FINAL
FEASIBILITY STUDY GREY GHOST HOUSING AREA – UNDEVELOPED MUNITIONS RESPONSE SITE WSTPT-010-R-02 U.S. ARMY GARRISON WEST POINT WEST POINT, NEW YORK

Prepared for:

United States Army Garrison West Point
Environmental Management Division
667 Ruger Road
West Point, New York 10996

Contract No. W91DR-14-D-009
Task Order: 0005

January 2019

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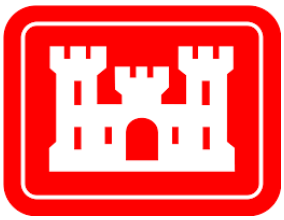

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ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
%	Percent
amsl	Above Mean Sea Level
ARAR	Applicable or Relevant and Appropriate Requirement
bgs	Below Ground Surface
BIP	Blow-in-Place
CDC	Contained Detonation Chamber
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CSM	Conceptual Site Model
DDESB	Department of Defense Explosives Safety Board
DERP	Defense Environmental Restoration Program
DGPS	Differential Global Positioning System
DMM	Discarded Military Munitions
DoD	Department of Defense
DoDM	Department of Defense Manual
EM	Engineering Manual
EMI	Electromagnetic Induction
EOD	Explosive Ordnance Disposal
ESS	Explosives Safety Submission
FDEMI	Frequency-Domain Electromagnetic Induction
FS	Feasibility Study
GGHA–U	Grey Ghost Housing Area – Undeveloped
GPR	Ground Penetrating Radar
GPS	Global Positioning System
HFD	Hazardous Fragment Distance
IA	Institutional Analysis
LIDAR	Light Detecting and Ranging
LUC	Land Use Control
MC	Munitions Constituents
MD	Munitions Debris
MEC	Munitions and Explosives of Concern
MEC HA	Interim Munitions and Explosives of Concern Hazard Assessment Methodology
MMRP	Military Munitions Response Program
MRS	Munitions Response Site
MSD	Minimum Separation Distance
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NTCRA LUCP	Non-Time Critical Removal Action Land Use Control Plan
NYNHP	New York Natural Heritage Program
O&M	Operation and Maintenance
PARS	PARS Environmental, Inc.
PETN	Pentaerythritol Tetranitrate
Plexus	Plexus Scientific Corporation
Plexus/PARS	Plexus/PARS Joint Venture
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goal
RAO	Remedial action objective

ACRONYMS AND ABBREVIATIONS (Continued)

RI	Remedial Investigation
SAM	Sub Audio Magnetics
SAR	Synthetic Aperture Radar
SI	Site Inspection
SUXOS	Senior UXO Supervisor
RTS	Robotic Total Station
TAL	Target Analyte List
TBC	To-Be-Considered
TBD	To-Be-Determined
TDEMI	Time-Domain Electromagnetic Induction
TMV	Toxicity, Mobility, or Volume
TP	Technical Paper
U.S.	United States
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	U.S. Environment Protection Agency
USMAPS	U.S. Military Academy Preparatory School
UU/UE	Unlimited Use/Unrestricted Exposure
UXO	Unexploded Ordnance
UXOSO	UXO Safety Officer
West Point	U.S. Army Garrison West Point
Weston	Weston Solutions, Inc.

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1.0 INTRODUCTION

The United States Army Corps of Engineers (USACE) Baltimore District contracted with the Plexus Scientific Corporation (Plexus)/PARS Environmental, Inc. (PARS) Joint Venture (Plexus/PARS) to complete this Feasibility Study (FS). This FS was prepared under Contract W91DR-14-D-009, Delivery Order 0005 for the Grey Ghost Housing Area – Undeveloped (GGHA – U) Munitions Response Site (MRS; WSTPT-010-R-02) located at the United States (U.S.) Army Garrison West Point (West Point; **Figure 1-1**). The GGHA–U MRS is included in the Defense Environmental Restoration Program's (DERP) Military Munitions Response Program (MMRP). The GGHA–U MRS was designated as an MRS in the MMRP because it includes a former 1,000-inch machine gun and rifle/pistol range complex and unexploded ordnance (UXO), discarded military munitions (DMM), and/or munitions constituents (MC) were suspected to be present.

This FS was developed under the MMRP to address MEC present at the GGHA–U MRS. The GGHA–U MRS was investigated as part of the original Grey Ghost Housing Area MRS (WSTPT-010-R-01) during the Site Inspection (SI) and Remedial Investigation (RI) conducted in 2006 and 2011, respectively. As a result of the RI, the original Grey Ghost Housing Area MRS (WSTPT-010-R-01) was subdivided into the Grey Ghost Housing Area MRS (WSTPT-010-R-01) and the GGHA–U MRS (WSTPT-010-R-02). The GGHA–U MRS is the focus of this FS (**Figure 1-2**).

The RI and FS processes were developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the extent practicable with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This FS was also prepared in accordance with the *Final United States Army Military Munitions Response Program Munitions Response Remedial Investigation / Feasibility Study Guidance* (U.S. Army, 2009) and the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (U.S. Environmental Protection Agency [USEPA], 1988).

1.1 Investigation History and Purpose

In Fiscal Year 2002, the U.S. Congress established the MMRP under the DERP to address MEC and MC located on current and former defense sites. In response to the establishment of the MMRP, the Army conducted investigations consistent with the requirements of CERCLA at the GGHA–U MRS. These investigations are presented in **Table 1-1**.

Table 1-1 Investigation History

Investigation/CERCLA Component	Date Range
Phase 3 Closed, Transferred, Transferring Range Inventory/Preliminary Assessment[1]	2002 to 2004
Historical Records Review/Site Inspection[1]	2004 to 2006
Field Activities/Site Inspection[1]	April 2006 to May 2006
Remedial Investigation[1]	2011 to 2014
1) The GGHA–U MRS (WSTPT-010-R-02) was investigated as part of the original Grey Ghost Housing Area MRS (WSTPT-010-R-01).	

The purpose of this FS is to identify, develop, and perform a detailed analysis of potential remedial alternatives that would meet the remedial action objectives (RAOs), and afford decision-makers adequate information to select the most appropriate remedial alternative for the GGHA–U MRS. The selected alternative is expected to mitigate, reduce, or eliminate the explosive hazards posed to human receptors by MEC, based on the current and intended future use of the property.

The following major steps are involved in the development of this FS:

- Identification of RAOs (Section 1);
- Identification of Applicable or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBC) guidance (Section 2);
- Identification of general response actions (Section 3);
- Identification and screening of potentially applicable remedial technologies and process options for the general response actions (Section 3);
- Development and screening of a range of remedial alternatives based on combinations of the remedial technologies that were retained (Section 4);
- Performance of a detailed analysis for each of the remedial alternatives using the evaluation criteria as required by the NCP (Section 5); and
- Performance of a comparative analysis of the remedial alternatives using the evaluation criteria as required by the NCP (Section 5).

1.2 West Point and GGHA–U MRS Description and History

West Point is located in Orange and Putnam Counties, New York, on the Hudson River. West Point is approximately 50 miles north of New York City and approximately 13 miles south of Newburgh. In its entirety, West Point encompasses 15,974 acres that are designated as three areas, the Main Post, the Military Reservation, and Constitution Island. The Main Post includes the majority of the academic, residential, and support facilities. The Military Reservation is largely undeveloped and contains operational training facilities, including firing ranges and bivouac areas used during the summer to house and train cadets. Constitution Island is located across the Hudson

River from the Main Post and is undeveloped and heavily forested. The GGHA–U MRS encompasses 11 acres within Orange County on the Main Post of West Point (**Figure 1-3**).

The GGHA–U MRS was designated as an MRS in the MMRP because it includes a former 1,000-inch machine gun and rifle/pistol range complex and UXO, DMM, and MC were suspected to be present. The exact location of firing points associated with the 1,000-inch machine gun and the rifle/pistol range complex are unknown, but were located north and outside of the GGHA–U MRS. The direction of fire from both the machine gun range and the rifle/pistol range was to the southwest, into the GGHA–U MRS (**Figure 1-4**). The 1,000-inch machine gun firing range was constructed in 1925 and renovated in 1928, at which time a pistol range was added. The pistol range was to be designed to permit firing at 75, 50, 25, and 15 yards with 12 targets. Operations conducted at the machine gun range occurred from approximately 1920 to 1940. During this time, cadets used the machine gun range for small arms training using a variety of weapon types. The rifle range was located in the area as early as 1939. While investigating the rifle/pistol range complex, the Army discovered a 3-inch Stokes mortar impact area. Based on the U.S. Army's use of the 3-inch Stokes mortar, the GGHA–U MRS could have been used for mortar and/or artillery practice from approximately 1918 to approximately 1945. The Grey Ghost Housing Area, located north and northeast of the GGHA–U, MRS was developed as a housing area in the 1950s (Weston Solutions, Inc. [Weston], 2014).

The GGHA–U MRS is comprised of forested, undeveloped land and includes a closed walking trail within its northern extent. A sign is posted at the eastern limit of the closed walking trail indicating that it is closed and not maintained by West Point. The southern half of the GGHA–U MRS is bound by forested, undeveloped land and operational range. The GGHU–U MRS is bound by the U.S. Military Academy Preparatory School (USMAPS) to the northwest and a residential neighborhood to the northeast. The layout of the GGHA–U MRS is presented on **Figure 1-5**.

1.3 Summary of Site Inspection and Remedial Investigation Results

This section provides a summary of the environmental setting and the results of the SI and the RI conducted at the GGHA–U MRS. The environmental setting and results are discussed in greater detail in the RI.

The SI was conducted from 2004 to 2006 to determine if UXO, DMM, or MC were present at the original Grey Ghost Housing Area MRS. The GGHA–U MRS was investigated as part of the original Grey Ghost Housing Area MRS during the SI. The SI consisted of visual surveys and the collection of one sediment sample and two surface soil samples. The visual surveys identified munitions debris (MD), including a 3-inch Stokes mortar, Stokes mortar fragments, and a fragment from a 37-millimeter projectile, and no MEC. The sediment and soil samples were analyzed for the Target Compound List explosives by USEPA Method 8330 and a subset of Target Analyte List (TAL) metals by USEPA Methods 6010B and 7471A. The following seven TAL metals: antimony, copper, iron, lead, mercury, potassium, and zinc were selected for analysis based on the munitions historically used by West Point. The sediment and soil sampling results were compared

to the residential soil USEPA Region 9 preliminary remediation goals (PRGs), if available. This comparison was made because background data were not available for the West Point area. The comparison indicated that MC (i.e., explosives and metals) were not detected above the USEPA Region 9 PRGs for residential soil. USEPA Region 9 PRGs were not available for one TCL explosive (pentaerythritol tetranitrate (PETN)) and one TAL metal (potassium). PETN was not detected above the reporting limit (0.5 mg/kg), and potassium was not detected above natural occurring concentrations (Sparks, D.L., 2001). Because MD was identified, the SI recommended that the original Grey Ghost Housing Area MRS be further investigated for MEC. The SI also recommended that further investigation for MC was unnecessary unless areas of concern were identified during further investigation (Weston, 2014).

The RI was conducted from 2011 to 2014 to determine the nature and extent of MEC at the original Grey Ghost Housing Area MRS. The GGHA–U MRS was investigated as part of the original Grey Ghost Housing Area MRS during the RI. The RI activities conducted at the GGHA–U MRS consisted of mag and dig surveys and incremental soil sampling. The mag and dig surveys recovered MD, including 35 fragments from unknown munitions and eight 3-inch Stokes mortars (sand-filled), from a depth of one to nine inches below ground surface (bgs). These surveys also recovered one MEC item (UXO: 3-inch Stokes mortar, Mk1 practice round, sand-filled and fuzed) from a depth of five inches bgs. The discovery of a 3-inch Stokes mortar impact area prompted the collection of incremental soil samples for MC analysis. The results of the MC sampling were utilized to determine that MC pathways to potential receptors were incomplete. As previously indicated, the RI recommended that the 24-acre original Grey Ghost Housing Area MRS (WSTPT-010-R-01) be subdivided into the 11-acre GGHA–U MRS (WSTPT-010-R-02) and the 13-acre Grey Ghost Housing Area MRS (WSTPT-010-R-01). The RI recommended no further action for the 13-acre Grey Ghost Housing Area MRS, while the RI recommended that the 11-acre GGHA–U MRS undergo an FS for MEC because MEC and MD were identified in the subsurface (Weston, 2014).

1.3.1 Environmental Setting

1.3.1.1 Climate

The climate of the region is characterized as a humid, continental one. Affected by the semi-permanent Bermuda High, which brings south to southwest warm and humid air, summers are warm with periods of high humidity. July is the hottest month with a mean temperature of 86 degrees Fahrenheit (ºF); January is the coldest month with a mean temperature of 27 ºF. Winters are cold with extended periods of snow accumulation and are influenced by the cold Hudson Bay air masses. Most winters are characterized by one or more warm periods when soil nearly or completely thaws. A third weather pattern that influences the climate of West Point is an air mass that flows inland from the North Atlantic Ocean, bringing cool, cloudy, and damp weather to the region. Prevailing winds are generally westerly (Weston, 2014).

Thunderstorms occur approximately 20 times per year. Tornadoes occur at a frequency of three to four times per year in the region, although no significant tornadoes have occurred at West Point for more than 20 years. Total annual precipitation is greater than 49.5 inches, with monthly precipitation ranging from approximately 3.5 inches (January/February) to approximately 4.9 inches (May) (Weston, 2014).

1.3.1.2 Geology

West Point lies in the Hudson Highlands, a low, rugged mountain range with a zone of metamorphic and igneous rock formations subjected to extensive weathering and erosion. The bedrock geology of the area is leucogranitic gneiss, rusty and gray biotite-quartz-feldspar gneisses, biotite-quartz-plagioclase gneiss, hornblende granite and granitic gneiss, and quartz plagioclase gneiss (Weston, 2014).

The metamorphic rocks of West Point exist in sequences. These sequences are composed of a hard, layered, banded rock, gneiss, which is sometimes intruded by igneous rocks. Marble, quartzite, schist, and amphibolite are other metamorphic rocks present in the Highlands area. The metamorphic rocks were deposited as marine sediments, volcanic ashes, and volcanic rocks. During the Precambrian period, these sediments and rocks were possibly subject to three phases of folding, extensive regional metamorphism, partial melting, and magmatic intrusion. The cantonment area, which is bounded by the Hudson River, is underlain by exposed bedrock and glacial alluvium (Weston, 2014).

The faults mapped at the surface near and within the habitation area at West Point include Long Pond, Crown Ridge, and Highland Brook. The habitation area includes most of the developed areas of West Point. The Long Pond fault trends northeast-southwest along the northwestern boundary of the habitation area and the Storm King Highway (New York Route 218). The Crown Ridge fault also trends northeast-southwest and extends through Lusk Reservoir. The Highland Brook fault trends northwest-southeast along Route 9W and the Storm King Highway (New York Route 218) between the Long Pond and Crown Ridge faults (Weston, 2014).

The surficial geologic formations on the West Point installation are outcroppings, talus, and glacial deposits. During glacier retreat, features were formed along the valley walls, the most prominent one being the Kame terraces. In all but the flat, marshy areas, bedrock can be observed. A thin veneer layer of Pleistocene-age glacial deposits, both stratified and unstratified, overlies the igneous and metamorphic bedrock sequence. The stratified drift consists primarily of sand and gravel deposited in glacial lakes and streams; the unstratified drift consists of glacial till material, which is mainly large boulders and clay, sand, and gravel deposited directly from glacial ice as it progressed or regressed across the area (Weston, 2014).

Site-specific geologic investigations were not conducted for the GGHA–U MRS. Regional geologic maps indicate that the bedrock geology of the original Grey Ghost Housing Area MRS is rusty and gray biotite-quartz-feldspar paragneiss and leucogranitic gneiss (Weston, 2014).

1.3.1.3 Topography

The topography of West Point is described as having moderately steep hills and numerous escarpments. Slopes from 10 to 60 percent (%) are common on the installation. Areas in between the hills are interspersed with small plains, basins, and narrow valleys with slopes less than 3%. The topography of the surrounding region is undulating and rugged. These characteristics, along with the alluvium and till deposits in the lowland areas and the relatively flat valley bottoms of the region, are the result of glaciation (Weston, 2014).

The elevation of the GGHA–U MRS ranges from approximately 310 feet above mean sea level (amsl) at the northern corner to approximately 510 feet amsl at the southern corner. The GGHA–U MRS contains steep terrain and bedrock outcrops. The presence of steep terrain and bedrock outcrops make the GGHA–U MRS difficult to traverse.

1.3.1.4 Soil

The GGHA–U MRS is comprised of sloping Hollis soils and moderately steep Hollis soils. Sloping Hollis soils are the primary soil type located throughout the GGHA–U MRS, and moderately steep Hollis soils comprise the remainder of the GGHA–U MRS. These soil types share the following features:

- Scattered stones, boulders, and bedrock outcrops present on the surface;
- Shallow thickness (10 to 20 inches);
- Well drained to somewhat excessively, well drained;
- Formed in glacial till deposits derived from crystalline rock that is predominantly schist, gneiss, and granite; and
- Naturally high in iron because of the oxidized iron content of the underlying geologic formation (Weston, 2014).

1.3.1.5 Hydrogeology

1.3.1.5.1 Surface Water

No surface water resources exist in the GGHA–U MRS; however, an ephemeral stream was observed along the northern border of the GGHA–U MRS during the SI in 2006. The unnamed ephemeral stream was not identified during the RI in 2011. This stream is not visible in topographic maps or aerial photography of the area; therefore, although this ephemeral stream is considered a surface water feature, it is not considered a surface water resource. In addition to the ephemeral stream, there are multiple surface water bodies located within a three-mile radius of the GGHA–U MRS (e.g., Cragston Lakes, Crow's Nest Brook, and Highland Brook).

1.3.1.5.2 Groundwater

Groundwater on West Point occurs in an unconsolidated aquifer consisting of alluvial deposits and a consolidated bedrock aquifer. Water within the unconsolidated aquifer occurs primarily in the

sands and gravels of the stratified drift deposits. These deposits represent the most prolific sources of groundwater on the installation, but the deposits are thin and generally have fairly small well yields that average about 40 gallons per minute. Water in the unconsolidated aquifer usually occurs under water table conditions. Recharge to the aquifer is primarily from local precipitation, but hydrologic communication occurs between the alluvial and the bedrock aquifers, and some upward seepage from the bedrock aquifer occurs in low-lying areas. Site-specific groundwater investigations were not conducted for the GGHA–U MRS (Weston, 2014).

1.3.1.6 Ecology

West Point lies in New York State, bordering the west bank of the Hudson River in the lower Hudson River Valley. Its environmental setting is unique as the five physiographic provinces (i.e., the Appalachian Plateaus, Folded Appalachians [Valley and Ridge], New England, Piedmont, and Coastal Plain) converge within a 35-mile radius of West Point. West Point is located in the New England Province in an area known as the Hudson Highlands (Weston, 2014).

1.3.1.6.1 Special Natural Areas

West Point has identified 12 sites that are to be specially managed because of ecological or geological significance, unique geological structure, and/or aesthetic and educational value to the installation. The GGHA–U MRS is not located within or adjacent to any of the 12 identified sites (Weston, 2014).

1.3.1.6.2 Wetlands

Approximately 1,010 acres of wetlands are located throughout West Point in association with streams, ponds, depressions, and seeps. The GGHA–U MRS does not contain wetlands (Weston, 2014).

1.3.1.6.3 Flora

The GGHA–U MRS is undeveloped and heavily forested.

1.3.1.6.4 Fauna

Forty-eight species of mammals, 249 species of birds, 22 species of reptiles, and 18 species of amphibians have been documented on West Point, in addition to many fish and invertebrate species. It is likely that some of these species rely on the GGHA–U MRS for habitation because it is undeveloped (Weston, 2014).

1.3.1.6.5 Other Species of Potential Concern

The following list contains other species of potential concern that have the potential to exist within the GGHA–U MRS:

- Mammals: Small-footed bat and Indiana bat;
- Birds: Cooper's hawk, Northern goshawk, sharp-shinned hawk, golden eagle, red-shouldered hawk, whip-poor-will, common nighthawk, cerulean warbler, Peregrine falcon,

bald eagle, yellow-breasted chat, red-headed woodpecker, osprey, vesper sparrow, and golden-winged warbler;

- Reptiles: Eastern wormsnake, timber rattlesnake, Eastern hognose, and Eastern box turtle;
- Amphibians: Jefferson salamander, blue-spotted salamander, and marbled salamander;
- S1* Plants: Virginia snakeroot, glomerate sedge, stripe-fruited sedge, and Carolina cranesbill;
- S2* Plants: Midland sedge, violet wood sorrel, Carey's smartweed, and small-flowered crowfoot; and
- S2S3* Plants: Cluster sedge, purple milkweed, Emmon's sedge, Bicknell's sedge, Bush's sedge, weak stellate sedge, yellow harlequin, racemed pinweed, violet bush clover, and slender knotweed.

