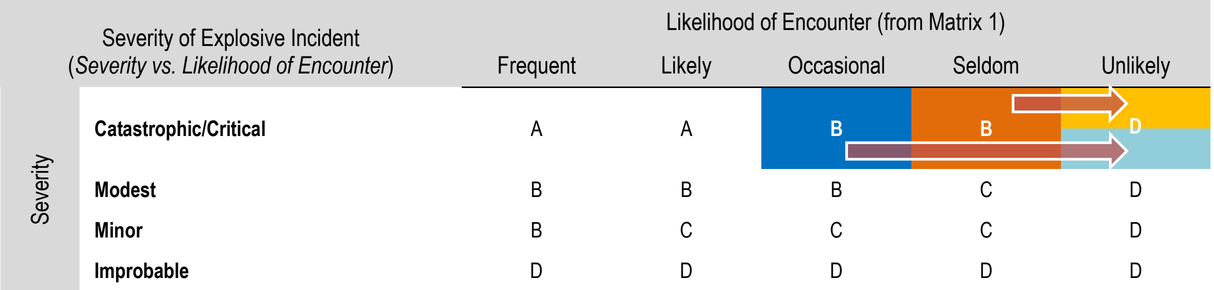


Likelihood of Encounter (*Amount of MEC versus Access Conditions*)		Access Conditions (frequency of use)			
		Regular	Often	Intermittent	Rare
Amount of MEC	**Category I (Most)**	Frequent	Frequent	Likely	Occasional
	Category II	Frequent	Likely	**Occasional**	Seldom
	Category III	Likely	Occasional	**Seldom**	Unlikely
	Category IV	**Occasional**	Seldom	Unlikely	Unlikely
	Category V	Seldom	Seldom	Unlikely	Unlikely
	Category VI (Least)	**Unlikely**	Unlikely	**Unlikely**	Unlikely

Rationale: *The complete surface and subsurface MEC removal would reduce the amount of MEC to Category VI (Least) via source removal and achieve UU/UE.*

HUA Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
King's Trail Baseline Conditions: 🟪
HUA Conditions After Remedial Response: ▨
LUA Conditions After Remedial Response: 🟨
King's Trail Conditions After Remedial Response: ▧
Result of Implementing Remedial Alternative →

Matrix 2: Severity of Incident

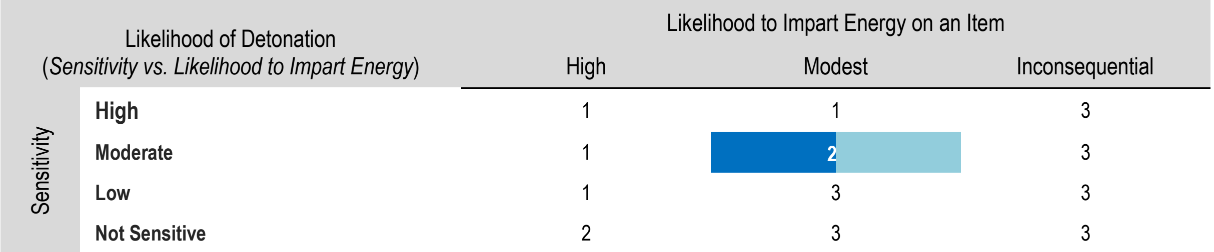


Severity of Explosive Incident (*Severity vs. Likelihood of Encounter*)		Likelihood of Encounter (from Matrix 1)				
		Frequent	Likely	Occasional	Seldom	Unlikely
Severity	**Catastrophic/Critical**	A	A	B	B	D
	Modest	B	B	B	C	D
	Minor	B	C	C	C	D
	Improbable	D	D	D	D	D

Rationale: *The surface and subsurface MEC removal would reduce the likelihood of encounter via source removal (see Matrix 1).*

HUA and King's Trail Baseline Conditions: 🟦
LUA Baseline Conditions: 🟧
HUA and King's Trail Conditions After Remedial Response: ▨
LUA Conditions After Remedial Response: 🟨
Result of Implementing Remedial Alternative →

Matrix 3: Likelihood of Detonation



Likelihood of Detonation (*Sensitivity vs. Likelihood to Impart Energy*)		Likelihood to Impart Energy on an Item		
		High	Modest	Inconsequential
Sensitivity	**High**	1	1	3
	Moderate	1	2	3
	Low	1	3	3
	Not Sensitive	2	3	3