*Notes:

S1 = Critically imperiled in New York State because of extreme rarity (five or fewer sites or very few remaining individuals) or extremely vulnerable to extirpation from New York State due to biological or human factors.

S2 = Imperiled in New York State because of rarity (6 to 20 sites or few remaining individuals) or highly vulnerable to extirpation from New York State due to biological or human factors.

S3 = Rare in New York State (usually 21 to 35 extant sites).

Double Ranks (i.e., S2S3) = The first rank indicates rarity based upon current documentation. The second rank indicates the probable rarity after all historical records and likely habitat have been checked.

1.3.1.7 Sensitive Environmental Resources within the Munitions Response Site

The New York Natural Heritage Program (NYNHP) identified the following species with the potential to occur within the West Point MRSs: one mammal species (small-footed myotis [bat, *Myotis leibii*]), two species of birds (bald eagle [*Haliaeetus leucocephalus*] and least bittern [*Ixobrychus exilis*]), one reptile species (timber rattlesnake [*Crotalus horridus*]), three fish (shortnose sturgeon [*Acipenser brevirostrum*], Atlantic sturgeon [*Acipenser oxyrhynchus*], and Atlantic silverside [*Menidia menidia*]), and one insect (Needham's skimmer [*Libellula needhami*]).

With the exception of the three-fish species, the least bittern, and the Needham's skimmer, the remaining species have the potential to occur in the GGHA–U MRS. The NYNHP did not identify any federally threatened or endangered plant species in any of the West Point MRSs (Weston, 2014).

1.3.1.8 Cultural and Archaeological Resources

Because West Point is one of the older training grounds in the U.S. that is still intact, it contains numerous cultural, archaeological, and historical sites. The GGHA–U MRS does not contain any known cultural resources (Weston, 2014).

1.3.1.9 Current and Projected Land Use

Most of the land area on the Main Post is highly developed or is considered undevelopable because of the steep slopes. West Point is divided into six land use zones based on the functional categories that reflect the West Point missions:

- Cadet Zone: Academic, intramural athletic, billeting, and parading;
- Cadet Support Zone: Intercollegiate athletic fields and some cadet support facilities;
- Community Support Zone: Housing, commercial, and service support to staff and faculty, non-West Point military personnel, and military retirees;
- Recreational, Industrial, Field Training Zone: Building and storage area support for industrial operations, field training areas, recreation areas, and open space;
- Candidate Zone: Encompasses the USMAPS and its supporting facilities; and
- Strategic Outreach Zone: Specialized areas where land use and facilities are dedicated to the positive interaction between the institution of West Point and the public (West Point, 2017).

The GGHA–U MRS is located within the Community Support Zone between the USMAPS (west) and a residential neighborhood (east). A closed walking trail is located within the northern extent of the GGHA–U MRS. The walking trail was closed following the construction of the USMAPS; however, site visitors (including resident adults and children) may continue to use the trail to walk from the residential neighborhood to the USMAPS because there is no physical barrier preventing use of the closed walking trail. The GGHA–U MRS contains no structures; however, maintenance workers periodically perform maintenance on water lines located within the GGHA–U MRS. The Real Property Master Plan includes the future construction (date of construction not yet determined) of a road within the GGHA–U MRS (West Point, 2017). The approximate location of the proposed new road is presented on **Figure 1-5**. The current and future land use zoning of the GGHA–U MRS is not expected to change.

1.3.2 Munitions and Explosives of Concern

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

- **UXO**—Military munitions that fulfill the following criteria:
    - Have been primed, fuzed, armed, or otherwise prepared for action;
    - Have been fired, dropped, launched, projected, or placed in such a manner as to constitute a hazard to operations, installations, personnel, or material; and
    - Remain unexploded either by malfunction, design, or any other cause (Department of Defense [DoD], 2008).

- **DMM**—Military munitions that have been abandoned without proper disposal or removed from storage in a military magazine or other storage area for the purpose of disposal. The term does not include UXO, military munitions that are being held for future use or planned disposal, or military munitions that have been properly disposed of consistent with applicable environmental laws and regulations (DoD, 2008; 10 United States Code [USC] 2710(e)(2)).

  MC—The definition of MEC also includes chemicals such as, trinitrotoluene and hexahydro-1,3,5-trinitro-1,3,5-triazine present in high enough concentrations to pose an explosive hazard.

  MC refers to any materials originating from MEC; discarded military munitions; or other military munitions, including explosive and nonexplosive materials, and emission, degradation, or breakdown elements of such munitions (10 USC 2710(e)(3)).

Although MD is not MEC, MD was investigated during the RI as evidence of potential MEC.

- **MD**—refers to any remnants of munitions (e.g., fragments, penetrators, projectiles, shell casings, links, fins) remaining after munitions use, demilitarization, or disposal (U.S. Army, 2009).

1.3.2.1 Nature and Extent of Munitions and Explosives of Concern

The nature and extent of MEC at the GGHA–U MRS was determined with mag and dig surveys. The mag and dig surveys utilized a statistical transect approach with 54-foot spacing to ensure a high probability of traversing and detecting an MEC impact area. These surveys traversed approximately 2.67 acres and identified 44 subsurface anomalies. Each subsurface anomaly was intrusively investigated. One MEC item (UXO: 3-inch Stokes mortar, Mk1 practice round, sand-filled and fuzed) and 43 MD items were recovered. The MD items included eight 3-inch Stokes mortars (sand-filled) and 35 fragments from unknown munitions. The MD and MEC items were composed of iron-containing or “ferrous” materials, and they were recovered from one inch to nine inches bgs; MD or MEC were not identified on the ground surface. The locations of the MD and MEC items recovered during the RI are presented on **Figure 1-6**. Information regarding these MD and MEC items are presented in **Table 1-2**.

Table 1-2 Summary of Munitions and Explosives of Concern and Munitions Debris at the GGHA–U MRS

Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)
UXO*	3-inch Stokes mortar, Mk1 practice round (sand-filled and fuzed)	07/14/2011	5	6
MD	8 x 3-inch Stokes mortar (sand-filled)	07/13/2011 – 07/14/2011	1 – 9	46
MD	35 fragments, unknown	07/13/2011 – 07/14/2011	1 – 8	61

Notes:
MD Munitions Debris
UXO Unexploded Ordnance

The UXO item was recovered at five inches bgs. The MD was recovered between one inch and nine inches bgs. The results of the mag and dig survey identified a 3-inch Stokes mortar impact area near the center of the GGHA–U MRS based on the discovery of UXO and the density of MD.

1.3.2.2 Munitions and Explosives of Concern Fate and Transport

The following physical processes can transport and relocate an MEC item from its original placement at the GGHA–U MRS:

- Picking up or moving a potential MEC item by a human receptor;
- Disturbance of MEC during intrusive activities conducted by a human receptor; and
- Soil erosion and frost heave.

The following human receptors were identified for the GGHA–U MRS: contractor personnel, maintenance workers, and site visitors (including resident adults and children). These receptors may pick up or move MEC because they have access to the surface of the GGHA–U MRS. Contractor personnel and maintenance workers may disturb subsurface MEC because they may conduct intrusive activities within the GGHA–U MRS. The human receptors identified for the GGHA–U MRS, and the activities they may conduct, are further detailed in the revised MEC conceptual site model (CSM) in Section 1.3.2.3.

The natural processes of soil erosion and frost heave are capable of transporting and relocating MEC from its original placement at the GGHA–U MRS. The erosion of soil caused by wind, gravity, or water (precipitation) may move MEC across the surface or move subsurface MEC to the surface. MEC movement caused by soil erosion may occur on the moderately to steeply sloped terrain of the GGHA–U MRS.

In addition to erosion, subsurface MEC may migrate to the surface during freezing and thawing cycles. The upward migration of MEC occurs when water below the MEC freezes and expands. This expansion gradually moves the subsurface MEC upward towards the surface. This

phenomenon, known as "frost heave," predominantly affects subsurface MEC located above the frost line. The type of soil influences the occurrence of frost heave (Chamberlain, 1981). The well drained to somewhat excessively drained soil types (sloping Hollis and moderately steep Hollis) present at the GGHA–U MRS are not typically susceptible to frost heave. Therefore, the soil type within the GGHA–U MRS indicates the transport of subsurface MEC to the surface caused by frost heave would likely be minimal.

1.3.2.3 Revised Munitions and Explosives of Concern Conceptual Site Model

This section presents the revised MEC CSM for the GGHA–U MRS. The MEC CSM revision was based on additional information provided by West Point in 2016. An MC CSM revision is not warranted because the RI determined that MC pathways to potential receptors were incomplete

1.3.2.3.1 Revised Munitions and Explosives of Concern Exposure Pathway Analysis

The MEC exposure pathway analyses consist of a source, receptor, and interaction component, and identify whether the pathway is complete, potentially complete, or incomplete. A pathway is considered complete when a source (MEC) is known to exist, and when receptors have access to the GGHA–U MRS while engaging in an activity that may result in contact with the source. A pathway is considered potentially complete when a source (MEC) has not been confirmed, but is suspected to exist (i.e., MD was recovered), and when receptors have access to the GGHA–U MRS while engaging in an activity that may result in contact with the source. A pathway is considered incomplete if any one of the three components (source, interaction, or receptors) are not present at the GGHA–U MRS.

1.3.2.3.1.1 Source

An MEC source was identified at the GGHA–U MRS. MEC and MD were recovered from the subsurface of the GGHA–U MRS, while no MEC or MD were identified on the surface. The results of the RI are presented in Section 1.3.2.1, summarized in **Table 1-1**, and depicted on **Figure 1-4**.

1.3.2.3.1.2 Receptors and Interaction

The human receptors that have are likely to have access to the GGHA–U MRS and the activities in which those human receptors engage were identified by West Point in 2016. These human receptors and the activities that they may conduct are summarized below:

- Contractor personnel may contact MEC potentially located on the surface by walking in the GGHA–U MRS during future road construction. Contractor personnel may also contact MEC located within the subsurface conducting intrusive activities during future road construction;
- Maintenance workers may contact MEC potentially located on the surface by walking in the GGHA–U MRS while conducting water line maintenance. Maintenance workers may also contact MEC located within the subsurface conducting intrusive activities during future water line maintenance; and
- Site visitors (including resident adults and children) from the adjacent residential neighborhood may contact MEC potentially located on the surface in the GGHA-U MRS by walking on the closed trail or when accessing the MRS for other reasons (i.e., chasing a ball or retrieving a lost dog in the woods behind the residential neighborhood).

1.3.2.3.1.3 Conclusions

The results of the RI and additional information provided by West Point was utilized to revise the MEC CSM for the GGHA–U MRS, and to identify complete, potentially complete, or incomplete exposure pathways for current and future land use. MEC and MD were recovered from the subsurface during the RI. Subsurface MEC, a principal threat waste[1], at the GGHA–U MRS may constitute a principal threat due to the potential for it to pose an explosive hazard if the material is moved, handled or disturbed. The presence of MEC within the subsurface indicates that the subsurface exposure pathway is complete because human receptors (e.g., contractor personnel and maintenance workers) may conduct intrusive activities within the GGHA–U MRS. The presence of MEC within the subsurface indicates that the surface exposure pathway is potentially complete because erosion and/or frost heave may move subsurface MEC to the surface and human receptors (e.g., site visitors (including resident adults and children), contractor personnel, and maintenance workers) have access to the surface of the GGHA–U MRS. The surface exposure pathway was revised from complete in the RI to potentially complete in the FS because an MEC source has not been confirmed on the surface. The revised MEC CSM for the GGHA–U MRS is presented on **Figure 1-7**.

1.3.2.4 Risk Methodology

In January 2017, the USACE established as guidance the process described in the *Study Paper: Decision Logic to Assess Risks Associated with Explosive Hazards, and to Develop Remedial Action Objectives (RAOs) for Munitions Response Sites* (USACE, 2016). The process, further referenced as the "Risk Methodology," has been implemented by the USACE for a two-year trial.

[1] *Principal threat wastes are those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health of the environment should exposure occur (USEPA, 1991).*

When used in the RI, it is intended to satisfy the NCP, 40 Code of Federal Regulations (CFR) Part 300.175(d)(4), requirement to conduct a site-specific risk assessment for MRSs. The Risk Methodology was designed to replace the Munitions and Explosives of Concern Hazard Assessment (MEC HA; USEPA, 2008). When applied in the FS, the Risk Methodology is used to identify acceptable conditions that are ultimately achievable via remedial actions for all portions of the GGHA–U MRS.

The Risk Methodology uses the same site-specific characteristics: accessibility, sensitivity, and severity as the MEC HA to determine if the risk posed by MEC to human receptors at an MRS is acceptable or unacceptable. These characteristics include:

- **Accessibility** – the likelihood that a receptor will be able to come in contact with MEC;
- **Sensitivity** – the likelihood that a receptor will be able to interact with MEC so that it will detonate; and
- **Severity** – the potential consequences (e.g., death, severe injury, property damage) of MEC detonating.

To determine risk, the Risk Methodology employs four matrices to relate accessibility, munitions sensitivity, and the severity of an incident if it were to occur. These matrices include:

- **Matrix 1** – *Likelihood of Encounter* – relates the amount of MEC present or potentially present at an MRS to its use, including accessibility, to determine the likelihood of encountering MEC;
- **Matrix 2** – *Severity of an Incident* – relates the likelihood of encountering MEC from Matrix 1 to the severity of an unintentional detonation;
- **Matrix 3** – *Likelihood of Detonation* – relates the sensitivity of the MEC present or potentially present at an MRS to the likelihood for energy to be imparted on an MEC item by a receptor, such that the interaction results in detonation; and
- **Matrix 4** – *Acceptable and Unacceptable Site Conditions* – relates the results of the preceding matrices to determine if the risk posed by MEC at an MRS is acceptable or unacceptable.

The site-specific characteristics, decision logic, and matrices used by the Risk Methodology for the evaluation of alternatives are presented in **Appendix A**.

1.4 Remedial Action Objectives

RAOs are developed to determine the effectiveness of the remedial action based on the CSM for the GGHA–U MRS and are focused on limiting or removing exposure pathways for MEC (U.S. Army, 2009). Per 40 CFR Part 300.430(e)(2)(i), RAOs specify:

1. Contaminants and media of concern;

2. Potential exposure pathways; and
3. Remediation goals.

The following RAOs were developed for the GGHA–U MRS:

- Reduce or eliminate direct contact of contractor personnel, maintenance workers, and site visitors (including resident adults and children) with the potential explosive hazards posed by subsurface MEC migrating to or present on the surface; and
- Reduce or eliminate direct contact of contractor personnel and maintenance workers with the potential explosive hazards posed by MEC in subsurface soil.

This FS assembles general response actions and technologies/technology process options into implementable alternatives that satisfy these RAOs.

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2.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND TO-BE-CONSIDERED GUIDANCE

ARARs are identified on a site-specific basis using a two-part analysis: (1) determining whether a given requirement is applicable; then, if it is not applicable, (2) determining whether a requirement is both relevant and appropriate (USEPA, 1988). To determine whether a requirement is relevant and appropriate, characteristics of the remedial action, the hazardous substances present, and the physical characteristics of the site must be compared to those addressed in the statutory or regulatory requirement. In some cases, a requirement may be relevant, but not appropriate, given site-specific circumstances; such requirements would not be an ARAR for the site. In other cases, only part of a requirement may be considered relevant and appropriate. When it is determined that a requirement is both relevant and appropriate, the requirement must be complied with (or waived) to the same degree as if it were applicable (USEPA, 1988).

As defined in the NCP, "Applicable Requirements" are cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental, state environmental, or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable (40 CFR 300.5).

"Relevant and Appropriate Requirements" are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable (40 CFR 300.5).

Section 121(d) of CERCLA requires that remedial actions be evaluated to determine if they meet any standard requirement, criteria, or limitation under any federal environmental law; any promulgated standard, requirement, criteria, or limitation under a state environmental or facility siting law that is more stringent than any federal standard, requirement, criteria, or limitation; and any standard, criteria, or limitation that is determined to be an ARAR. The NCP requires compliance with ARARs during and upon completion of remedial actions. Under limited circumstances, ARARs for on-site remedial actions may be waived.

There are three types of ARARs: action-specific, chemical-specific, and location-specific.

Action-specific ARARs—action-specific ARARs are usually technology- or activity-based requirements or limitations placed on actions taken with respect to cleanup actions, or requirements to conduct certain actions to address particular circumstances at a site. Set performance, design, or other similar operational controls or restrictions on particular activities

related to management of hazardous substances or pollutants. These requirements address specific activities that are used to accomplish a remedy. Action-specific ARARs do not, in and of themselves, determine the remedial action; rather, they define how a selected remedial action alternative must be designed, operated, or managed.

Chemical-specific ARARs—usually health- or risk-based numerical values, which, when applied to site-specific conditions, result in the establishment of an acceptable amount or concentration of a chemical that may be found in or discharged to, the ambient environment. Preliminary chemical-specific ARARs are typically identified in the RI to provide benchmarks with which to compare environmental sampling results for metals and explosives.

Location-specific ARARs—generally restrictions may be placed on the types of activities that may occur in particular locations. Location-specific ARARs generally prevent damage to unique or sensitive areas, such as flood plains, historic places, wetlands, and fragile ecosystems, and restrict other activities that are potentially harmful because of where they take place.

CERCLA and the NCP also recognize the TBC category, which includes non-promulgated advisories or guidance issued by Federal or state government that are not legally binding and do not have the status of potential ARARs. However, TBCs are considered along with ARARs as part of the site risk assessment and may be used in determining the necessary level of cleanup for protection on health or the environment. When this is the case, at the discretion of the lead agency, they can be specified as TBC criteria. TBC criteria can be taken into consideration during evaluation of remedial alternatives but, unlike ARARs, identification of TBCs is not mandatory nor is compliance with TBCs a selection criterion for a remedial action.

TBC—non-promulgated policies, criteria, advisories, guidance, and proposed standards developed by Federal and State environmental and public health agencies that are not legally enforceable but contain helpful information are collectively referred to as TBC criteria. They can be helpful in carrying out selected remedies or in determining the level of protectiveness of selected remedies. The TBCs are meant to complement the use of ARARs, not compete with or replace them.

Preliminary ARARs were identified and documented in the RI. Preliminary chemical-specific ARARs were not identified because MC pathways to potential receptors were determined to be incomplete at the GGHA–U MRS. Preliminary location-specific ARARs also were not identified for the GGHA–U MRS because it does not contain ecologically sensitive or unique areas. However, preliminary action-specific ARARs were identified for the GGHA–U MRS. The preliminary action-specific ARARs were based on the development of alternatives which would not include on-site treatment, on-site storage (greater than 90 days), or on-site disposal of hazardous waste (Weston, 2014).

The preliminary action-specific ARARs were evaluated for applicability and appropriateness and relevance. The ARARs that were determined to be either applicable or relevant and appropriate for the GGHA–U MRS are summarized in **Table 2-1**.

Table 2-1 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments (Applicable or Relevant and Appropriate)
Resource Conservation and Recovery Act, Subpart X, Miscellaneous Units	40 CFR Part 264, Subpart X, Section 264.601 (Environmental Performance Standards)	Miscellaneous units used for the disposal of munitions must be located, designed, constructed, operated, maintained, and closed in a manner that will ensure protection of human health and the environment.	*Relevant and Appropriate* Subpart X is a promulgated standard but is not applicable because the Army is not an owner of a facility that will treat, store, or dispose of hazardous waste in a miscellaneous unit. However, 40 CFR 264.601, is relevant and appropriate because it addresses a similar activity (e.g., consolidated shot) that may be conducted at the GGHA–U MRS during the remedial action.

Notes:
CFR Code of Federal Regulations
GGHA–U Grey Ghost Housing Area – Undeveloped
MRS Munitions Response Site

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3.0 IDENTIFICATION OF GENERAL RESPONSE ACTIONS AND TECHNOLOGIES, AND SCREENING OF TECHNOLOGY PROCESS OPTIONS

This section identifies general response actions and technologies utilized for MEC remediation and screens their constituent technology process options based on criteria specific to the GGHA–U MRS.

3.1 General Response Action Identification

Remedial alternatives are developed from general response actions to satisfy the RAOs for an MRS. The general response actions available for remedial alternative development to address MEC are relatively limited and differ from those used for MC or other environmental contaminants (U.S. Army, 2009). As a result, only the following three general response actions are considered for the GGHA–U MRS:

- **No Action**—The No Action alternative is evaluated to satisfy the NCP requirement of 40 CFR 300.430(e)(6), which requires consideration of this alternative as a baseline against which other alternatives may be compared;
- **Risk Management**—Risk management, which is considered a "limited" action alternative by EPA, includes administrative mechanisms, engineering controls, and educational controls; and
- **MEC Removal**—MEC can be detected and removed from the ground surface and/or below the ground surface. MEC removal includes technologies for detection, removal, and disposal.

3.2 Identification of Munitions and Explosives of Concern Remediation Technologies

The general response actions identified above utilize a limited number of technologies to remediate MEC. Risk management utilizes administrative mechanisms, engineering controls, and educational controls while MEC removal utilizes detection, removal, and disposal technologies. These technologies consist of individual technology process options which are screened for further consideration and alternative development. The process option screening is detailed in the next section.

3.3 Screening of Munitions and Explosives of Concern Remediation Technology Process Options

MEC remediation technology process options are screened in the following sections. The screening evaluation is conducted in a two-step process. The initial screening step is conducted to remove from further consideration the technology process options that are not technically implementable based on site-specific conditions. The second screening step evaluates the remaining technology process options for effectiveness, implementability, and cost to determine

their viability for alternative development. The development and screening of alternatives are described in Section 4. The screening criteria used in the second step are described in Section 3.3.1.

3.3.1 Screening Criteria

MEC remediation technology process options are screened for effectiveness, implementability, and cost, to ensure that minimum standards are met. The technology process options screening criteria are described below. The technology process options screening is presented in Section 3.3.2 through Section 3.3.5.

3.3.1.1 Effectiveness

In accordance with 1988 USEPA guidance, identified technologies and process options are evaluated on their effectiveness relative to other processes within the same technology/alternative type. This evaluation focuses on three criteria:

1. The potential effectiveness of the technology and process options in handling the estimated areas or volumes of media and meeting the RAOs;
2. The potential impact to human health and the environment during the removal or implementation phase; and
3. How proven and reliable the technology and process options are with respect to the MEC and conditions at the site.

3.3.1.2 Implementability

Implementability, as a measure of both technical and administrative feasibility, is used during screening to evaluate technology/process options with respect to conditions specific to the GGHA–U MRS. Technical feasibility refers to the ability to construct and reliably operate a technology/process option. Administrative feasibility refers to the ability to obtain approvals from other offices and agencies; the availability of treatment, storage, and disposal services (including capacity); and the requirements for and availability of necessary equipment, skilled workers, and technical specialists (USEPA, 1988).

3.3.1.3 Cost

Cost plays a limited role in the screening of technology/process options. Relative capital and operation and maintenance (O&M) costs are used rather than detailed cost estimates. For this screening step, the cost analysis is based on engineering judgment. Each process option is evaluated as to whether its cost is high, low, or medium relative to other process options in the same technology (USEPA, 1988).

3.3.2 Risk Management Technologies

Risk management or Land Use Controls (LUCs) include technologies developed to protect human health from the presence of hazards without actively remediating the source of the hazard (i.e., removal and disposal of MEC from an MRS).

LUCs include the following technologies: administrative mechanisms, engineering controls, or educational controls that warn of potential hazards or limit access to mitigate risk associated with potential human exposure to explosive hazards. The Interim LUCs detailed in the *Non-Time Critical Removal Action Land Use Control Plan* (NTCRA LUCP) were placed on the GGHA–U MRS in 2012 (URS/Arcadis, 2012). An Institutional Analysis (IA) was performed (**Appendix B**) to collect data to support the implementation of a LUC program. Additionally, the IA screened the current interim LUCs (administrative mechanisms and educational controls) and additional LUCs (engineering controls) for effectiveness, implementability, and cost to determine their viability.

The current interim LUC screening conducted in the IA determined that the administrative and educational controls implemented by the NTCRA LUCP were viable for implementation at the GGHA–U MRS. The engineering control screening conducted in the IA determined that fencing and signage were viable for potential implementation at MRSs located at West Point; however, West Point has indicated that fencing and signage are not viable for the GGHA–U MRS for the following reasons:

- The installation of fencing and signage would not be administratively feasible because MEC has not been recovered from the ground surface and the Army has determined that there is a low probability of encountering MEC[2] (West Point, 2017); and
- Public advisories would be as effective as fencing and signs without the additional maintenance requirements.

The viable LUC technologies and technology process options for the GGHA–U MRS are presented in **Table 3-1**.

Table 3-1 Viable Land Use Control Technology Process Options Summary for the GGHA–U MRS

Administrative Mechanisms	Educational Controls	Engineering Controls
• Land Use Restrictions • Master Plan Notation • Excavation ("Dig") Permit Program and Construction Support • Annual Review	• Public Advisories	• None

[2] *Construction/excavation and/or soil disturbance activities conducted at the GGHA–U MRS, which could inadvertently cause an MEC item to function, were determined to have a low probability of encountering MEC. The determination was based on guidance established by the Department of Defense Manual (DoDM) 6055.09M.*

3.3.3 Munitions and Explosives of Concern Detection

MEC detection includes the methods and instruments used to locate surface and subsurface MEC. The best detection method is selected based on MEC properties, including the depth and size of the suspected MEC item, and the physical characteristics of the GGHA–U MRS (e.g., soil type, topography, vegetation, and local geology).

There are two basic forms of MEC detection:

- Visual searching—Successfully used at a number of MRSs where MEC is located on the ground surface. When performing a visual search of an MRS, the area to be searched is typically divided into 5-foot lanes that are systematically inspected for MEC. A metal detector is sometimes used to supplement the visual search in areas where ground vegetation may conceal surface MEC. Typically, any MEC found during these searches is flagged or marked for immediate disposal; and
- Geophysics—Includes various detection instruments designed to locate subsurface MEC and is integrated with the equipment and methods used for location positioning. Each piece of equipment has its own inherent advantages and disadvantages based on its operating characteristics. Therefore, selecting the appropriate type of geophysical instrument is critical to survey success. The instruments designed to locate subsurface MEC include magnetometers and electromagnetic instruments. Positioning technologies include various equipment and instruments that establish geo-referenced positions for detected subsurface anomalies. The viability of positioning technologies is affected by site-specific conditions, including terrain, tree canopy, and vegetation density.

MEC detection and positioning technology process options are described and screened using a two-step process (refer to Section 3.2) in **Table 3-2** and **Table 3-3**, respectively.

Table 3-2 Munitions and Explosives of Concern Detection Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
Visual Searching: Search area is typically divided into 5-foot lanes that are systematically inspected for MEC on the surface. A hand-held geophysical sensor is sometimes used to assist the visual search in areas where ground vegetation or leaf litter may conceal surface MEC. Any MEC found during these searches is flagged or marked for immediate disposal. Notes: Typically supported with a flux-gate magnetometer or FDEMI metal detector. This technology is typically used for surface removal projects and as a preliminary step in removing surface metal and MEC in support of subsurface removal.	**Retained:** This process option is technically implementable for the GGHA–U MRS because MEC may potentially be present on the surface of the GGHA–U MRS.	**Low:** Not effective in vegetated areas. Cannot detect subsurface MEC. Must be used in conjunction with another process option capable of detecting subsurface MEC. GGHA–U MRS is undeveloped and heavily forested. Minimal to no adverse effect on natural resources.	**High:** Easily implemented process option that uses readily available equipment and workers.	**Low:** Low cost relative to other detection systems.	Not Applicable	**Retained:** This process option is viable and has been retained because it is low cost and highly implementable, although it isn't effective without being assisted by a handheld metal detector.
Flux-Gate Magnetometers: Flux-gate magnetometers measure the vertical component of the geomagnetic field along the axis of the sensor and not the total intensity of the geomagnetic field. Notes: Detects ferrous objects only. Light and compact. Flux-gate magnetometers are commonly used for mag and dig surveys to detect both surface and subsurface MEC. High industry familiarization.	**Retained:** This process option is technically implementable for this MRS because the MEC at the GGHA–U MRS are ferrous and located at a detectable depth.	**Medium:** Effectively detects surface and subsurface MEC located at the GGHA–U MRS; however, the high iron content in the local geology could lead to the investigation of numerous false positives (anomalies). Minimal to no adverse effect on natural resources.	**High:** Easily implemented process option that uses readily available equipment and workers.	**Low:** Low cost relative to other detection systems.	Chicago Steel Tape (Magna-Trak 102) Ebinger MAGNEX 120 LW Foerster FEREX 4.032 Foerster FEREX 4.032 DLG Schonstedt GA-72CX Vallon EL1302D1 or 1303D	**Retained:** This process option is viable and has been retained because it is low cost and highly implementable.
Optically Pumped Magnetometers: This technology is based on the theory of optical pumping and operates at the atomic level, rather than proton precession magnetometers, which operate at the nuclear level. Notes: Detects ferrous objects only. Standard detector for UXO detection. High industry familiarization.	**Retained:** This process option is technically implementable for this MRS because the MEC at the GGHA–U MRS are ferrous and located at a detectable depth.	**Medium:** Effectively detects surface and subsurface MEC located at the GGHA–U MRS; however, the high iron content in the local geology could lead to the investigation of numerous false positives (anomalies). Minimal to no adverse effect on natural resources.	**Medium:** Easily implemented process option that uses readily available equipment. Requires trained specialists to process and interpret data.	**Medium:** Medium cost relative to other detection systems.	GEM Systems GSMP-40 Geometrics G-858 Geometrics G-822 Scientrex Smart Mag	**Retained:** This process option is viable and has been retained because it is effective and implementable with costs that are not excessive.

Table 3-2 Munitions and Explosives of Concern Detection Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
FDEMI Metal Detectors: FDEMI sensors generate one or more defined frequencies in a continuous mode of operation. Notes: Detects both ferrous and non-ferrous metallic objects. Moderate industry familiarization. The White's All-Metals Detector was proven effective during the RI at this MRS.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it was effectively used during the RI.	**High:** Effectively detects surface and subsurface MEC located at the GGHA–U MRS. Minimal to no adverse effect on natural resources.	**High:** Easily implemented process option that uses readily available equipment and workers.	**Low:** Low cost relative to other detection systems.	Fisher 1266X Foerster MinexMinelabs Explorer II White's All Metals Detector	**Retained:** This process option is viable and has been retained because it is highly effective and implementable and requires low cost.
Ground Penetrating Radar: GPR works by propagating electromagnetic waves into the ground via an antenna. The transmitted signals are reflected by objects and features that possess contrasts in electrical properties with the surrounding medium. Notes: Detects both metallic and non-metallic objects. Medium industry familiarization. Data output is usually viewed in transects not maps.	**Not Retained:** This process option is not technically implementable for the GGHA–U MRS due to the presence of rock outcrops and steep terrain, which prevent use of the large sensors that are required.					
TDEMI Metal Detectors: TDEMI is a technology used to induce a pulsed magnetic field beneath the earth's surface with a transmitter coil, which in turn causes a secondary magnetic field to emanate from nearby objects that have conductive properties. Notes: Detects ferrous and non-ferrous metallic objects. High industry familiarization. Detection depths are highly dependent on coil size and transmitter power.	**Not Retained:** This process option is not technically implementable for the GGHA–U MRS due to the presence of rock outcrops and steep terrain, which prevent use of the large sensors that are required.					
Advanced EMI Sensors and Anomaly Classification: Advanced sensors have the ability to precisely capture measurements from enough locations to sample all principal axis responses of an anomaly or item of interest. Provides the necessary information for analysis and classification of hazardous and non-hazardous items. Notes: Sensors have limited industry availability. Requires advanced training and certification for operation, data processing, and analysis.	**Not Retained:** This process option is not technically implementable for the GGHA–U MRS due to the presence of rock outcrops and steep terrain, which prevent use of the large sensors that are required.					

Table 3-2 Munitions and Explosives of Concern Detection Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
SAM: SAM is a patented methodology. A total field magnetic sensor is used to simultaneously acquire both magnetic and electromagnetic response of subsurface conductive items. Notes: Not commercially available. No established performance track record.	**Not Retained:** This process option is not technically implementable for the GGHA–U MRS because it is not commercially available and has not yet been proven reliable (i.e., no established track record of performance).					
Magnetometer-Electromagnetic Detection Dual Sensor Systems: Utilizes large dual sensor systems to detect surface and subsurface MEC. Notes: Detects both metallic and non-metallic objects. Commercially available.	**Not Retained:** This process option is not technically implementable for the GGHA–U MRS due to the presence of rock outcrops and steep terrain, which prevent use of the large dual sensor systems that are required.					
Airborne SAR: This airborne method uses strength and travel time of microwave signals that are emitted by a radar antenna and reflected off a distant surface object. Notes: No established performance track record.	**Not Retained:** Because MEC was only recovered from the subsurface, this process option is not technically implementable for the GGHA–U MRS because it only detects large surface objects, requires line of sight, and is only available from a few sources.					
Airborne LIDAR: Uses a pulsed laser directed towards the ground and mounted from relatively high-flying aircraft to detect MEC. GPS and inertial navigation systems are used to precisely measure the position and orientation of the laser.	**Not Retained:** This process option is not technically implementable for the GGHA–U MRS because it is used to detect large surface objects and MEC is present in the subsurface based on the results of the RI.					

Notes:

EMI	Electromagnetic Induction	FDEMI	Frequency-Domain Electromagnetic Induction
GGHA–U	Grey Ghost Housing Area – Undeveloped	GPR	Ground Penetrating Radar
LIDAR	Light Detection and Ranging	MEC	Munitions and Explosives of Concern
MRS	Munitions Response Site	RI	Remedial Investigation
SAM	Sub Audio Magnetics	SAR	Synthetic Aperture Radar
TDEMI	Time-Domain Electromagnetic Induction	UXO	Unexploded Ordnance

Table 3-3 Positioning System Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
DGPS: An advanced form of GPS, which can provide locations to sub-centimeter accuracy. This system requires the use of a base station or subscription service to correct for errors in positioning and other sources, including clock errors, atmospheric effects, and signal reflections. Notes: DGPS is the primary navigation method for munitions geophysical surveys.	**Retained:** This process option is technically implementable for the GGHA–U MRS if used following significant vegetation removal (i.e., clearcutting of part or all of the GGHA–U MRS) because it can provide accurate location data.	**Low – High**: Effective positioning technology limited by tree cover present at the GGHA–U MRS; however, effectiveness increases significantly following vegetation removal (partial or clearcut) from the GGHA–U MRS. Major adverse effect on natural resources based on clearcutting.	**Medium**: Easily implemented process option that uses readily available equipment and workers. Reliably operated in clearcut areas.	**Medium**: Medium cost relative to other positioning systems.	Hemisphere S320 OmniSTAR VBS/HP Trimble Model 5800	**Retained:** This process option is viable and has been retained because it is sufficiently effective and implementable with costs that are not excessive.
RTS: RTS is a laser-based survey station that derives its position from survey methodology. Includes a servo-operated mechanism that tracks a prism mounted on the geophysical sensor. Notes: Typically used with TDEMI metal detectors (e.g., Geonics EM61-MK2) and digital magnetometers (e.g., Geometrics G-858). This process option was used for anomaly reacquisition during the RI. RTS can also be used for data positioning for digital detector systems in moderately wooded areas.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it was effectively used during the RI.	**Medium – High**: Effective positioning technology limited by wooded terrain present at the GGHA–U MRS; however, effectiveness increases following vegetation removal (partial or clearcut) from the GGHA–U MRS. Major adverse effect on natural resources based on clearcutting.	**Medium – High**: Easily implemented process option that uses readily available equipment and workers. More reliably operated in clearcut areas.	**Medium**: Medium cost relative to other positioning systems.	Leica RTS 1200 Trimble Model 5600	**Retained:** This process option is viable and has been retained because it is sufficiently effective and implementable with costs that are not excessive.
Fiducial Method: The fiducial method consists of digitally marking a data string with an indicator of a known position. Typically, markers are placed on the ground at known positions (e.g., 25 feet). Notes: Useful method if digital positioning systems are unavailable. This process option was used during RIs conducted at other MRSs.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it can provide accurate location data without significant vegetation removal.	**High**: Effective positioning technology not limited by wooded, steep, or rocky terrain present at the GGHA–U MRS. Minimal to no adverse effect on cultural or natural resources.	**Medium**: Easily implemented process option that uses readily available equipment. Requires trained specialists to process and interpret data.	**Low**: Low cost relative to other positioning systems.	Not Applicable	**Retained:** This process option is viable and has been retained because it is highly effective and sufficiently implementable with low costs.

Notes:

DGPS	Differential Global Positioning System	GGHA–U	Grey Ghost Housing Area – Undeveloped
GPS	Global Positioning System	MRS	Munitions Response Site
RI	Remedial Investigation	RTS	Robotic Total Station
TDEMI	Time-Domain Electromagnetic Induction		

3.3.4 Munitions and Explosives of Concern Removal

Removal operations can take the form of a surface-only removal, an intrusive (subsurface) removal, or a combination of the two methods. The decision on the appropriate level of removal operation is based on the nature and extent of the hazards, as well as the current land use and intended future land use of the GGHA–U MRS.

For a surface removal operation, exposed MEC or suspected hazardous items are identified during the detection phase. The MEC are then inspected, identified, collected (if possible), and transported to a designated area for cataloging and eventual disposal. MEC cannot be removed from the GGHA–U MRS unless explosive ordnance disposal (EOD) authorizes. MEC can only be moved within an MRS if the Senior UXO Supervisor (SUXOS) and UXO Safety Officer (UXOSO) agree that the item is acceptable to move. If it is determined during the inspection that an item is unacceptable to move, then it may be necessary to destroy the item in place.

Potential subsurface MEC identified by a geophysical survey or other detection methods requires excavation for removal or detonation. Because the actual nature of the buried item cannot be determined without it being uncovered, the evacuation of non-essential personnel is necessary within a predetermined minimum separation distance (MSD). The MSD is based on the munition with the greatest fragmentation distance that may be present within the GGHA–U MRS. All non-essential personnel and the general public must be evacuated from, and maintain their distance beyond, the MSD during the intrusive operation. Potential MEC is excavated using hand tools. Once an item has been exposed, it is then inspected, identified, collected (if possible), and transported to a designated area for cataloging and disposal. MEC cannot be removed from the GGHA–U MRS unless EOD authorizes. MEC can only be moved within an MRS if the SUXOS and UXOSO agree that the item is acceptable to move. If it is determined during the inspection that the item is unacceptable to move, then it may be necessary to destroy the item in place. For intentional detonations, all personnel must observe the MSD. The MSD may be increased or decreased based on the actual item identified and may also be reduced if engineering controls are used. The MSD may only be changed through an amendment to an approved Explosives Safety Submission (ESS). MEC removal technology process options are described and screened using a two-step process (refer to Section 3.2) in **Table 3-4**.

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Table 3-4 Munitions and Explosives of Concern Removal Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
Hand Excavation: Technique includes digging individual anomalies using commonly available hand tools. Notes: This technology was successfully used during the RI at this MRS. This process option is considered the industry standard for MEC removal.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it was effectively used during the RI.	**High**: Highly effective process option for removing the small quantity of MEC expected at the GGHA–U MRS. Minimal to no adverse effect on natural resources.	**High**: Easily implemented process option that uses readily available equipment and workers. Requires readily obtained dig permits.	**Low**: Low cost relative to other removal techniques.	Probe, trowel, shovel, pick axe.	**Retained:** This process option is viable and has been retained because it is highly effective and implementable with low costs.
Mechanical Excavation of Individual Anomalies: This method uses commonly available mechanical excavating equipment to support hand excavation. The equipment would need to be armored to protect the operator. Notes: Easy to rent and operate.	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because steep terrain and rock outcrops would significantly reduce the effectiveness of mechanical excavating equipment.					
Mass Excavation and Sifting: Armored excavation and transportation equipment protects the operator and equipment from unintentional detonation. Once soil is excavated and transported to the processing area, it is then processed through a series of screening devices and conveyors to segregate MEC from soil. Notes: Can be rented and armor installed, and equipment delivered almost anywhere. Significant maintenance costs.	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because the steep terrain and rock outcrops would significantly reduce the effectiveness of mechanical excavating equipment.					
Magnetically Assisted Removal: Magnets are used to separate conductive material from soil. Notes: Installed by sifting equipment owner.	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because Mass Excavation and Sifting is not technically implementable, and this process option is used in conjunction with Mass Excavation and Sifting.					
Remotely Operated Removal Equipment: This option has additional controls that allows the equipment to be operated remotely. Notes: EOD robots are almost exclusively used for military and law enforcement reconnaissance and render-safe operations.	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because it has not yet been proven to be an effective MEC removal method.					

Notes:
EOD Explosive Ordnance Disposal
MEC Munitions and Explosives of Concern
RI Remedial Investigation
GGHA–U Grey Ghost Housing Area – Undeveloped
MRS Munitions Response Site

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3.3.5 Munitions and Explosives of Concern Disposal

Recovered MEC is normally destroyed on-site, either at the location of discovery or at the location on the GGHA–U MRS that has been sited and approved. In some cases, recovered MEC may be transported off the GGHA–U MRS for destruction. The decision regarding the disposition of any recovered MEC is determined by qualified personnel based on site-specific characteristics and the nature of the recovered MEC. MEC disposal technology process options are described and screened using a two-step process (refer to Section 3.2) in **Table 3-5**.