Rationale: *The surface and subsurface MEC removal would not affect human behavior, resulting in no change to the likelihood of detonation.*

HUA, LUA, and King's Trail Baseline Conditions: 🟦
HUA, LUA, and King's Trail Conditions After Remedial Response: ▨
Result of Implementing Remedial Alternative →

Matrix 4: Acceptable and Unacceptable Site Conditions

Acceptable and Unacceptable Site Conditions		Result from Matrix 2			
		A	B	C	D
Result from Matrix 3	**1**	**Unacceptable**	**Unacceptable**	**Unacceptable**	Acceptable
	2	**Unacceptable**	**Unacceptable**	Acceptable	Acceptable
	3	**Unacceptable**	Acceptable	Acceptable	Acceptable

CONCLUSION: *Implementing Alternative 5 would change the site risk conditions from the baseline under current and anticipated future conditions.*

HUA, LUA, and King's Trail Baseline Conditions: 🟦

HUA, LUA, and King's Trail Conditions After Remedial Response: ▨

Result of Implementing Remedial Alternative ➡

Appendix J
Cost Backup

J.1 OVERVIEW

J.1.1 INTRODUCTION

This appendix presents the assumptions used to calculate the costs for the various remedial alternatives presented in the FS for MEC. Each set of alternatives comprises one or more discrete components (e.g., land use controls, MEC removal, soil excavation, etc.). The costs for each component are totaled to provide the overall cost for the alternative. For this reason, the cost assumptions are presented for each component rather than by remedial alternative. The cost breakdown for each remedial alternative is presented in **Table J.1.**

J.1.2 GENERAL COST ASSUMPTIONS

J.1.2.1 The total costs for each for each remedial alternative include direct, indirect, and long-term O&M costs. Direct costs are those costs associated with the implementation of the alternative. Indirect costs are those costs associated with administration, oversight, and contingencies. For periodic costs, such as five-year reviews and O&M, the estimate is based on a project life of 30 years for consistency and comparability as well as in accordance with EPA guidance. Cost estimates presented are order-of-magnitude level estimates based on a variety of information including productivity estimates (based on MRS conditions), cost estimating guides, and prior experience at the MRS. The actual costs will depend on true labor rates, actual weather conditions, final project scope, and other variable factors fully developed during pre-design.

J.1.2.2 In accordance with USEPA guidance, a present value analysis is conducted to evaluate costs (capital and O&M) that occur over different periods. The TPV is the amount needed to be set aside at the initial point in time (the “base year,” or “Year 0”) to ensure funds will be available in the future as they are needed. A discount rate of 7 percent was used to estimate TPV per the USEPA guidance, A Guide to Developing and Documenting Cost Estimates During the Feasibility Study, (USEPA, 2000). It should be noted that while USEPA suggests the TPV be presented in the FS, USACE projects are not typically funded in this way. For this reason, the total non-discounted constant dollar cost provides a better indication of the total cost to USACE.

J.1.2.3 Also in accordance with USEPA (2000) guidance, a contingency cost is factored into the cost estimate to address unknowns, unforeseen circumstances, or unanticipated conditions. For the purposes of the FS, the contingency is applied as a percentage of the total cost of construction or O&M activities costs, rather than being applied to individual cost elements. Scope contingency is included to cover unknown costs due to scope changes that may occur during design, and typically ranges from 10 to 25 percent. Bid contingency represents costs that are unforeseeable at the time of estimate preparation, which are likely to become known as the remedial action construction or O&M proceeds, and typically ranges from 10 to 20 percent. For this FS cost estimate, scope and bid contingency costs were each estimated to be 10 percent for a total overall contingency of 20 percent.

J.1.2.4 Remedial action alternative cost estimates for the detailed analysis are intended to provide a measure of total resource costs over time (i.e., “life cycle costs”) associated with any given alternative. As such, these estimates generally are based on more detailed information and should achieve a greater level of accuracy than screening-level estimates. The detailed analysis level accuracy range of –30 to +50 percent means that, for an estimate of $100,000, the actual cost of an alternative is expected to be between $70,000 and $150,000 (USEPA, 2000).