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Table 3-5 Munitions and Explosives of Concern Disposal Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
BIP: BIP is used to destroy MEC for which the risk of movement beyond the immediate vicinity of discovery is considered not acceptable. Normally, BIP is accomplished by placing an explosive charge alongside the MEC item. Notes: Disposition of resultant waste streams must be addressed in BIP operations planning. BIP already proven effective during the RI at this MRS.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it was effectively used during the RI.	**High:** Effective because it permanently eliminates the explosive hazard associated with MEC. Requires engineering controls.	**Medium – High:** Easily implemented process option with readily available equipment and workers. Engineering controls further increase implementability.	**Medium:** Medium cost relative to other disposal techniques.	Electric Demolition Procedures Non-electric Demolition Procedures (e.g., Non-el, Time Fuse)	**Retained:** This process option is viable and has been retained because it is highly effective and implementable with costs that are not excessive.
Consolidated Shots: Consolidated shots include the collection, configuration, and subsequent destruction by explosive detonation of MEC that has been deemed acceptable to move, either within the GGHA–U MRS or to an established demolition ground. Notes: Disposition of resultant waste streams must be addressed. Increased areas require additional access and safety considerations.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it can destroy the recovered MEC if the recovered MEC is determined acceptable to move.	**High:** Effective because it permanently eliminates the explosive hazard associated with MEC. Only conducted for MEC deemed acceptable to move. Requires engineering controls.	**Medium – High:** Easily implemented process option with readily available equipment and workers. Engineering controls further increase implementability.	**Medium:** Medium cost relative to other disposal techniques.	Electric Demolition Procedures Non-electric Demolition Procedures (e.g., Non-el, Time Fuse)	**Retained:** This process option is viable and has been retained because it is highly effective and implementable with costs that are not excessive.
CDCs—Stationary/Mobile: CDCs involve destruction of certain types of munitions in a chamber, vessel, or facility designed and constructed specifically for the purpose of containing blasts and fragments. CDCs can only be employed for MEC that has been deemed acceptable to move. Notes: System cleaning and maintenance usually requires PPE and worker training. Probable permitting issues with employment of technology.	**Retained:** This process option is technically implementable for the GGHA–U MRS because it can destroy the recovered MEC if the recovered MEC is determined acceptable to move.	**High:** Effective because it permanently eliminates the explosive hazard associated with MEC. Only conducted for MEC deemed acceptable to move.	**Medium:** Requires specialized equipment and skilled workers. Stationary systems typically must meet regulatory and construction standards for waste disposal facilities. These facilities are not typically used for munitions responses.	**High:** High cost relative to other disposal techniques.	Stationary systems typically designed on case-by-case basis. Mobile systems include, T-series (10, 25, 30/60) and Kobe Blast Chamber	**Not Retained:** This process option is not viable and has been not retained because it requires excessive costs and is not more effective or implementable than the other disposal technology process options.

Table 3-5 Munitions and Explosives of Concern Disposal Technology Process Option Screening

Process Option	Technical Implementability	Effectiveness	Implementability	Cost	Representative Systems	Viability and Retention
Laser Initiation: Portable (vehicle mounted) lasers are used from a safe distance to destroy UXO or DMM lying on the ground surface. Notes: Offers added safety through significant stand-off (up to 300 meters). Acceptable safety stand-offs must be evaluated for specific MEC types and location scenarios. ZEUS prototype deployed/employed in Afghanistan (2003).	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because it only destroys surface MEC and has not been demonstrated to be reliable.					
Chemical Decontamination: Uses chemical processes to eliminate all explosives residues from MEC. Notes: National Defense Center for Energy and Environment is working on a mobile system, but it treats only scrap metal and not MEC.	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because explosive residues from MEC were not detected above screening levels during the RI.					
Thermal Treatment: Explosive residue from MEC is destroyed by exposing debris to high temperatures (between 600 and 1,400 degrees Fahrenheit) for specified periods of time.	**Not Retained:** This process option is not technically implementable at the GGHA–U MRS because only a practice round was recovered.					

Notes:

BIP	Blow-in-Place	CDCs	Contained Detonation Chambers	DMM	Discarded Military Munitions
GGHA–U	Grey Ghost Housing Area – Undeveloped	MEC	Munitions and Explosives of Concern	MRS	Munitions Response Site
PPE	Personal Protective Equipment	RI	Remedial Investigation	UXO	Unexploded Ordnance

3.3.6 Viable Munitions and Explosives of Concern Remediation Technologies and Process Options for the GGHA–U MRS

The viable LUC technologies and process options for the GGHA–U MRS are summarized in **Table 3-1**. The viable technology process options listed in **Table 3-2** through **Table 3-5** for the GGHA–U MRS are summarized in **Table 3-6** and are included in the development of remedial alternatives in Section 4.

Table 3-6 Viable Munitions and Explosives of Concern Remediation Technologies and Process Options for the GGHA–U MRS

MEC Detection		**MEC** Removal	**MEC Disposal**
Geophysical Detection	**Positioning**		
• Visual Searching • Flux-Gate Magnetometers • Optically Pumped Magnetometers • FDEMI Metal Detectors	• DGPS • RTS • Fiducial Method	• Hand Excavation	• BIP • Consolidated Shots

Notes:
BIP Blow-in-Place
DGPS Differential Global Positioning System
FDEMI Frequency-Domain Electromagnetic Induction
MEC Munitions and Explosives of Concern
RTS Robotic Total Station

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4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

In this section, the technologies and process options deemed viable for use at the GGHA–U MRS are combined to form remedial alternatives. In accordance with DoDM 4715.2, an FS must consider at least the following three alternatives: (1) no action (baseline), (2) action that requires LUCs, and (3) remediation to an unlimited use and unrestricted exposure (UU/UE) condition. For the purpose of this evaluation, UU/UE is defined as conditions that indicate a "negligible probability" of encountering MEC based on a comprehensive assessment of current and previous land use (Engineering Manual [EM] 385-1-97).

MEC remedial alternatives are evaluated against short-term and long-term aspects of three broad criteria: (1) effectiveness, (2) implementability, and (3) cost. Because the purpose of the alternatives screening evaluation is to reduce the number of alternatives that will undergo detailed analysis against the nine criteria, alternatives are evaluated more generally in this step than during the detailed analysis (USEPA, 1988). The three screening criteria are described below.

4.1 Alternatives Screening Criteria

4.1.1 Effectiveness

A key aspect of the screening evaluation is the effectiveness of each alternative in protection of human health and the environment. The focus of the effectiveness screening criterion is the degree to which the alternative reduces toxicity, mobility, or volume through treatment, minimizes residual explosive hazards and provides long-term protection, complies with ARARs, and minimizes short-term effects. Also taken into consideration is how quickly the alternative achieves protection of human health and the environment. Alternatives that provide significantly less effectiveness than other, more promising, alternatives may be eliminated. Alternatives that do not provide adequate protection of human health and the environment are eliminated from further consideration [40 CFR 300.430(e)(7)(i)].

4.1.2 Implementability

The implementability screening criterion focuses on the technical feasibility and availability of the technologies that comprise the alternative. Similar to the implementability screening of technologies/process options, technical feasibility for the alternatives screening includes the ability to construct, reliably operate, and meet technology-specific regulations until a remedial action is complete. Technical feasibility also includes operation, maintenance, replacement, and monitoring of technical alternative components, if required, after the remedial action is complete. The administrative feasibility of implementing the alternative is also evaluated. Administrative feasibility includes the ability to obtain approvals from stakeholders, the availability of treatment, storage, and disposal services and capacity, and the requirements for, and availability of, specific equipment and technical specialists. Alternatives that are technically or administratively infeasible or that would require equipment, specialists, or facilities that are not available within a reasonable

period of time may be eliminated from further consideration [USEPA, 1988; 40 CFR 300.430(e)(7)(ii)].

4.1.3 Cost

The costs of construction and any long-term costs to operate and maintain the alternative are considered in the cost screening criterion. Ranges or approximations of relative capital and O&M costs are used rather than detailed estimates. It is not necessary that the costs of alternatives be defined with the accuracy desired for the detailed analysis (i.e., + 50% to –30%). The evaluation of costs includes those O&M costs that will be incurred for as long as necessary, even after the initial remedial action is complete. Present value analyses are used to evaluate expenditures that occur over different time periods. All costs are discounted to a common base year. Alternatives whose costs are grossly excessive compared to their overall effectiveness may be eliminated from further consideration. An alternative that provides similar effectiveness and implementability to that of another alternative by employing a similar method of treatment or engineering control, but at greater cost, may also be eliminated from further consideration [40 CFR 300.430(e)(7)(iii); USEPA, 1988].

4.2 Alternative 1—No Action

No actions would be taken under Alternative 1 to address the explosive hazards posed by MEC at the GGHA–U MRS. No MEC would be removed or destroyed and the LUCs implemented at the GGHA–U MRS as part of the NTCRA LUCP would be allowed to expire. In addition, no MEC awareness/safety training would be provided with regard to the hazards associated with MEC. Further, it is assumed that current land use of the GGHA–U MRS would not change. It is important to note that the Army would respond to any future MEC discoveries at the GGHA–U MRS, if this alternative is selected. This alternative will be utilized for comparison with the other alternatives; therefore, this alternative will be carried forward to the detailed analysis of alternatives for the GGHA–U MRS.

4.3 Alternative 2—Risk Management

4.3.1 Description of Alternative 2

Alternative 2 would implement LUCs at the GGHA–U MRS. These LUCs would include the administrative mechanisms and educational controls detailed in the IA (**Appendix B**). A LUCP would be prepared to detail LUC implementation at the GGHA–U MRS. The extent of the LUCs is presented on **Figure 4-1**. At the GGHA–U MRS, the following LUC technology process options would be implemented:

- Land Use Restrictions—New uses of the GGHA–U MRS for residential purposes, daycare facilities, hospitals, or schools would be prohibited without prior approval from West Point;

- Master Plan Notation—The installation master plan would include a notation requiring a record of all 911 calls involving MEC in a geographic information system database to facilitate explosive hazard delineation;
- Dig Permits and Construction Support—Dig permits and construction support would be required whenever ground is broken at the GGHA–U MRS. There is a low probability of encountering MEC at the GGHA–U MRS; therefore, on-call construction support and site-specific MEC awareness/safety training would be required according to the *Probability Assessment for Determining the Probability of Encountering MEC*. The site-specific MEC awareness/safety training would be provided to workers performing ground disturbing activities. The site-specific MEC awareness/safety training would identify explosives safety concerns/measures to be taken during ground disturbing activities, and the proper reporting procedures to be utilized in the highly unlikely event an MEC item is discovered (West Point, 2017). On-call construction support and worker training would be required during the construction of the proposed road and water line maintenance;
- Public Advisories—Brochures (e.g., 3Rs pamphlet) detailing the potential hazards associated with MEC would be developed and provided to site visitors (including resident adults and children); and
- Annual Review—Inspections would be required annually to ensure that the LUCs are uncompromised and that erosion has not exposed MEC, causing potential migration to the surface.

In the event that a suspected munition is discovered, the location of the suspected munition would be marked and installation officials notified (i.e., 3R's protocol). Installation officials would assume control and security of the item until such time as the responding EOD team arrived on site. The responding EOD team would dispose and/or remove the item in accordance with current EOD procedures.

Because this alternative would result in MEC potentially remaining at the GGHA–U MRS, Five-Year Reviews would be conducted no less often than every five years after initiation of the remedial action until the GGHA–U MRS qualifies for UU/UE. Five-Year Reviews would include the following general steps:

- Existing documentation review;
- New information and current site conditions review and identification; and
- Five-Year Review report preparation.

4.3.2 Screening of Alternative 2

- Effectiveness: This alternative would protect human health by restricting land use and modifying/guiding human behavior. These actions would reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS. This alternative would not

intentionally reduce the toxicity, mobility or volume (TMV) of the principal threat waste (MEC) at the GGHA–U MRS; however, it would reduce the TMV of MEC following MEC discovery and removal, but would not satisfy the statutory preference for treatment as a principal element of the selected remedy. This alternative may expose Department of Defense Explosives Safety Board (DDESB) Technical Paper (TP)-18–qualified personnel to the explosive hazards posed by MEC removal if MEC is found during construction support. MEC removal (i.e., BIP or consolidated shot) would utilize exclusion zones, engineering controls, and DDESB TP-18–qualified personnel. This alternative would comply with the substantive requirements of 40 CFR 264.601 (Environmental Performance Standards) by utilizing exclusion zones, engineering controls, and DDESB TP-18–qualified personnel when performing a consolidated shot. This alternative would require EOD response if MEC is discovered outside of construction support. This alternative would require approximately six months to employ to reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS.

- Implementability: The LUCs required for this alternative are readily available and reliable because similar LUCs were successfully implemented on an interim basis by West Point. If MEC is discovered during construction support, then an exclusion zone would be established to coordinate access of non-essential personnel during its removal. Depending on the type and location of the discovered MEC, the establishment of an exclusion zone may require coordination from the Directorate of Public Works, the Residential Housing Contractor, the USMAPS, and West Point. If established during construction support, an exclusion zone may prevent use/occupancy of the residential neighborhoods and/or the USMAPS for a short period of time; approximately one day for each MEC item discovered. Outside of construction support, EOD would be available to respond to the discovery of MEC.
- Cost: The total present value of this alternative would be $185,785.75. The total present value was derived from capital ($51,400.61), annual O&M ($117,900.30) and periodic ($45,769.15) costs based on a discount rate of 1.5% over a 30-year period. The total current year dollar value of this alternative would be $215,070.06. The costs for the five-year review were not included in the costs of this alternative; the total current year dollar value for five-year reviews over a 30-year period would be $32,340.00.

Alternative 2 would effectively protect human receptors from the explosive hazards posed by MEC at the GGHA–U MRS. Alternative 2 is readily implementable but may require some coordination if MEC is discovered. The costs for Alternative 2 would not be grossly excessive compared to its overall effectiveness. For these reasons, Alternative 2 will be carried forward to the detailed analysis of alternatives for the GGHA–U MRS.

4.4 Alternative 3—Munitions and Explosives of Concern Removal to Qualify for Unlimited Use and Unrestricted Exposure

4.4.1 Description of Alternative 3

Alternative 3 would include removal of MEC from all areas of the GGHA–U MRS. The extent of the MEC removal is presented on **Figure 4-2**. This removal would result in UU/UE qualification. This alternative consists of the following general components: planning document preparation, clearcutting and grubbing, and mag and dig removal of all identified MEC. The following planning documents would be prepared for this alternative: accident prevention plan/site safety and health plan, ESS, evacuation plan, storm water pollution prevention, uniform federal policy–quality assurance project plan, and work plan.

Clearcutting and grubbing would be performed with hand tools and mechanical equipment. The clearcutting and grubbing team would be assisted by a DDESB TP-18 qualified individual conducting UXO avoidance activities. Cleared and grubbed vegetation would be mulched, temporarily stored on-site, and trucked off-site for use by West Point.

The surface and subsurface MEC removal would be managed according to established removal protocols and applicable guidance. The MEC removal teams would be composed of DDESB TP-18–qualified personnel. The MEC removal activities would utilize mag and dig surveys. The survey activities would be conducted by DDESB TP-18–qualified personnel utilizing handheld metal detectors (e.g., optically pumped, flux-gate, or FDEMI) and an appropriate positioning technology. MEC identified during the MEC removal activities would be BIP or disposed by consolidated shot. Disposal operations would follow established protocols and applicable guidance. MEC removal would be conducted in lifts to ensure that the GGHA–U MRS qualifies for UU/UE.

An exclusion zone would be established to coordinate access of non-essential personnel and protect human receptors from the explosive hazards posed by MEC during disposal operations. If established, an exclusion zone may prevent use/occupancy of the residential neighborhoods and the USMAPS. The exclusion zone would depend on the type and location of the MEC item(s) that are identified. An evacuation plan would be developed to outline alternative housing provisions for those impacted by MEC disposal operations. For cost estimating purposes, it is assumed that the residential neighborhoods and the USMAPS adjacent to the GGHA–U MRS would need to be evacuated for approximately up to eight weeks.

4.4.2 Screening of Alternative 3

- Effectiveness: This alternative would protect human health by removing surface and subsurface MEC. These actions would eliminate human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS. This alternative would intentionally reduce the TMV of the principal threat waste (MEC) at the GGHA–U MRS and satisfy the statutory preference for treatment as a principal element of the selected remedy. This alternative would expose DDESB TP-18–qualified personnel to the explosive hazards associated with MEC

removal. MEC removal (i.e., BIP or consolidated shot) would utilize exclusion zones, engineering controls, and DDESB TP-18–personnel. The need to clearcut the forested, undeveloped areas of the GGHA–U MRS would adversely affect the woodland ecosystem. It would take many years for trees to reestablish themselves after clearcutting, and the clearcutting would accelerate soil erosion resulting in additional ecosystem damage. This alternative would comply with the substantive requirements of 40 CFR 264.601 (Environmental Performance Standards) by utilizing exclusion zones, engineering controls, and DDESB TP-18–qualified personnel when performing a consolidated shot. This alternative would require approximately one year to employ to eliminate human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS.

- Implementability: The technology and equipment required for MEC removal can be reliably operated with readily available equipment and skilled workers; however, the ability to maneuver and operate heavy equipment would be limited by the presence of steep terrain and bedrock outcrops on the GGHA–U MRS. The removal of MEC would be conducted with standard equipment and procedures. MEC removal activities would take approximately six months to complete. An exclusion zone would be established to coordinate access of non-essential personnel during MEC removal. Depending on the type and location of the discovered MEC, the establishment of an exclusion zone may require coordination from the Directorate of Public Works, the Residential Housing Contractor, the USMAPS, and West Point. If established, an exclusion zone may prevent use/occupancy of the residential neighborhoods and the USMAPS for a portion of the six-month period required for MEC removal. Clearcutting and grubbing to remove MEC would significantly reduce the aesthetic value of the GGHA–U MRS.
- Cost: The total present value of this alternative would be $1,774,473.37. The total present value was based only on a non-discounted capital cost of $1,774,473.37. The total current year dollar value of this alternative would also be $1,774,473.37.

Alternative 3 would effectively protect human receptors from the explosive hazards posed by MEC at the GGHA–U MRS. Alternative 3 would not require costs that are grossly excessive compared to its overall effectiveness because no additional actions would be required. Alternative 3 would not be implementable because it requires clearcutting and grubbing of the GGHA–U MRS, which is unlikely to be approved by West Point. Because it would not be implementable, Alternative 3 will not be carried forward to the detailed analysis of alternatives for the GGHA–U MRS.

4.5 Alternative 4—Partial Munitions and Explosives of Concern Removal with Risk Management

Alternative 4 would include the partial removal of surface and subsurface MEC and the implementation of LUCs at the GGHA–U MRS. The removal of MEC would be conducted in all areas of the GGHA–U MRS except below trees that are greater than 3-inches diameter at breast height. The partial MEC removal would be followed by the implementation of LUCs, including

administrative mechanisms and educational controls. The components of this alternative are discussed in detailed below.

Because this alternative would result in MEC potentially remaining at the GGHA–U MRS, Five-Year Reviews would be performed no less often than every five years after initiation of the remedial action until the GGHA–U MRS qualifies for UU/UE. Five-Year Reviews would include the following general steps:

- Existing documentation review;
- New information and current site conditions review and identification; and
- Five-Year Review report preparation.

4.5.1 Partial Munitions and Explosives of Concern Removal Component

The partial MEC removal component of Alternative 4 would be conducted from all areas of the GGHA–U MRS except below trees that are greater than 3-inches diameter at breast height. The extent of the partial MEC removal is presented on **Figure 4-3**. Because the GGHA–U MRS is heavily forested, it is assumed that approximately 0.5 acres of the GGHA–U MRS are covered by trees that are greater than 3-inches diameter at breast height; therefore, 10.5 acres of the GGHA–U MRS would be accessible for the partial MEC removal. The following general activities would be conducted for the partial MEC removal components of this alternative: planning document preparation, vegetation removal, and mag and dig removal. The following planning documents would be prepared for this alternative: accident prevention plan/site safety and health plan, ESS, evacuation plan, storm water pollution prevention, uniform federal policy–quality assurance project plan, and work plan.

Vegetation removal would be performed with hand tools and mechanical equipment. The vegetation removal team would be assisted by a DDESB TP-18 qualified individual to conduct UXO avoidance activities. Removed vegetation would be mulched, temporarily stored on-site, and used on-site or trucked off-site for use by West Point

The surface and subsurface MEC removal would be conducted according to established removal protocols and applicable guidance. The MEC removal teams would be composed of DDESB TP-18–qualified personnel. The MEC removal activities would utilize mag and dig surveys. The survey activities would be conducted by DDESB TP-18–qualified personnel utilizing handheld metal detectors (e.g., optically pumped, flux-gate, or FDEMI) and an appropriate positioning technology. MEC identified during the MEC removal activities would be BIP or disposed by consolidated shot. Disposal operations would follow established protocols and applicable guidance.

An exclusion zone would be established to coordinate access of non-essential personnel and protect human receptors from the explosive hazards posed by MEC during disposal operations. An exclusion zone may prevent use/occupancy of the residential neighborhoods and the USMAPS. The exclusion zone would depend on the type and location of the MEC item(s) that are identified.

An evacuation plan would be developed to outline alternative housing provisions for those impacted by MEC disposal operations. For cost estimating purposes, it is assumed that the residential neighborhoods and the USMAPS adjacent to the GGHA–U MRS would need to be evacuated for approximately up to four weeks.