J.2 COST ESTIMATE ASSUMPTIONS FOR ALTERNATIVE COMPONENTS

J.2.1 COMPONENTS OF MUNITIONS AND EXPLOSIVES OF CONCERN ALTERNATIVES

The cost assumptions for the various components of each remedial alternative for MEC are presented below. The costs for all components assume right of entry has been granted for 100% of site acreage. **Table J.1** includes the cost summaries for the remedial alternatives.

J.2.1.1 PLANNING, REPORTING, AND MEETINGS

This component includes the costs for implementing the systematic project planning (SPP) process, development of a Project Management Plan/Quality Assurance Surveillance Plan, Remedial Action Work Plan (including all supporting plans), Site-Specific Final Report, and After-Action Report (for MEC). For SPP, three meetings are assumed coupled with Public Meetings same day and include associated costs for travel to Maui. These costs are capital costs that are assumed to occur in the base year (Year 0). This component does not include the costs for five-year reviews, which are addressed separately (see below).

J.2.1.2 IMPLEMENTATION OF LAND USE CONTROLS

This component includes the base year (Year 0) costs for installation of warning signs at Kanaio LTA access points (e.g., Along the highway to the north and the hiking trails to the south) along with the production and distribution of educational materials.

J.2.1.3 MAINTENANCE OF LAND USE CONTROLS

This component includes the costs for purchase and replacement of 5 warning signs per year (roughly 20%) along with the yearly production and distribution of educational materials. In the base year – Year 0, costs include the installation of warning signs at Kanaio LTA access points.

J.2.1.4 VEGETATION REMOVAL

J.2.1.4.1 Because of the geographic profile of the site and experience from past activities there is very little to no vegetation on site therefore vegetation removal is not expected to be impactful to the overall costs of any of the alternatives.

J.2.1.5 SURFACE MEC REMOVAL

J.2.1.5.1 The costs for this component assume a visual surface removal of MEC over the entire 1983-acre MRS. Production estimated based on adjusted actual average production of clearance during the RI phase, working 10-hour days and 5-day weeks.

J.2.1.5.2 If surface MEC is recovered, each item will be photographed and cataloged and consolidated or BIP. Demolition shots are assumed to occur once a week during the surface MEC removal.

J.2.1.5.3 Costs are based on an estimated 52-week surface clearance effort. Surface MEC clearance estimate is based upon a clearance rate of 1.5 acres per day per team and utilizing 5 teams for the roughly 1834 acres of lava field and a clearance rate of 2 acres per day per team and utilizing 2 teams for the roughly 149 acres of area that is covered in soil, each team consisting of 1 UXO Technician III (Team Lead) and 5 UXO Technicians II. The clearances of the lava field area and soil area can occur simultaneously. A Senior UXO Supervisor (SUXOS)/site manager and a UXO Quality Control Specialist (UXOQCS)/UXO Safety Officer (UXOSO) will be maintained for the duration of field operations. A two-week management overlap is assumed for the surface MEC removal operations to give an overall duration of 54 weeks.

J.2.1.5.4 Costs are duration-based and include supervisory costs, labor, airfare/travel, and per diem. Additional costs include rental vehicles, equipment, shipping, sanitation, communications, and other associated field purchases and equipment rentals. Disposal costs for storage and disposal of MD are included as well as demolition costs for consolidated shot/BIP procedures.

J.2.1.6 FOCUSED SURFACE AND SUBSURFACE MEC REMOVAL

J.2.1.6.1 The costs for this component assume a complete analog survey over the 126-acre “focus” area in the MRS. The costs for this component assume onsite personnel consist of a site management team of a Site Manager, UXOSO, and UXOQCS. A SUXOS will be present during intrusive operations. Analog investigation of anomalies will be conducted by three teams, each led by a UXO Technician III and including three UXO Technicians II. Production estimated based on adjusted actual average production during the RI, working 10-hour days and 5-day weeks. A one-week overlap is assumed for the MEC removal operations to give an overall duration of 18 weeks.

J.2.1.6.2 If surface MEC is recovered, each item will be photographed and cataloged and consolidated or BIP. Demolition shots are assumed to occur once a week during the focused MEC removal.