4.5.2 Risk Management Component

The risk management component of Alternative 4 would implement LUCs at the GGHA–U MRS. These LUCs would include the administrative mechanisms and educational controls detailed in the IA (**Appendix B**). A LUCP would be prepared to detail LUC implementation at the GGHA–U MRS. The extent of the LUCs is presented on **Figure 4-3**. At the GGHA–U MRS, the following LUC technology process options would be implemented:

- Land Use Restrictions—New uses of the GGHA–U MRS for residential purposes, daycare facilities, hospitals, or schools would be prohibited without prior approval from West Point;
- Master Plan Notation—The installation master plan would include a notation requiring a record of all 911 calls involving MEC in a geographic information system database to facilitate explosive hazard delineation;
- Dig Permits and Construction Support—Dig permits and construction support would be required whenever ground is broken at the GGHA–U MRS. There is a low probability of encountering MEC at the MRS; therefore, on-call construction support and site-specific MEC awareness/safety training would be required according to the *Probability Assessment for Determining the Probability of Encountering MEC*. The site-specific MEC awareness/safety training would be provided to workers performing ground disturbing activities. The site-specific MEC awareness/safety training would identify explosives safety concerns/measures to be taken during ground disturbing activities, and the proper reporting procedures to be utilized in the highly unlikely event an MEC item is discovered (West Point, 2017). On-call construction support and worker training would be required during the construction of the proposed road and water line maintenance;
- Public Advisories—Brochures (e.g., 3Rs pamphlet) detailing the potential hazards associated with MEC would be developed and provided to site visitors (including resident adults and children); and
- Annual Review—Inspections would be required annually to ensure that the LUCs are uncompromised and that erosion has not exposed MEC, causing potential migration to the surface.

In the event that a suspected munition is discovered after the partial MEC removal, the location of the suspected munition would be marked and installation officials notified (i.e., 3R's protocol). Installation officials would assume control and security of the item until such time as the

responding EOD team arrived on site. The responding EOD team would dispose and/or remove the item in accordance with current EOD procedures.

4.5.3 Screening of Alternative 4

- Effectiveness: This alternative would protect human health by removing surface and subsurface MEC from approximately 10.5 acres of the GGHA–U MRS and restricting land use and modifying/guiding human behavior. These actions would reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS. This alternative would intentionally reduce the TMV of the principal threat waste (MEC) at the GGHA–U MRS and satisfy the statutory preference for treatment as a principal element of the selected remedy. This alternative would expose DDESB TP-18–qualified personnel to the explosive hazards associated with MEC removal. MEC removal (i.e., BIP or consolidated shot) would utilize exclusion zones, engineering controls, and DDESB TP-18–personnel. The need to remove vegetation from the GGHA–U MRS would adversely affect the woodland ecosystem. It would take a few years for vegetation to reestablish itself after vegetation removal. This alternative would comply with the substantive requirements of 40 CFR 264.601 (Environmental Performance Standards) by utilizing exclusion zones, engineering controls, and DDESB TP-18–qualified personnel when performing a consolidated shot. This alternative would require approximately one year to employ to eliminate human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS.

- Implementability: The technology and equipment required for MEC removal can be reliably operated with readily available equipment and skilled workers. The LUCs required for this alternative are also reliable and readily available because similar LUCs were successfully implemented on an interim basis by West Point. The removal of MEC would be conducted using standard equipment and procedures. MEC removal activities would take approximately six months to complete. An exclusion zone would be established to coordinate access of non-essential personnel during MEC removal. Depending on the type and location of the discovered MEC, the establishment of an exclusion zone may require coordination from the Directorate of Public Works, the Residential Housing Contractor, the USMAPS, and West Point. If established, an exclusion zone may prevent use/occupancy of the residential neighborhoods and the USMAPS for a portion of the six-month period required for MEC removal.

- Cost: The total present value of this alternative would be $1,837,929.83. The total present value was derived from capital ($1,703,544.69), annual O&M ($117,900.30), and periodic ($45,769.15) costs based on a discount rate of 1.5% over a 30-year period. The total current year dollar value of this alternative would be $1,867,214.14. The costs for the five-year review were not included in the costs of this alternative; the total current year dollar value for five-year reviews over a 30-year period would be $32,340.00.

Alternative 4 would effectively protect human receptors from the explosive hazards posed by MEC. Alternative 4 is readily implementable but requires some coordination. The costs for

Alternative 4 would not be grossly excessive compared to its overall effectiveness. For these reasons, Alternative 4 will be carried forward to the detailed analysis of alternatives for the GGHA–U MRS.

5.0 DETAILED ANALYSIS OF ALTERNATIVES

This section provides a detailed analysis of the remedial alternatives developed and retained for further evaluation in Section 4. This assessment consists of evaluating each retained alternative using seven of the nine criteria listed in the NCP. The remaining two criteria, state and community acceptance, will be evaluated following the Proposed Plan public comment period. The cost estimates are preliminary and based on currently available data. The cost estimates developed for this FS are expected to provide an accuracy of +50% to –30% based on available data and engineering judgment (USEPA, 1988). The purpose of this detailed evaluation of alternatives is to provide performance and cost data that may be used to evaluate further remedial actions at the GGHA–U MRS.

5.1 Evaluation Criteria

Evaluation criteria are described in the NCP, 40 CFR Section 300.430(e)(9). The criteria were developed to address the CERCLA requirements and considerations, and to address the additional technical and policy considerations that are important in selecting remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analyses during an FS and for selecting an appropriate remedial action. The evaluation criteria with the associated statutory considerations are described below.

The "threshold criteria" are requirements that each alternative must meet or have specifically waived to be eligible for selection. As stated in the *Final United States Army Military Munitions Response Program Munitions Response Remedial Investigation/Feasibility Study Guidance*, in the absence of thresholds for MEC, the primary objective of the response is to reduce hazards while meeting ARARs. The threshold criteria that each alternative must meet, as described in the NCP, include:

1. **Overall Protectiveness of Human Health and the Environment**—Assesses whether the alternatives can adequately protect human health and the environment, in both the short and long term, from the explosive hazards present at an MRS by eliminating, reducing, or controlling exposures to MEC. Overall protection of human health and the environment draws on the assessment of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.
2. **Compliance with ARARs**—Evaluates whether the alternative complies with MRS-specific ARARs or whether a waiver is justified. MRS-specific ARARs are summarized in Section 2.

The five "balancing criteria" described below are those that form the basis for comparison among alternatives that meet the threshold criteria. The balancing criteria are weighed against each other to determine which remedies are cost effective and are "permanent" to the maximum extent practicable:

3. **Long-Term Effectiveness and Permanence**—Considers the magnitude of residual hazard remaining at the conclusion of remedial activities and the adequacy and reliability of the response in managing any treatment residuals and untreated waste;

4. **Reduction of TMV of Contaminants through Treatment**—Assesses the degree to which response alternatives employ recycling or treatment that reduces the TMV of the principal threat waste (MEC). Remedial alternatives, at a minimum, address the principal threats posed by an MRS to the local environment. Considerations in the evaluation of this criterion may include:

    - Disposal processes for MEC;
    - Management of MEC and the amount of MEC to be destroyed, treated, or recycled.
    - Degree of expected reduction in TMV, including the means by which the principal threat is addressed.
    - Degree to which the alternative is irreversible.
    - Type, quantity, or volume of residuals that will remain, considering persistence, toxicity, and mobility.
    - The degree to which an alternative reduces the inherent hazards posed by the principal threats (U.S. Army, 2009).

5. **Short-Term Effectiveness**—Considers worker and community safety, as well as ecological, socioeconomic, and cultural impacts during implementation of the alternative. Also considers the effectiveness and reliability of the protective measures employed and the time until protection is achieved. The evaluation of socioeconomic impacts addresses if environmental justice is a concern or potential concern.

6. **Implementability**—Considers the technical and administrative feasibility of implementing the alternative and includes, as appropriate, the following factors:

    - Technical requirements:
        - Access due to terrain, vegetation, soils, water, or hazards;
        - Availability of technology;
        - Availability of equipment;
        - Available technology; and
        - Ability to determine effectiveness.
    - Administrative requirements:
        - Ability to obtain approvals;
        - Coordination and time requirements;

- Access due to ownership;
- Personnel/equipment shortages; and
- Funding availability.

7. **Cost**—This balancing criterion is used to evaluate the capital cost, annual O&M cost, periodic cost, and the total present value associated with implementing each alternative and considers a discount rate of 1.5% over a 30-year period. The 30-year period does not place a limitation on the length of the response but is used during the comparative analysis to evaluate the cost differences among the alternatives. Cost estimates for each alternative have a desired accuracy of +50% to –30% (USEPA, 1988).

The last two criteria, the "modifying criteria," will be fully evaluated following receipt of stakeholder and regulatory comments on this FS and community review of and comment on the Proposed Plan. Public comment on the Proposed Plan is addressed in the Decision Document:

8. **Regulatory Agency Acceptance**—Assesses the technical and administrative issues and concerns the state (New York State Department of Environmental Conservation) and USEPA Region II may have regarding each of the alternatives evaluated in this FS, as well as the preferred alternative presented in the Proposed Plan. State and USEPA acceptance of an alternative will be evaluated after the Proposed Plan is issued for public comment. Therefore, the regulatory acceptance criterion is not addressed in this FS.
9. **Community Acceptance**—Assesses the issues and concerns the public may have regarding each of the alternatives evaluated in this FS, as well as the preferred alternative presented in the Proposed Plan. Community acceptance of an alternative will be evaluated after the Proposed Plan is issued for public comment. Therefore, the community acceptance criterion is not addressed in this FS.

5.2 Individual Analysis of Alternatives

The following remedial alternatives are evaluated for the GGHA–U MRS against each of the NCP criteria except for regulatory agency and community acceptance in this section:

- Alternative 1—No Action;
- Alternative 2—Risk Management; and
- Alternative 4—Partial MEC Removal with Risk Management.

5.2.1 Alternative 1—No Action

Alternative 1 is evaluated against each of the NCP criteria except for regulatory agency and community acceptance in the following bullets:

1. **Overall Protectiveness of Human Health and the Environment**—Alternative 1 would not meet the criterion for overall protectiveness of human health because no actions would be taken to address the explosive hazards present at the GGHA–U MRS. Therefore, there

will be no reduction in the explosive hazards posed to current and future receptors. No explosive hazards to the environment are posed by residual MEC.

Application of the Risk Methodology determined that the residual risk posed by MEC at the GGHA–U MRS would be unacceptable under the No Action alternative (baseline conditions). The GGHA–U MRS-specific characteristics, decision logic, and matrices used by the Risk Methodology for the evaluation of the No Action alternative (baseline conditions) are presented in **Appendix A**.

2. **Compliance with ARARs**—Alternative 1 would meet the criterion for compliance with ARARs because no action would be taken.
3. **Long-Term Effectiveness and Permanence**—Alternative 1 would not be effective or permanent in the long term because no action would be taken to address the explosive hazards present at the GGHA–U MRS. The magnitude of residual hazards caused by MEC would not be reduced. This alternative would require no technical components.
4. **Reduction of TMV of Contaminants Through Treatment**—Alternative 1 would not reduce the TMV of the principal threat waste (MEC) or satisfy the statutory preference for treatment as a principal element of the remedy because no action would be taken to address the explosive hazards present at the GGHA–U MRS.
5. **Short-Term Effectiveness**—Alternative 1 would not expose workers to the hazards posed by MEC removal because no action would be taken. There would be no adverse ecological, socioeconomic, or cultural effects resulting from the implementation of this alternative, and it would require no time to employ.
6. **Implementability**—Alternative 1 would be technically and administratively feasible because it would include no action.
7. **Cost**—Alternative 1 would require no action; therefore, the total present value to perform it would be $0.

5.2.2 Alternative 2—Risk Management

Alternative 2 is evaluated against each of the NCP criteria except for regulatory agency and community acceptance in the following bullets:

1. **Overall Protectiveness of Human Health and the Environment**—Alternative 2 would meet the criterion for overall protectiveness of human health. No hazards to the environment are posed by residual MEC. Alternative 2 would protect human health by restricting land use and modifying/guiding human behavior with LUCs. These actions would reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS. Specific activities and actions that would be implemented by each LUC to reduce human receptor exposure to the explosive hazards posed by MEC are detailed in the following bullets:

- The preparation and dissemination of public advisories (e.g., 3Rs pamphlet) would educate site visitors (including resident adults and children) on the presence of potential munitions and provide instructions on what to do if suspected munitions are encountered;
- The tracking of 911 calls regarding the identification of munitions in a master plan would identify locations where explosive hazards are present. The tracking data may be used to educate contractor personnel, maintenance workers, and site visitors (including resident adults and children) on the presence of munitions and provide instructions on what to do if suspected munitions are encountered, i.e., site-specific MEC awareness/safety training;
- On-call construction support is required when conducting intrusive activities at the GGHA–U MRS. The on-call construction support would be conducted by specially trained personnel who are equipped to properly handle and dispose of explosive hazards.
- Land use restrictions would prevent future incompatible development and reduce contact hours and exposure pathways.
- An annual review would provide West Point with an opportunity to collect periodic data for use during the Five-Year Review to evaluate and ensure the LUC program remains protective.

In the event that a suspected munition is discovered, the location of the suspected munition would be marked and installation officials notified (i.e., 3R's protocol). Installation officials would assume control and security of the item until such time as the responding EOD team arrived on site. The responding EOD team would dispose and/or remove the item in accordance with current EOD procedures.

Application of the Risk Methodology determined that the residual risk posed by MEC at the GGHA–U MRS would be acceptable following the implementation of LUCs. The site-specific characteristics, decision logic, and matrices used by the Risk Methodology for the evaluation of Alternative 2 are presented in **Appendix A**.

2. **Compliance with ARARs**—If MEC discovered at the GGHA–U MRS is destroyed by consolidated shot, then compliance with the substantive requirements of 40 CFR 264.601 (Environmental Performance Standards) would be achieved by using exclusion zones, engineering controls, and DDESB TP-18–qualified personnel during MEC removal if MEC is found during construction support. Alternative 2 would meet the criterion for compliance with ARARs.
3. **Long-Term Effectiveness and Permanence**—Alternative 2 would mitigate the residual explosive hazards posed by MEC to human receptors at the GGHA–U MRS by implementing LUCs. Remaining hazards to human receptors due to direct contact with

residual MEC would be mitigated by LUCs. Similar LUCs implemented on an interim basis by West Point have proven effective. If MEC is discovered, its subsequent destruction by BIP or consolidated shot would be permanent. The continued mitigation of residual explosive hazards at the GGHA–U MRS would require West Point to maintain and enforce the LUCs. As discussed in the IA (**Appendix B**), the LUCs included in this alternative would be supported by West Point.

Because this alternative would result in MEC remaining at the GGHA–U MRS, Five-Year Reviews would be performed, as required by CERCLA, until the GGHA–U MRS qualifies for UU/UE (i.e., negligible probability) to verify that this alternative remains protective.

4. **Reduction of TMV of Contaminants through Treatment**—Alternative 2 would not intentionally reduce the TMV of the principal threat waste (MEC) at the GGHA–U MRS. However, the TMV of MEC would be irreversibly reduced in those instances where MEC is discovered and BIP or disposed of by consolidated shot. Alternative 2 does not, however, satisfy the statutory preference for treatment as a principal element.

5. **Short-Term Effectiveness**—Alternative 2 would expose DDESB TP-18–qualified personnel to the explosive hazards posed by MEC removal. There would be no adverse cultural, ecological, or socioeconomic effects resulting from the implementation of this alternative. This alternative would require approximately six months to employ to reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS.

6. **Implementability**—The LUCs required for Alternative 2 are readily available and reliable because similar LUCs were successfully implemented on an interim basis by West Point. If MEC is discovered during construction support, then an exclusion zone would be established to coordinate access of non-essential personnel during its removal. Depending on the type and location of the discovered MEC, the establishment of an exclusion zone may require coordination from the Directorate of Public Works, the Residential Housing Contractor, the USMAPS, and West Point. If established during construction support, an exclusion zone may prevent use/occupancy of the residential neighborhoods and/or the USMAPS for a short period of time; approximately one day for each MEC item discovered. Outside of construction support, EOD would be available to respond to the discovery of MEC. The protectiveness of the remedy would be monitored annually by West Point and through Five-Year Reviews. West Point has full access to the GGHA–U MRS to implement this alternative because the GGHA–U MRS is located on Army-controlled property. The funding for this alternative would be made available because the GGHA–U MRS is not an operational range, an active munitions demilitarization facility, or an active waste military munitions treatment or disposal unit.

7. **Cost**—The total present value of this alternative would be $185,785.75. The total present value was derived from capital ($51,400.61), annual O&M ($117,900.30) and periodic ($45,769.15) costs based on a discount rate of 1.5% over a 30-year period. The total current year dollar value of this alternative would be $215,070.06. The costs for the five-year

review were not included in the costs of this alternative; the total current year dollar value for five-year reviews over a 30-year period would be $32,340.00. The detailed cost estimate for this alternative is provided in **Appendix C**.

5.2.3 Alternative 4—Partial Removal of Munitions and Explosives of Concern and Risk Management

Alternative 4 is evaluated against each of the NCP criteria except for regulatory agency and community acceptance in the following bullets:

1. **Overall Protectiveness of Human Health and the Environment**—Alternative 4 meets the criterion for overall protectiveness of human health. No hazards to the environment are posed by residual MEC. Alternative 4 would protect human health by removing surface and subsurface MEC from approximately 10.5 acres of the GGHA–U MRS and restricting land use and modifying/guiding human behavior in the remaining 0.5 acres of the GGHA–U MRS. These actions would reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS.

   In the event that a suspected munition is discovered after the partial MEC removal, the location of the suspected munition would be marked and installation officials notified (i.e., 3R's protocol). Installation officials would assume control and security of the item until such time as the responding EOD team arrived on site. The responding EOD team would dispose and/or remove the item in accordance with current EOD procedures.

   Application of the Risk Methodology determined that the residual risk posed by MEC at the GGHA–U MRS would be acceptable following the partial MEC removal and implementation of LUCs. The site-specific characteristics, decision logic, and matrices used by the Risk Methodology for the evaluation of Alternative 4 are presented in **Appendix A**.

2. **Compliance with ARARs**—If MEC removed from the GGHA–U MRS is destroyed by consolidated shot, then compliance with the substantive requirements of 40 CFR 264.601 (Environmental Performance Standards) would be achieved by using exclusion zones, engineering controls, and DDESB TP-18–qualified personnel during MEC disposal. Alternative 4 would meet the criterion for compliance with ARARs.

3. **Long-Term Effectiveness and Permanence**—Alternative 4 would mitigate the residual explosive hazards posed by MEC to human receptors at the GGHA–U MRS by removing surface and subsurface MEC from 10.5 acres of the GGHA–U MRS and implementing LUCs to address residual MEC in the remaining 0.5 acres of the GGHA–U MRS. Removal of surface and subsurface MEC is a standard approach to MEC and is considered effective. The subsequent destruction of MEC by BIP or consolidated shot would be permanent. Remaining hazards to human receptors due to direct contact with residual MEC in the remaining 0.5 acres of the GGHA–U MRS would be mitigated by LUCs. The continued mitigation of residual explosive hazards at the GGHA–U MRS would require West Point

to maintain and enforce the LUCs. As discussed in the IA (**Appendix B**), the LUCs included in this alternative would be supported by West Point.

Because this alternative would result in MEC remaining at the GGHA–U MRS, Five-Year Reviews would be performed, as required by CERCLA, until the GGHA–U MRS qualifies for UU/UE (i.e., negligible probability) to verify that this alternative remains protective.

4. **Reduction of TMV of Contaminants through Treatment**—Alternative 4 would irreversibly remove MEC from 10.5 acres of the GGHA–U MRS, thereby significantly reducing the TMV associated with the principal threat waste (MEC) at the GGHA–U MRS. As a result, this alternative satisfies the statutory preference for treatment as a principal element.

5. **Short-Term Effectiveness**—Alternative 4 would expose DDESB TP-18–qualified personnel to the explosive hazards associated with MEC removal. The need to remove vegetation from the GGHA–U MRS would adversely affect the woodland ecosystem. It would take a few years for vegetation to reestablish itself after vegetation removal. There would be no adverse cultural or socioeconomic effects resulting from the implementation of this alternative. This alternative would require approximately one year to employ to reduce human receptor exposure to the explosive hazards posed by MEC at the GGHA–U MRS.

6. **Implementability**—The technology and equipment required for MEC removal is readily available and can be reliably operated with skilled workers. The LUCs required for this alternative are also reliable and readily available because similar LUCs were successfully implemented on an interim basis by West Point. MEC removal would be conducted with standard equipment and procedures. MEC removal activities would take approximately six months to complete. An exclusion zone would be established to coordinate access of non-essential personnel during MEC removal. Depending on the type and location of the discovered MEC, the establishment of an exclusion zone may require coordination from the Directorate of Public Works, the Residential Housing Contractor, the USMAPS, and West Point. If established, an exclusion zone may prevent use/occupancy of the residential neighborhoods and the USMAPS for a portion of the six-month period required for MEC removal. The protectiveness of the remedy would be monitored annually by West Point and through Five-Year Reviews. West Point has full access to the GGHA–U MRS to implement this alternative because the GGHA–U MRS is located on Army-controlled property. The funding for this alternative would be made available because the GGHA–U MRS is not an operational range, an active munitions demilitarization facility, or an active waste military munitions treatment or disposal unit.