J.2.1.6.3 Costs based on a 17-week analog survey. The Analog survey estimate is based on a production rate of 0.5 acres per day each for three teams consisting of 3 UXO Technician I and 1 UXO Technician II over the 126-acre focus area

J.2.1.6.4 Costs are duration-based and include supervisory costs, labor, airfare/travel, and per diem. Additional costs include rental vehicles, equipment, shipping, sanitation, communications, and other associated field purchases and equipment rentals. Disposal costs for storage and disposal of MD are included as well as demolition costs for BIP procedures.

J.2.1.7 COMPLETE SURFACE AND SUBSURFACE MEC REMOVAL

J.2.1.7.1 The costs for this component assume AGC mapping and intrusive investigation of all TOIs over all the area in the MRS that it is physically possible to perform AGC on, roughly 149 acres, and an analog survey over the rest of the MRS, roughly 1,834. The costs for this component assume onsite personnel consist of a site management team of a Site Manager, UXOSO, and UXOQCS. A SUXOS will be present during intrusive operations. Dynamic AGC will be conducted by two teams consisting of an instrument operator with a UXO Technician II escort. Intrusive investigation of anomalies will be conducted by two teams, each led by a UXO Technician III and including two UXO Technicians II. Production estimated based on adjusted actual average production during the RI, working 10-hour days and 5-day weeks. A two-week overlap is assumed for the MEC removal operations to give an overall duration of 75 weeks.

J.2.1.7.2 If surface MEC is recovered, each item will be photographed and cataloged and consolidated or BIP. Demolition shots are assumed to occur once a week during the complete surface and subsurface MEC removal.

J.2.1.7.3 Costs based on a 20-week AGC survey, 48 weeks of intrusive investigation, and a 73-week Analog survey. Duration estimate is based on a AGC survey production rate of 0.75 acres per day per team utilizing 3 teams, each consisting of 1 instrument operator and 1 UXO Technician II escort. AGC processing is assumed to require 40 hrs per field team week. The Intrusive investigation is based on a production rate of 125 anomalies per team per day (resulting in an estimated 11,898 TOIs based upon data from the RI; based on an 85% reduction), utilizing 2 teams consisting of 1 UXO Technician III (Team Lead) and 2 UXO Technicians II. Based on the RI data, the average anomaly density is estimated to be 80 anomalies per acre which for 149 acres yields 11,898 anomalies. The Analog survey estimate is based on a production rate of 1 acre per day each for 5 teams consisting of 4 UXO Technician II and 1 UXO Technician III over the 1834 acre lava field. Based on the site layout and duration of the analog survey, the AGC survey and intrusive investigation are assumed to be run in parallel to the analog survey.

J.2.1.7.4 Costs are duration-based and include supervisory costs, labor, airfare/travel, and per diem. Costs include a AGC survey to identify anomalies for removal. Additional costs include rental vehicles, equipment, shipping, sanitation, communications, and other associated field purchases and equipment rentals. Disposal costs for storage and disposal of MD are included as well as demolition costs for BIP procedures.

J.2.1.8 FIVE-YEAR REVIEW

The costs for this component assume recurring five-year reviews conducted over a 30-year period (a total of six reviews: Years 5, 10, 15, 20, 25, and 30). Individual reviews are estimated to cost $83,408. The costs of five-year reviews are included in the Alternative cost estimates.

Table J.1 Cost Summary of Remedial Alternatives

Remedial Components			Costs (1)		
		Alternative 2	Alternative 3	Alternative 4	Alternative 5
Capital (Year 0) Costs	Planning, Reporting, and Meetings	$0	$127,695	$127,695	$127,695
	LUCs (Signs, Educational Materials)	$47,871	$47,871	$47,871	$0
	Surface MEC Removal	$0	$11,945,962	$0	$0
	Complete Surface and Subsurface MEC Removal	$0	$0	$2,126,623	$19,252,556
Year 0 Cost (2)		**$47,871**	**$12,121,528**	**$2,302,189**	**$19,380,250**
Year 0 Cost, plus 20% Contingency		**$57,445**	**$14,545,834**	**$2,762,627**	**$23,256,301**
Periodic Costs	$91,049	$83,408	$83,408	$83,408	$0
	$22,449	$24,597	$24,597	$24,597	$0
Total 30-Year Cost – "Constant Dollars"		**$1,286,229**	**$13,359,887**	**$3,540,547**	**$19,380,251**
Total 30-Year Cost, plus 20% Contingency – TPV (3)		**$639,694**	**$15,128,084**	**$3,344,876**	**$23,256,301**

(1) Unless otherwise noted, costs are estimated in non-discounted "constant dollars" which are not affected by general price inflation.
(2) Includes capital costs of remedial action but excludes long-term monitoring and maintenance.
(3) Total Present Value (TPV) costs are based on a 7 percent discount rate.

Table J.2 Alternative 2. Calculations of Total Present Value (Lower and Upper Ranges)

Year	Capital Cost ($)	Annual Cost ($)	Periodic Cost ($) (5-Year Review)	Total Cost + 0% Tax ($)	Discount Factor at 7%	Present Value at 7%
0	$47,871			$47,871	1.000	$47,871
1		$24,597		$24,597	0.935	$22,988
2		$24,597		$24,597	0.873	$21,484
3		$24,597		$24,597	0.816	$20,079
4		$24,597		$24,597	0.763	$18,765
5		$24,597	$83,408	$108,005	0.713	$77,006
6		$24,597		$24,597	0.666	$16,390
7		$24,597		$24,597	0.623	$15,318
8		$24,597		$24,597	0.582	$14,316
9		$24,597		$24,597	0.544	$13,379
10		$24,597	$83,408	$108,005	0.508	$54,905
11		$24,597		$24,597	0.475	$11,686
12		$24,597		$24,597	0.444	$10,921
13		$24,597		$24,597	0.415	$10,207
14		$24,597		$24,597	0.388	$9,539
15		$24,597	$83,408	$108,005	0.362	$39,146
16		$24,597		$24,597	0.339	$8,332
17		$24,597		$24,597	0.317	$7,787
18		$24,597		$24,597	0.296	$7,277
19		$24,597		$24,597	0.277	$6,801
20		$24,597	$83,408	$108,005	0.258	$27,911
21		$24,597		$24,597	0.242	$5,941
22		$24,597		$24,597	0.226	$5,552
23		$24,597		$24,597	0.211	$5,189
24		$24,597		$24,597	0.197	$4,849
25		$24,597	$83,408	$108,005	0.184	$19,900
26		$24,597		$24,597	0.172	$4,236
27		$24,597		$24,597	0.161	$3,958
28		$24,597		$24,597	0.150	$3,700
29		$24,597		$24,597	0.141	$3,457
30		$24,597	$83,408	$108,005	0.131	$14,189
Total	$47,871	$737,911	$500,447	$1,286,229	TPV	**$533,079**

TPV + 20% Contingency	**$639,694**
Total Cost + 0% Tax ($)	**$1,286,229**
Lower end of TPV Range at -30%	**$373,155**
Upper end of TPV Range at +50%	**$799,618**

Table J.3 Alternative 3. Calculations of Total Present Value (Lower and Upper Ranges)

Year	Capital Cost ($)	Annual Cost ($)	Periodic Cost ($) (5-Year Review)	Total Cost + 0% Tax ($)	Discount Factor at 7%	Present Value at 7%
0	$12,121,529			$12,121,529	1.000	$12,121,529
1		$24,597		$24,597	0.935	$22,988
2		$24,597		$24,597	0.873	$21,484
3		$24,597		$24,597	0.816	$20,079
4		$24,597		$24,597	0.763	$18,765
5		$24,597	$83,408	$108,005	0.713	$77,006
6		$24,597		$24,597	0.666	$16,390
7		$24,597		$24,597	0.623	$15,318
8		$24,597		$24,597	0.582	$14,316
9		$24,597		$24,597	0.544	$13,379
10		$24,597	$83,408	$108,005	0.508	$54,905
11		$24,597		$24,597	0.475	$11,686
12		$24,597		$24,597	0.444	$10,921
13		$24,597		$24,597	0.415	$10,207
14		$24,597		$24,597	0.388	$9,539
15		$24,597	$83,408	$108,005	0.362	$39,146
16		$24,597		$24,597	0.339	$8,332
17		$24,597		$24,597	0.317	$7,787
18		$24,597		$24,597	0.296	$7,277
19		$24,597		$24,597	0.277	$6,801
20		$24,597	$83,408	$108,005	0.258	$27,911
21		$24,597		$24,597	0.242	$5,941
22		$24,597		$24,597	0.226	$5,552
23		$24,597		$24,597	0.211	$5,189
24		$24,597		$24,597	0.197	$4,849
25		$24,597	$83,408	$108,005	0.184	$19,900
26		$24,597		$24,597	0.172	$4,236
27		$24,597		$24,597	0.161	$3,958
28		$24,597		$24,597	0.150	$3,700
29		$24,597		$24,597	0.141	$3,457
30		$24,597	$83,408	$108,005	0.131	$14,189
Total	$12,121,529	$737,911	$500,447	$13,359,887	TPV	**$12,606,737**
					TPV + 20% Contingency	**$15,128,084**
					Total Cost + 0% Tax ($)	**$13,359,887**
					Lower end of TPV Range at -30%	**$8,824,716**
					Upper end of TPV Range at +50%	**$18,910,105**