7. **Cost**—The total present value of this alternative would be $1,837,929.83. The total present value was derived from capital ($1,703,544.69), annual O&M ($117,900.30), and periodic ($45,769.15) costs based on a discount rate of 1.5% over a 30-year period. The total current year dollar value of this alternative would be $1,867,214.14. The costs for the five-year

review were not included in the costs of this alternative; the total current year dollar value for five-year reviews over a 30-year period would be $32,340.00. The detailed cost estimate for this alternative is provided in **Appendix C**.

5.3 Comparative Analysis of Remedial Alternatives

Based on the detailed analysis of remedial alternatives in Section 5.2, the strengths and weaknesses of the remedial alternatives relative to one another are evaluated with respect to each of the NCP criteria, except for regulatory agency and community acceptance. Alternatives 1, 2 and 4 are compared in the discussions below.

1. **Overall Protectiveness of Human Health and the Environment**—All of the alternatives, except Alternative 1 would meet the criterion of overall protectiveness of human health. No hazards to the environment are posed by residual MEC; therefore, all three alternatives would be protective of the environment. Alternative 4 would protect human health by restricting land use and modifying/guiding human behavior and removing surface and subsurface MEC from approximately 10.5 acres of the GGHA–U MRS. Alternative 2 would protect human health by restricting land use and modifying/guiding human behavior with LUCs.

2. **Compliance with ARARs**—Alternative 2 and Alternative 4 would comply with the substantive requirements of 40 CFR 264.601 (Environmental Performance Standards) if MEC is destroyed by consolidated shot by establishing exclusion zones, using engineering controls, and performing MEC removal operations with DDESB TP-18–qualified personnel. Therefore, Alternative 2 and Alternative 4 would comply with ARARs. Alternative 1 would also comply with ARARs because it would include no action.

3. **Long-Term Effectiveness and Permanence**—For long-term effectiveness and permanence, Alternative 4 is the best, Alternative 2 is the second best, and Alternative 1 is the least favorable. Alternative 4 would reduce the residual explosive hazards posed by MEC at the GGHA–U MRS more than Alternative 2 because Alternative 4 would remove MEC from 10.5 acres of the GGHA–U MRS and Alternative 2 would not intentionally remove any MEC from the GGHA–U MRS. Alternative 2 and Alternative 4 would utilize LUCs to mitigate the residual explosive hazards posed by MEC at the GGHA–U MRS, although Alternative 2 would leave more residual MEC at the GGHA–U MRS than Alternative 4. Because Alternative 2 and Alternative 4 would result in MEC remaining at the GGHA–U MRS, Five-Year Reviews would be performed as required by CERCLA. Alternative 1 would not reduce or mitigate residual explosive hazards because no action would be taken.

4. **Reduction of TMV of Contaminants through Treatment**—For reduction of TMV of contaminants through treatment, Alternative 4 is the best, Alternative 2 is the second best, and Alternative 1 is the least favorable. Alternative 4 would reduce the TMV of the principal threat waste (MEC) more than Alternative 2 because Alternative 4 would

intentionally remove MEC from 10.5 acres of the GGHA–U MRS. Only Alternative 4 satisfies the statutory preference for treatment as a principal element. Alternative 1 would not reduce the TMV of MEC because no action would be taken.

5. **Short-Term Effectiveness**— For short-term effectiveness, Alternative 1 is the best, Alternative 2 is the second best, and Alternative 4 is the least favorable. Alternative 1 would not expose workers to hazards posed by MEC removal because no action would be taken. Alternative 2 would be more effective in the short term than Alternative 4 because workers would only be exposed to explosive hazards when MEC is unintentionally discovered and removed from the GGHA–U MRS. Alternative 2 would be more effective in the short term than Alternative 4 because Alternative 2 would not be detrimental to the ecosystem and it would take less time to employ. Alternatives 1, 2, and 4 would cause no adverse cultural or socioeconomic effects.

6. **Implementability**— For implementability, Alternative 1 is the best, Alternative 2 is the second best, and Alternative 4 is the least favorable. Alternative 1 would be most implementable because no action would be taken. Alternative 2 would be more implementable than Alternative 4 because Alternative 2 may require stakeholder coordination only if MEC is discovered during construction support. Alternative 2 and Alternative 4 would utilize reliable and readily available components. The protectiveness of Alternative 2 and Alternative 4 would be monitored annually by West Point and through Five-Year Reviews. The GGHA–U MRS is readily accessible, because it is located on Army-controlled property, for the implementation of Alternative 2 and Alternative 4. The funding for Alternative 2 and Alternative 4 would be made available because they are not operational ranges, active munitions demilitarization facilities, or active waste military munitions treatment or disposal units.

7. **Cost**— For cost, Alternative 1 is the best, Alternative 2 is the second best, and Alternative 4 is the least favorable. The total present value to perform each alternative is provided below:

    - Alternative 1 = $0
    - Alternative 2 = $185,785.75
    - Alternative 4 = $1,837,929.83

Table 5-1 Summary of Comparative Analysis of Alternatives

Screening Criterion		Alternative 1—No Action	Alternative 2—Risk Management	Alternative 4—Partial MEC Removal and Risk Management
Threshold	Overall Protectiveness of Human Health and Environment	F	P	P
	Compliance with ARARs	P	P	P
Balancing	Long-Term Effectiveness	3	2	1
	Reduction of TMV through Treatment	3	2	1
	Short-Term Effectiveness	1	2	3
	Implementability	1	2	3
	Cost[1]	$0	$185,785.75	$1,837,929.83
Modifying[2]	Regulatory Agency Acceptance	TBD	TBD	TBD
	Community Acceptance	TBD	TBD	TBD

Notes:
ARARs Applicable or Relevant and Appropriate Requirements
MEC Munitions and Explosives of Concern
TBD To-Be-Determined
TMV Toxicity, Mobility, or Volume
UU/UE Unlimited Use/Unrestricted Exposure

Threshold criterion scored as Pass (P) or Fail (F).

Balancing criterion analyses scored from 1 to 3, where a score of 3 indicates least favorable and a score of 1 indicates most favorable.

[1] Costs are detailed in **Appendix C**.

[2] The modifying criteria of regulatory agency and community acceptance are To-Be-Determined following review and input from these parties.

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FIGURES

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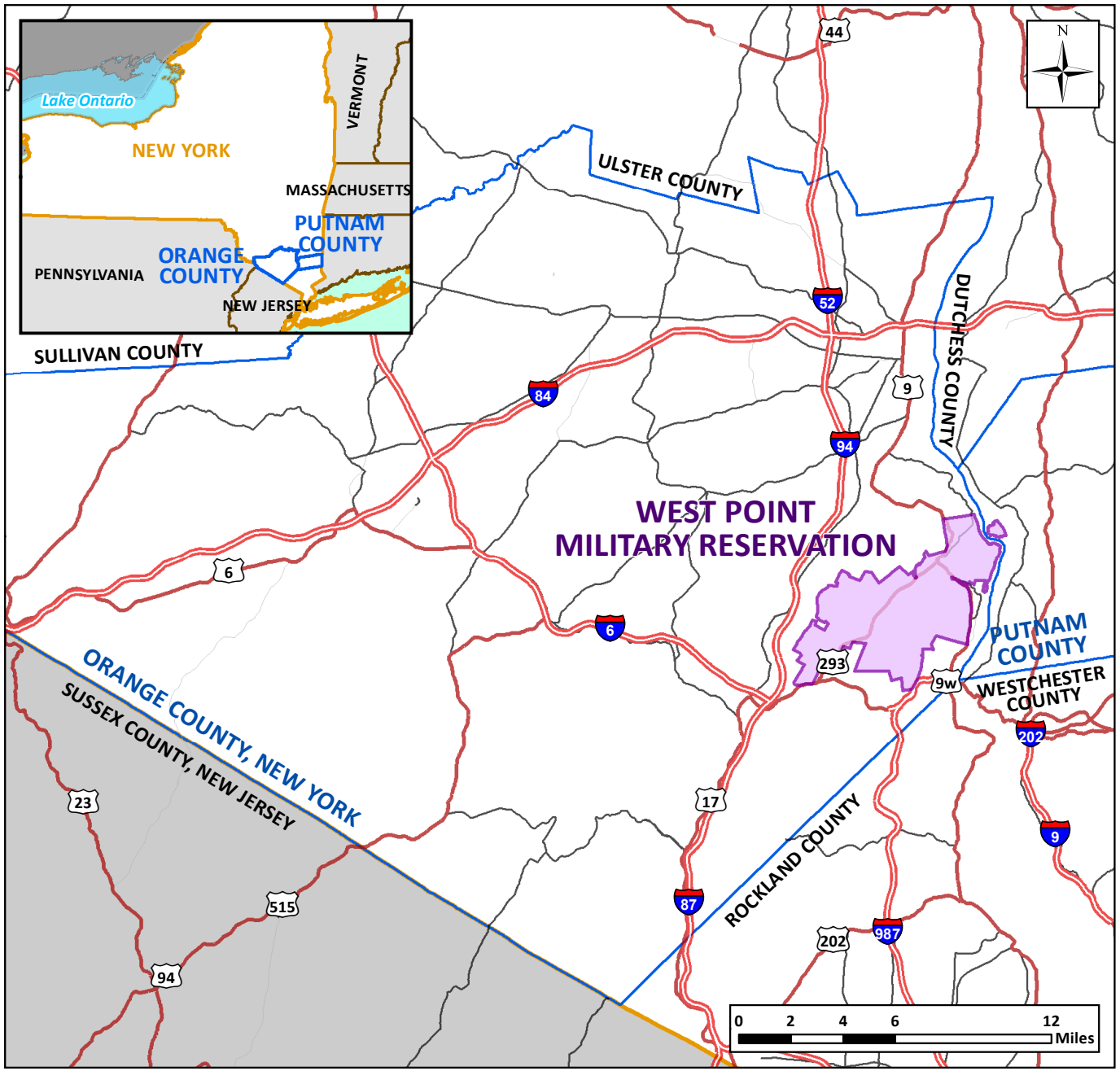

Map Key:

- State Boundary
- County Boundary
- West Point Boundary
- Lake Ontario
- Interstate
- Highway
- Major Road
- Local Road

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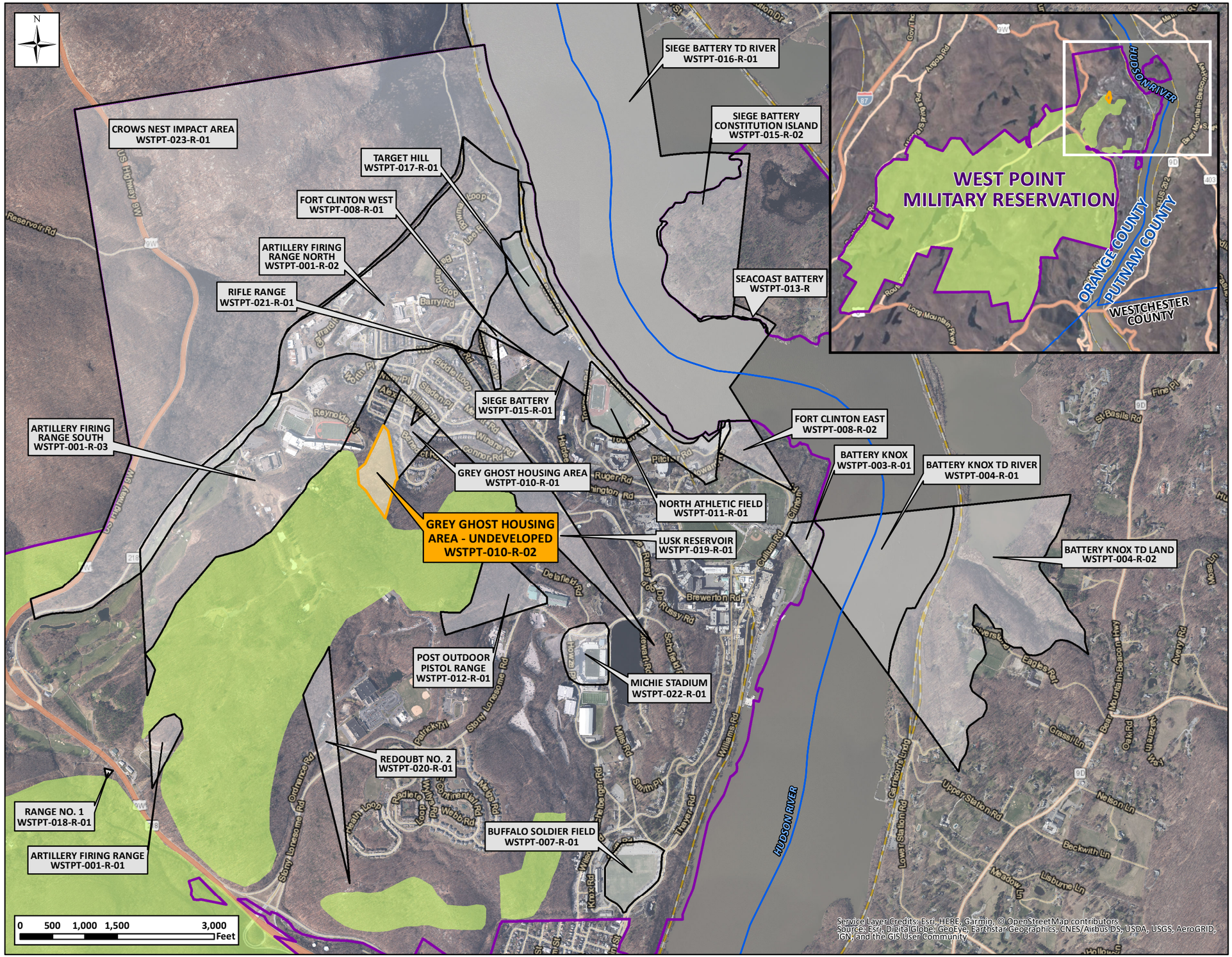
Date: March 2016

FIGURE 1-1

Regional Location Map

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY



Map Key:

- County Boundary
- West Point Boundary
- Grey Ghost Housing Area - Undeveloped MRS Boundary
- MRS Boundary
- Operational Range Area

Notes:

MRS boundaries are for display purposes only.
Official boundaries are maintained in Army database.
Imagery provided for visual representation only and may not reflect current site conditions.

Abbreviation Key:

MRS = Munitions Response Site

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FIGURE 1-2

Grey Ghost Housing Area - Undeveloped MRS Location

Feasibility Study
Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point
West Point, NY

C:\Users\bbouton\OneDrive - Plexus Scientific Corp\Documents\GIS_PRJ_BU\West Point MMRP\Maps\GGHA FS\Figure 1-2 - GGHA Site Location.mxd

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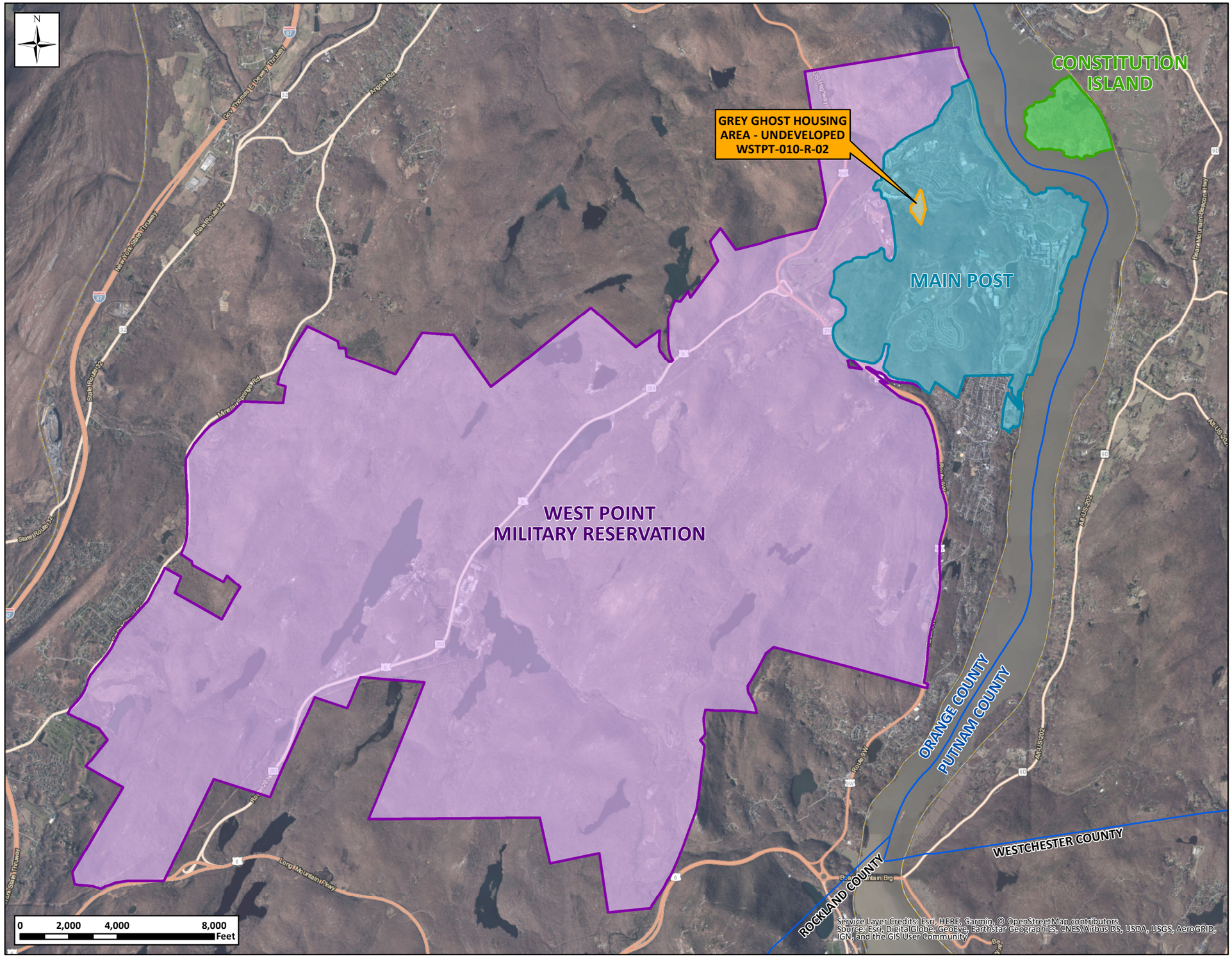

Map Key:

- County Boundary
- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Military Reservation Area
- Main Post
- Constitution Island

Notes:

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Abbreviation Key:

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FIGURE 1-3

West Point Areas and Grey Ghost Housing Area - Undeveloped MRS

Feasibility Study
Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point
West Point, NY

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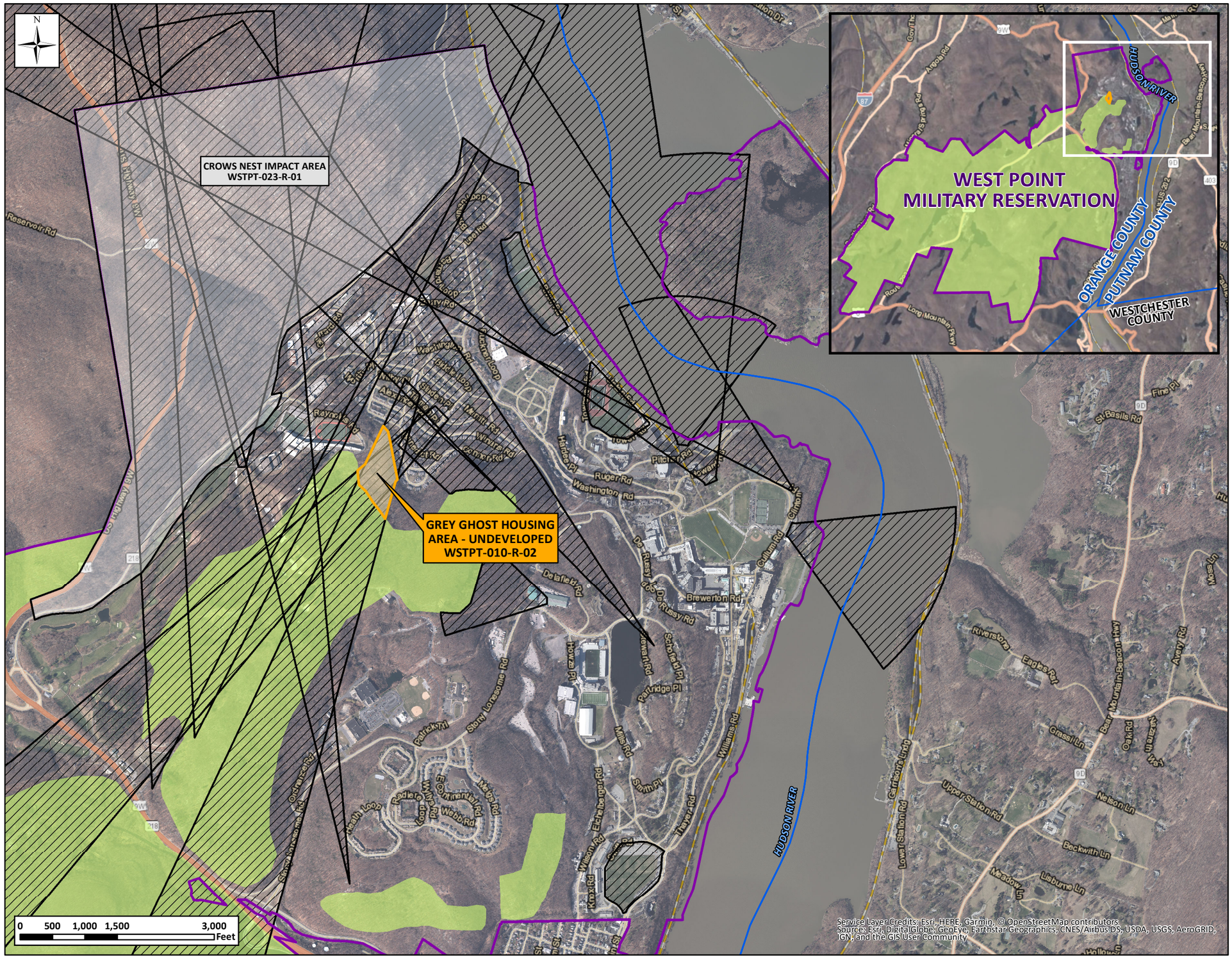