Table J.4 Alternative 4. Calculations of Total Present Value (Lower and Upper Ranges)

Year	Capital Cost ($)	Annual Cost ($)	Periodic Cost ($) (5-Year Review)	Total Cost + 0% Tax ($)	Discount Factor at 7%	Present Value at 7%
0	$2,302,189			$2,302,189	1.000	$2,302,189
1		$24,597		$24,597	0.935	$22,988
2		$24,597		$24,597	0.873	$21,484
3		$24,597		$24,597	0.816	$20,079
4		$24,597		$24,597	0.763	$18,765
5		$24,597	$83,408	$108,005	0.713	$77,006
6		$24,597		$24,597	0.666	$16,390
7		$24,597		$24,597	0.623	$15,318
8		$24,597		$24,597	0.582	$14,316
9		$24,597		$24,597	0.544	$13,379
10		$24,597	$83,408	$108,005	0.508	$54,905
11		$24,597		$24,597	0.475	$11,686
12		$24,597		$24,597	0.444	$10,921
13		$24,597		$24,597	0.415	$10,207
14		$24,597		$24,597	0.388	$9,539
15		$24,597	$83,408	$108,005	0.362	$39,146
16		$24,597		$24,597	0.339	$8,332
17		$24,597		$24,597	0.317	$7,787
18		$24,597		$24,597	0.296	$7,277
19		$24,597		$24,597	0.277	$6,801
20		$24,597	$83,408	$108,005	0.258	$27,911
21		$24,597		$24,597	0.242	$5,941
22		$24,597		$24,597	0.226	$5,552
23		$24,597		$24,597	0.211	$5,189
24		$24,597		$24,597	0.197	$4,849
25		$24,597	$83,408	$108,005	0.184	$19,900
26		$24,597		$24,597	0.172	$4,236
27		$24,597		$24,597	0.161	$3,958
28		$24,597		$24,597	0.150	$3,700
29		$24,597		$24,597	0.141	$3,457
30		$24,597	$83,408	$108,005	0.131	$14,189
Total	$2,302,189	$737,911	$500,447	$3,540,547	TPV	**$2,787,397**
					TPV + 20% Contingency	**$3,344,876**
					Total Cost + 0% Tax ($)	**$3,540,547**
					Lower end of TPV Range at -30%	**$1,951,178**
					Upper end of TPV Range at +50%	**$4,181,095**

Table J.5 Alternative 5. Calculations of Total Present Value (Lower and Upper Ranges)

Year	Capital Cost ($)	Annual Cost ($)	Periodic Cost ($) (5-Year Review)	Total Cost + 0% Tax ($)	Discount Factor at 7%	Present Value at 7%
0	$19,380,251			$19,380,251	1.000	$19,380,251
1					0.935	
2					0.873	
3					0.816	
4					0.763	
5					0.713	
6					0.666	
7					0.623	
8					0.582	
9					0.544	
10					0.508	
11					0.475	
12					0.444	
13					0.415	
14					0.388	
15					0.362	
16					0.339	
17					0.317	
18					0.296	
19					0.277	
20					0.258	
21					0.242	
22					0.226	
23					0.211	
24					0.197	
25					0.184	
26					0.172	
27					0.161	
28					0.150	
29					0.141	
30					0.131	
Total	$19,380,251			$19,380,251	TPV	$19,380,251
					TPV + 20% Contingency	$23,256,301
					Total Cost + 0% Tax ($)	$19,380,251
					Lower end of TPV Range at -30%	$13,566,176
					Upper end of TPV Range at +50%	$29,070,377