Map Key:

- County Boundary
- West Point Boundary
- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Firing Range
- Operational Range Area

Notes:

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Abbreviation Key:

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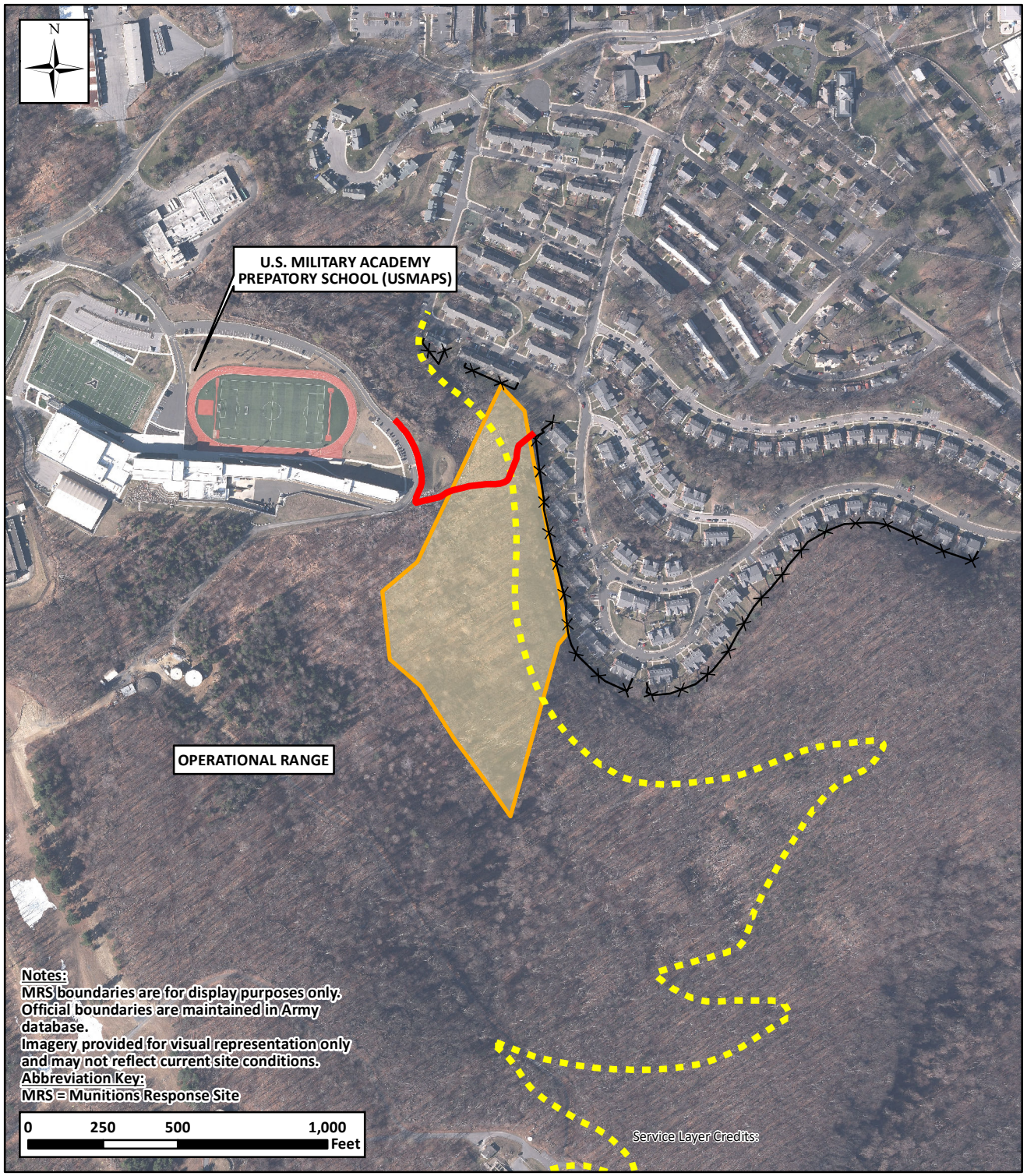
Date: April 2018

FIGURE 1-4

Firing Ranges and Grey Ghost Housing Area - Undeveloped MRS

Feasibility Study
Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point
West Point, NY



Map Key:

- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Closed Walking Trail
- Approximate Location of Proposed New Road
- Fence

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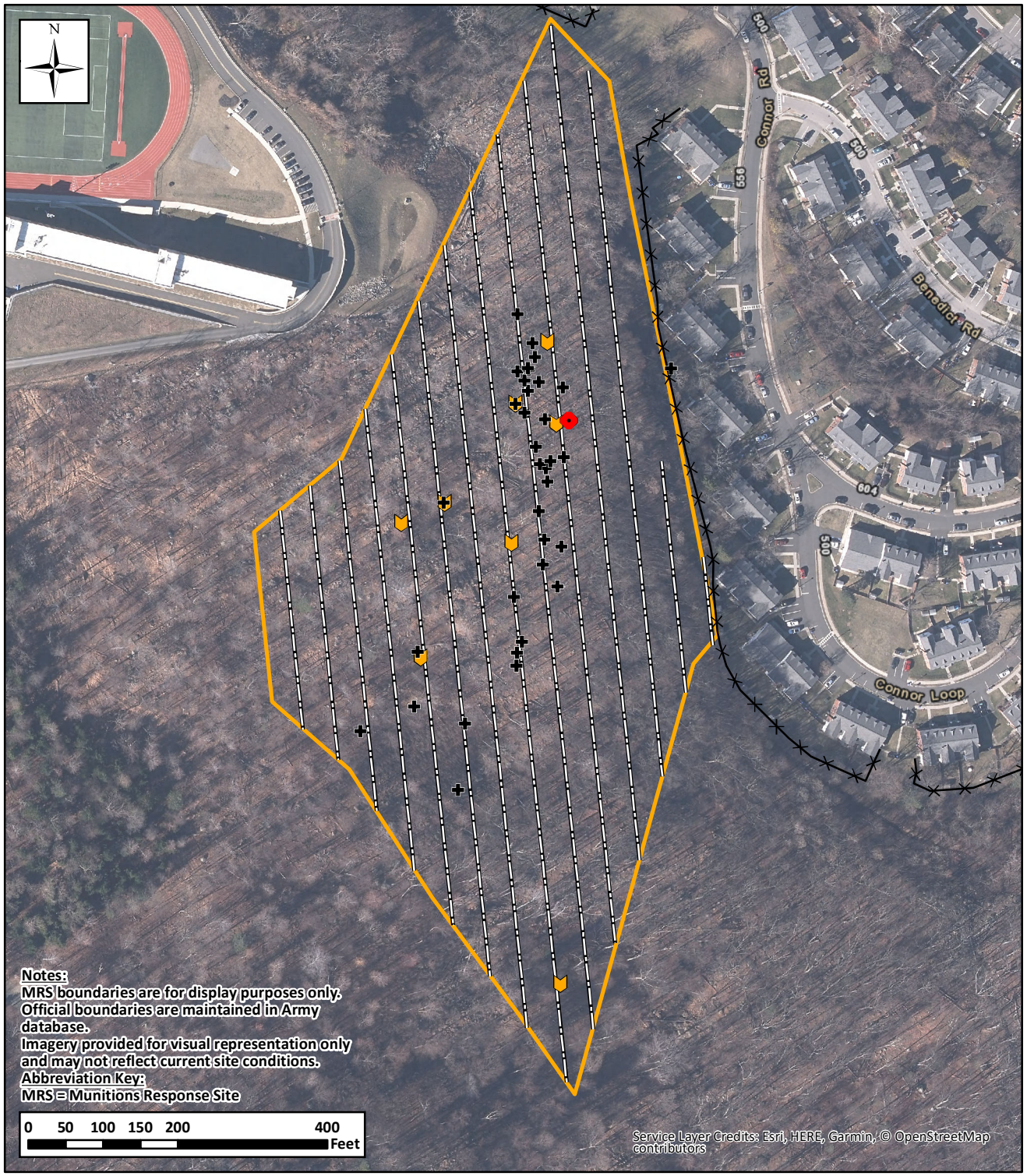
FIGURE 1-5

Grey Ghost Housing Area - Undeveloped MRS Site Layout

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY



Map Key:

- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Mag and Dig Transects
- Fence

MEC Items:

- 3" Stokes Mortar (UXO) (sand filled, fuzed)

MD Items:

- Frag
- 3" Stokes Mortar (empty)

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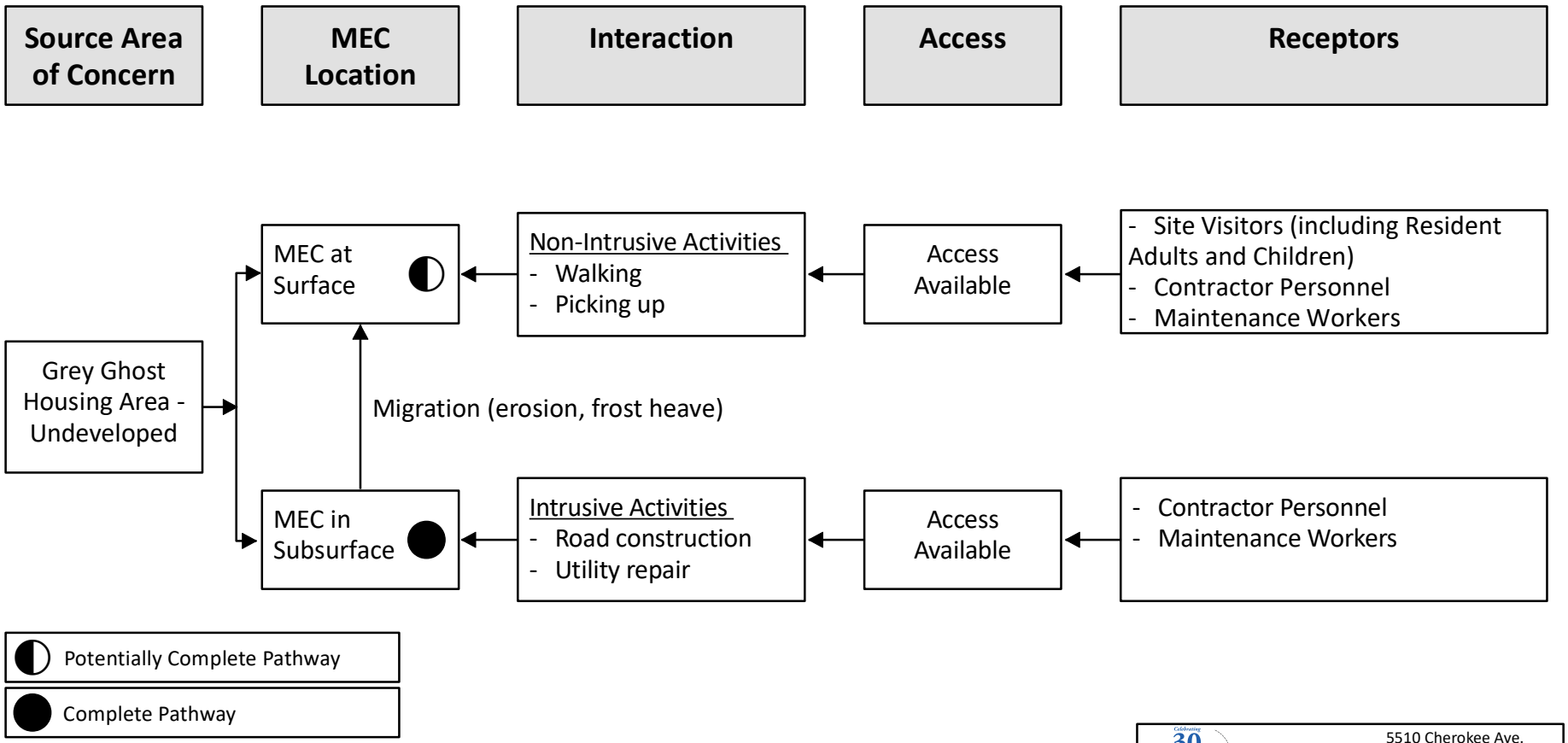
FIGURE 1-6

Grey Ghost Housing Area - Undeveloped MRS Dig Results

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY



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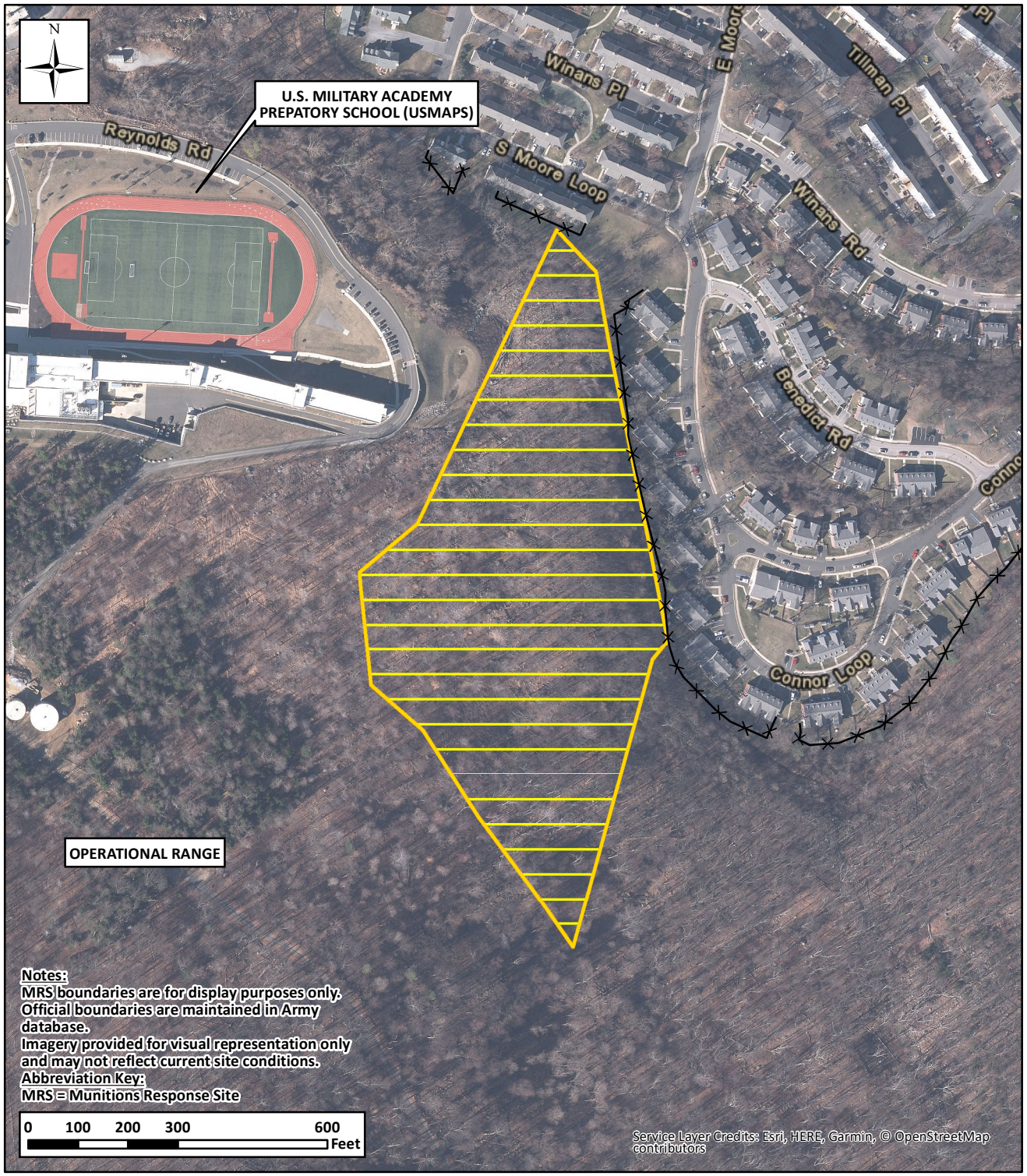
Date: April 2018

FIGURE 1-7

Revised Conceptual Site Model

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY



Map Key:

- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Land Use Controls
- Fence

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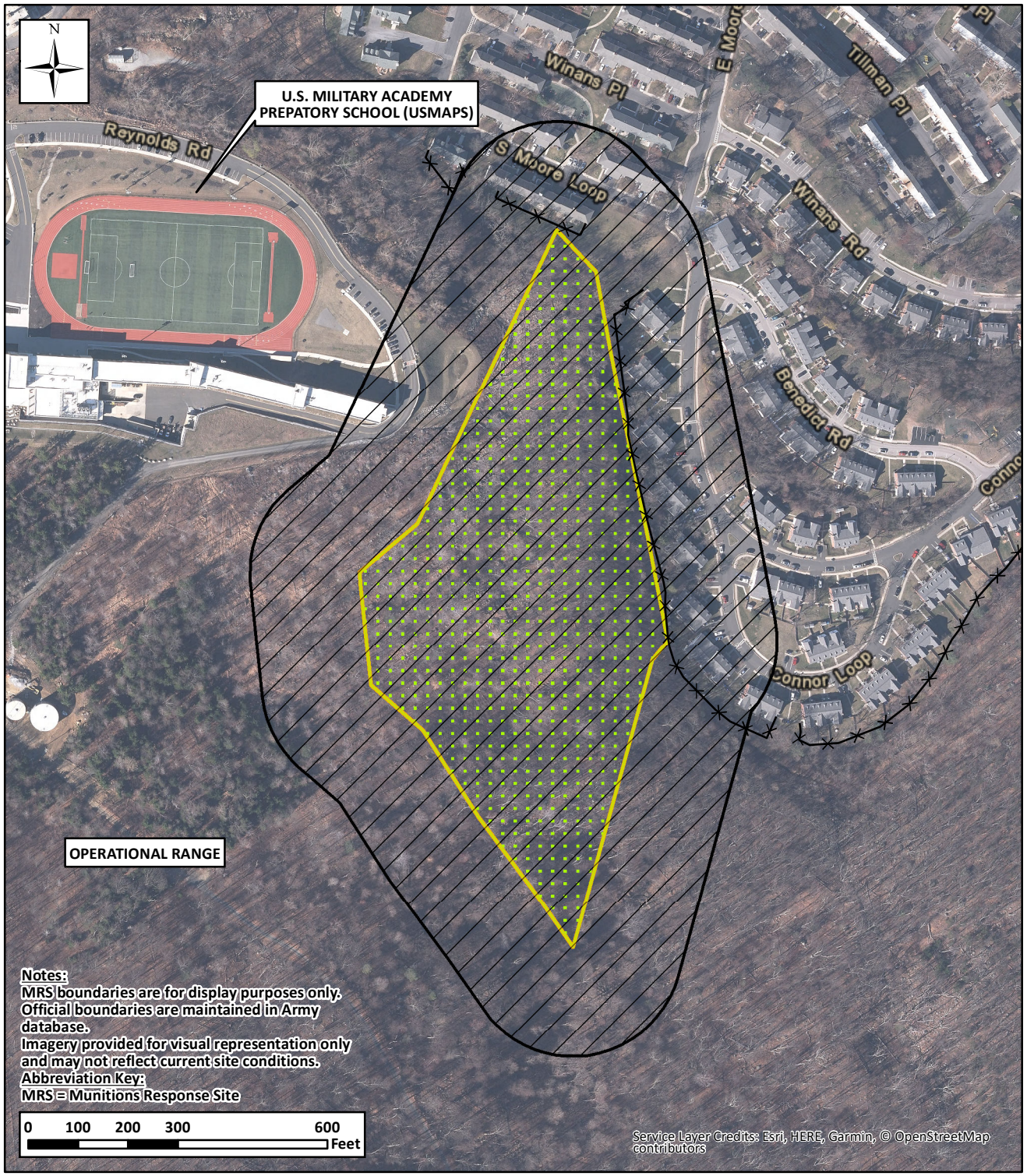
FIGURE 4-1

Alternative 2: Risk Management

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY



Map Key:

- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Surface/Subsurface Removal
- Potential Exclusion Zone during Remediation
- Fence

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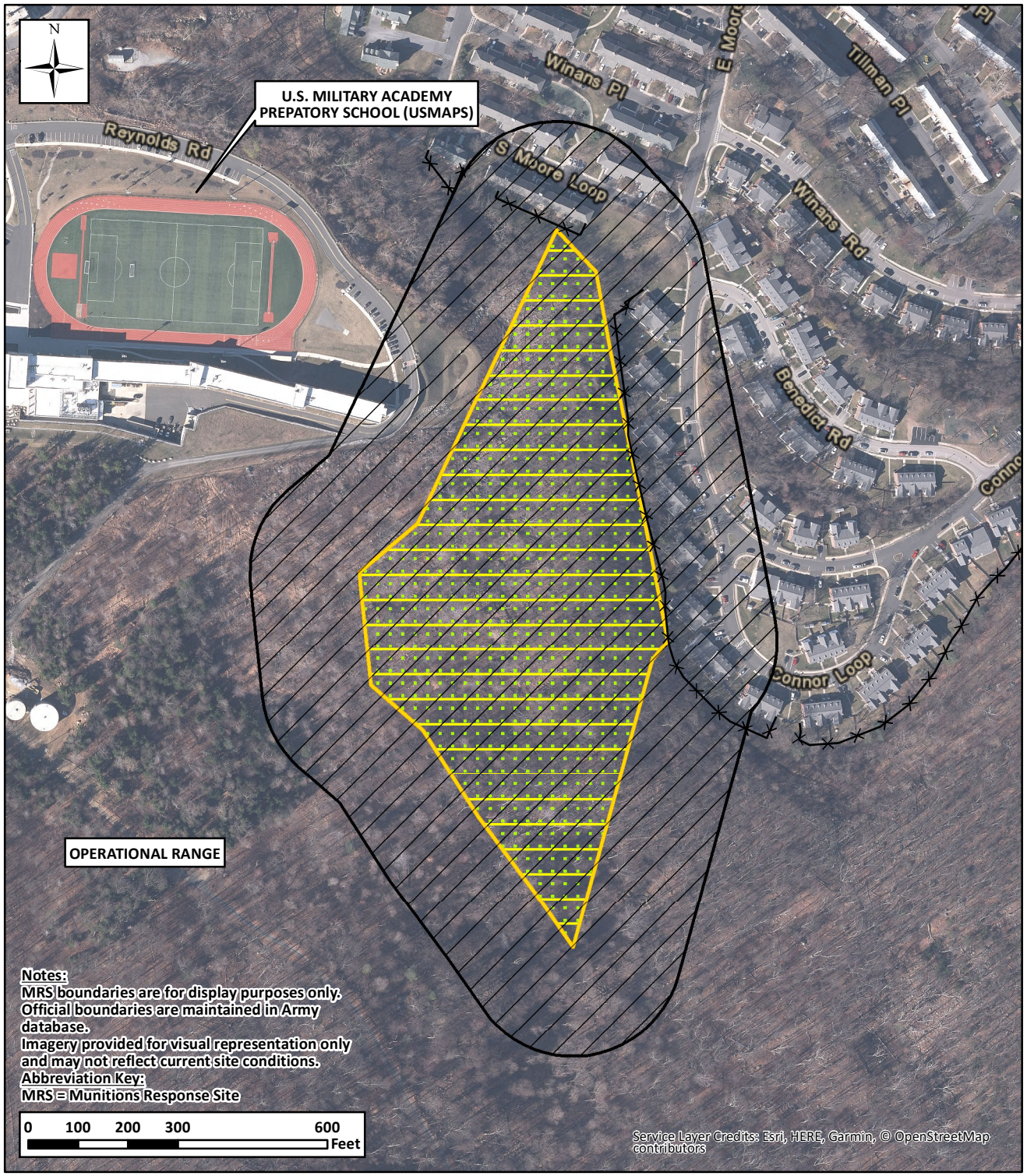
Date: July 2018

FIGURE 4-2

Alternative 3: MEC Removal to Qualify for UU/UE

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY



Map Key:

- Grey Ghost Housing Area - Undeveloped MRS Boundary
- Land Use Controls
- Surface/Subsurface Removal
- Potential Exclusion Zone during Remediation
- Fence

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FIGURE 4-3

Alternative 4: Partial MEC Removal with Risk Management

Feasibility Study Grey Ghost Housing Area - Undeveloped MRS
U.S. Army Garrison West Point, West Point, NY

APPENDIX A
RISK METHODOLOGY MATRICES

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Matrix 1. Likelihood of Encounter

Likelihood of Encounter, Matrix 1: Amount of MEC vs. Access Conditions		**Access Conditions (frequency of use)**			
		Regular (e.g. Daily use, open access)	**Often** (e.g., less regular or periodic use, some access)	**Intermittent** (e.g., some irregular use, or access limited)	**Rare** (e.g., very limited use, access prevented)
Amount of MEC	• MEC is visible on the surface and detected in the subsurface.	**Frequent**	**Frequent**	**Likely**	**Occasional**
	• The area is identified as a Concentrated Munitions Use Area (CMUA) where MEC is known or suspected (e.g., MD indicative of MEC is identified) to be present in surface and subsurface.	**Frequent**	**Likely**	**Occasional**	**Seldom**
	• MEC presence based on physical evidence (e.g., MD indicative of MEC), although the area is not a CMUA. • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 1.0/acre at 95% confidence).	**Likely**	**Occasional**	**Seldom**	**Unlikely**
	• 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).	**Occasional**	**Seldom**	**Unlikely**	**Unlikely**
	• 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 (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).	**Seldom**	**Seldom**	**Unlikely**	**Unlikely**
	• Investigation of the MRS did not identify evidence of MEC presence. • A DERP response action has been conducted that will achieve UU/UE.	**Unlikely**	**Unlikely**	**Unlikely**	**Unlikely**

Amount of MEC Justification:

As documented in the RI, MEC was not found on the surface, therefore, the highest amount (i.e., first row) of MEC is not appropriate. Because the target area identified in the RI was not determined to be a Concentrated Munitions Use Area (CMUA), the second highest amount of MEC (i.e., second row) is also not appropriate.

The RI identified one MEC item, a 3-inch Stokes Mortar (sand filled, fuzed). Additionally, the Probability Assessment for Determining the Probability of Encountering MEC During Site Activities at West Point, New York dated April 14, 2017 identified the MRS as a Group A MRS: an MRS with a "Low Probability" of encountering MEC during intrusive activities. Therefore, the isolated historical discovery is consistent with selection of the fourth row based on the following bullet: MEC presence is based on isolated historical discoveries (e.g., EOD report).

Access Conditions Justification:

To determine the access conditions (frequency of use), the following information was considered:

- The MRS is not currently fenced, but residential properties adjacent to the MRS have fenced backyards.
- Potential maintenance work to repair the waterline located in the MRS may occur.
- A road may be constructed through the MRS in the future.
- A trail connects the residential area to the USMAPS. West Point has indicated that the trail is used by residents to access the USMAPS during games. It was conservatively assumed that games at the USMAPS occur year-round. The trail has been officially closed, but West Point suspects that the trail continues to be used.
- Individuals from the residential area may enter the MRS to chase a ball or to retrieve a lost dog.
- The steeply sloped topography of the MRS limits the ability of receptors to access the MRS.

Based on the preceding information, the frequency of use is "Often".

Matrix 1 Result, Likelihood of Encounter: Seldom

Matrix 2. Severity of Incident

Severity of Incident, Matrix 2: Severity vs. Likelihood of Encounter		**Likelihood of Encounter**				
		Frequent: Regular, or inevitable occurrences	**Likely:** Several or numerous occurrences	**Occasional:** Sporadic or intermittent occurrences	**Seldom:** Infrequent, rare occurrences	**Unlikely:** Not probable
Severity Associated with Specific Munitions Items	**Catastrophic/Critical:** May result in 1 or more deaths, permanent total or partial disability, or hospitalization	A	A	B	B	D
	Modest: May result in 1 (or more) injury resulting in emergency medical treatment, without hospitalization	B	B	B	C	D
	Minor: May result in 1 or more injuries requiring first aid or medical treatment	B	C	C	C	D
	Improbable: No injury is anticipated	D	D	D	D	D

"A" indicates conditions most likely to result in determination of an unacceptable risk.
"D" indicates conditions most likely to result in determination of an acceptable scenario.

Severity Justification:

The RI identified one MEC item, a 3-inch Stokes Mortar (sand filled, fuzed). Technical Paper-18 qualified UXO personnel indicated that a complete fuze, if unintentionally detonated, is likely to result in emergency medical treatment, but is unlikely to result in death, disability, or require hospitalization. Therefore, the severity associated with the specific munitions items is "Modest".

Likelihood of Encounter Justification: Matrix 1 Result, Likelihood of Encounter: Seldom

Matrix 2 Result, Severity of Incident: C

Matrix 3. Likelihood of Detonation

Likelihood of Detonation, Matrix 3: Munitions Sensitivity vs. Likelihood of Energy to be Imparted		**Likelihood to Impart Energy on an Item**		
		High e.g., areas planned for development, or seasonal tilled	**Modest** e.g. Undeveloped, wildlife refuge, parks	**Inconsequential** e.g., not anticipated, prevented, mitigated
Sensitivity: Susceptibility to Detonation	***High*** (e.g., classified as sensitive)	1	1	3
	Moderate (e.g., high explosive (HE) or pyrotechnics)	1	2	3
	Low (e.g., propellant or bulk secondary explosives)	1	3	3
	Not Sensitive	2	3	3

Sensitivity Justification:

The RI MEC Hazard Analysis identified the fuze found in the 3" Stokes mortar (sand filled, fuzed) as an impact fuze. An impact fuze is conservatively assumed to be highly sensitive. Therefore, the munitions sensitivity is identified as "High".

Likelihood to Impart Energy Justification:

To determine the likelihood to impart energy, the following information was considered:

- The road that may be constructed in the future is not the same level of development as a residential or commercial development and is a one-time occurrence.
- The MRS is undeveloped, steeply sloped, and heavily forested and would deter future development of the MRS.
- Potential maintenance work to repair the waterline located in the MRS may occur.

Based on the preceding information, the likelihood to impart energy is "Modest."

Matrix 3 Result, Likelihood of Detonation: 1

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**

Matrix 2 Result, Severity of Incident: C

Matrix 3 Result, Likelihood of Detonation: 1

Matrix 4 Result, Acceptable and Unacceptable Site Conditions: Unacceptable

Matrix 1. Likelihood of Encounter

Likelihood of Encounter, Matrix 1: Amount of MEC vs. Access Conditions		**Access Conditions (frequency of use)**			
		Regular (e.g. Daily use, open access)	**Often** (e.g., less regular or periodic use, some access)	**Intermittent** (e.g., some irregular use, or access limited)	**Rare** (e.g., very limited use, access prevented)
Amount of MEC	• MEC is visible on the surface and detected in the subsurface.	**Frequent**	**Frequent**	**Likely**	**Occasional**
	• The area is identified as a Concentrated Munitions Use Area (CMUA) where MEC is known or suspected (e.g., MD indicative of MEC is identified) to be present in surface and subsurface.	**Frequent**	**Likely**	**Occasional**	**Seldom**
	• MEC presence based on physical evidence (e.g., MD indicative of MEC), although the area is not a CMUA. • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 1.0/acre at 95% confidence).	**Likely**	**Occasional**	**Seldom**	**Unlikely**
	• 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).	**Occasional**	**Seldom**	**Unlikely**	**Unlikely**
	• 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 (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).	**Seldom**	**Seldom**	**Unlikely**	**Unlikely**
	• Investigation of the MRS did not identify evidence of MEC presence. • A DERP response action has been conducted that will achieve UU/UE.	**Unlikely**	**Unlikely**	**Unlikely**	**Unlikely**

Amount of MEC Justification:

Under this scenario, the amount of MEC remains unchanged from baseline conditions because no removal would be performed. However, if MEC were encountered, it would be removed, thus reducing the amount of MEC in the MRS.

Access Conditions Justification:

To determine the access conditions (frequency of use), the following information was considered:

- The MRS is not currently fenced, but residential properties adjacent to the MRS have fenced backyards.
- Potential maintenance work to repair the waterline located in the MRS may occur.
- A road may be constructed through the MRS in the future.
- Issuance of public advisories regarding the potential presence of MEC at the MRS would modify the behavior of residents. The advisories would deter residents from using the trail or entering the MRS to retrieve a lost ball or pet.
- The steeply sloped topography of the MRS limits the ability of receptors to access the MRS.

Based on the preceding information, the frequency of use is “Intermittent”.

Matrix 1 Result, Likelihood of Encounter: Unlikely

Matrix 2. Severity of Incident

Severity of Incident, Matrix 2: Severity vs. Likelihood of Encounter		**Likelihood of Encounter**				
		Frequent: Regular, or inevitable occurrences	**Likely:** Several or numerous occurrences	**Occasional:** Sporadic or intermittent occurrences	**Seldom:** Infrequent, rare occurrences	**Unlikely:** Not probable
Severity Associated with Specific Munitions Items	**Catastrophic/Critical:** May result in 1 or more deaths, permanent total or partial disability, or hospitalization	A	A	B	B	D
	Modest: May result in 1 (or more) injury resulting in emergency medical treatment, without hospitalization	B	B	B	C	D
	Minor: May result in 1 or more injuries requiring first aid or medical treatment	B	C	C	C	D
	Improbable: No injury is anticipated	D	D	D	D	D

"A" indicates conditions most likely to result in determination of an unacceptable risk.
"D" indicates conditions most likely to result in determination of an acceptable scenario.

Severity Justification:

The "Severity" factor is a static characteristic of the MRS and remains unchanged from the baseline.

Likelihood of Encounter Justification: Matrix 1 Result, Likelihood of Encounter: Unlikely

Matrix 2 Result, Severity of Incident: D

Matrix 3. Likelihood of Detonation

Likelihood of Detonation, Matrix 3: Munitions Sensitivity vs. Likelihood of Energy to be Imparted		**Likelihood to Impart Energy on an Item**		
		High e.g., areas planned for development, or seasonal tilled	**Modest** e.g. Undeveloped, wildlife refuge, parks	**Inconsequential** e.g., not anticipated, prevented, mitigated
Sensitivity: Susceptibility to Detonation	***High*** (e.g., classified as sensitive)	1	1	3
	Moderate (e.g., high explosive (HE) or pyrotechnics)	1	2	3
	Low (e.g., propellant or bulk secondary explosives)	1	3	3
	Not Sensitive	2	3	3

Sensitivity Justification:

The "Sensitivity" of a munitions item is a static component, inherent to the known or suspected munitions present at the MRS and remains unchanged from the baseline.

Likelihood to Impart Energy Justification:

To determine the likelihood to impart energy, the following information was considered:

- The road that may be constructed in the future is not the same level of development as a residential or commercial development and is a one-time occurrence.
- The MRS is undeveloped, steeply sloped, and heavily forested and would deter future development of the MRS.
- The issuance of public advisories would deter residents from using the trail or entering the MRS.
- Dig permits, on-call construction support, and site-specific MEC awareness/safety training would be required during maintenance work and road construction in the MRS, reducing the likelihood of energy being imparted from an item to maintenance workers or contractor personnel.

Based on the preceding information, the likelihood to impart energy is “Modest”.

Matrix 3 Result, Likelihood of Detonation: 1

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**

Matrix 2 Result, Severity of Incident: D

Matrix 3 Result, Likelihood of Detonation: 1

Matrix 4 Result, Acceptable and Unacceptable Site Conditions: Acceptable

Matrix 1. Likelihood of Encounter

Likelihood of Encounter, Matrix 1: Amount of MEC vs. Access Conditions		**Access Conditions (frequency of use)**			
		Regular (e.g. Daily use, open access)	**Often** (e.g., less regular or periodic use, some access)	**Intermittent** (e.g., some irregular use, or access limited)	**Rare** (e.g., very limited use, access prevented)
Amount of MEC	• MEC is visible on the surface and detected in the subsurface.	**Frequent**	**Frequent**	**Likely**	**Occasional**
	• The area is identified as a Concentrated Munitions Use Area (CMUA) where MEC is known or suspected (e.g., MD indicative of MEC is identified) to be present in surface and subsurface.	**Frequent**	**Likely**	**Occasional**	**Seldom**
	• MEC presence based on physical evidence (e.g., MD indicative of MEC), although the area is not a CMUA. • The MEC concentration is below a project-specific threshold to support this selection (e.g., less than 1.0/acre at 95% confidence).	**Likely**	**Occasional**	**Seldom**	**Unlikely**
	• 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).	**Occasional**	**Seldom**	**Unlikely**	**Unlikely**
	• 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 (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).	**Seldom**	**Seldom**	**Unlikely**	**Unlikely**
	• Investigation of the MRS did not identify evidence of MEC presence. • A DERP response action has been conducted that will achieve UU/UE.	**Unlikely**	**Unlikely**	**Unlikely**	**Unlikely**

Amount of MEC Justification:

MEC would be removed from the surface and subsurface throughout the entire MRS to the extent possible without clearcutting the MRS. Brush and trees would be removed to facilitate MEC removal, but trees greater than 3-inches in diameter at breast height would not be removed. The implementation of this option would consist of an action to physically remove surface and subsurface MEC, but UU/UE will not be achieved. Therefore, the amount of MEC post-removal would be consistent with the fifth row: A DERP response action has been conducted to physically remove surface and subsurface MEC (UU/UE not achieved).

Access Conditions Justification:

To determine the access conditions (frequency of use), after the implementation of this option, the following information was considered:

- The MRS is not currently fenced, but residential properties adjacent to the MRS have fenced backyards.
- Potential maintenance work to repair the waterline located in the MRS may occur.
- A road may be constructed through the MRS in the future.
- Issuance of public advisories regarding the potential presence of MEC at the MRS would modify the behavior of residents. The advisories would deter residents from using the trail or entering the MRS to retrieve a lost ball or pet.
- The steeply sloped topography of the MRS limits the ability of receptors to access the MRS.

Based on the preceding information, the frequency of use is “Intermittent”.

Matrix 1 Result, Likelihood of Encounter: Unlikely

Matrix 2. Severity of Incident

Severity of Incident, Matrix 2: Severity vs. Likelihood of Encounter		**Likelihood of Encounter**				
		Frequent: Regular, or inevitable occurrences	**Likely:** Several or numerous occurrences	**Occasional:** Sporadic or intermittent occurrences	**Seldom:** Infrequent, rare occurrences	**Unlikely:** Not probable
Severity Associated with Specific Munitions Items	**Catastrophic/Critical:** May result in 1 or more deaths, permanent total or partial disability, or hospitalization	A	A	B	B	D
	Modest: May result in 1 (or more) injury resulting in emergency medical treatment, without hospitalization	B	B	B	C	D
	Minor: May result in 1 or more injuries requiring first aid or medical treatment	B	C	C	C	D
	Improbable: No injury is anticipated	D	D	D	D	D

"A" indicates conditions most likely to result in determination of an unacceptable risk.
"D" indicates conditions most likely to result in determination of an acceptable scenario.

Severity Justification:

The "Severity" factor is a static characteristic of the MRS and remains unchanged from the baseline.

Likelihood of Encounter Justification: Matrix 1 Result, Likelihood of Encounter: Unlikely

Matrix 2 Result, Severity of Incident: D

Matrix 3. Likelihood of Detonation

Likelihood of Detonation, Matrix 3: Munitions Sensitivity vs. Likelihood of Energy to be Imparted		**Likelihood to Impart Energy on an Item**		
		High e.g., areas planned for development, or seasonal tilled	**Modest** e.g. Undeveloped, wildlife refuge, parks	**Inconsequential** e.g., not anticipated, prevented, mitigated
Sensitivity: Susceptibility to Detonation	***High*** (e.g., classified as sensitive)	1	1	3
	Moderate (e.g., high explosive (HE) or pyrotechnics)	1	2	3
	Low (e.g., propellant or bulk secondary explosives)	1	3	3
	Not Sensitive	2	3	3

Sensitivity Justification:

The "Sensitivity" of a munitions item is a static component, inherent to the known or suspected munitions present at the MRS and remains unchanged from the baseline.

Likelihood to Impart Energy Justification:

To determine the likelihood to impart energy, the following information was considered:

- Surface and subsurface MEC will have been removed, except from below trees greater than 3-inches in diameter at breast height.
- The large trees prevent direct contact by contractor personnel, maintenance workers, and site visitors with MEC that may remain beneath these features.
- The road that may be constructed in the future is not the same level of development as a residential or commercial development and is a one-time occurrence, but would likely result in the removal of large trees which could potentially expose MEC.
- The MRS is undeveloped, steeply sloped, and heavily forested and would deter future development of the MRS.
- The issuance of public advisories would deter residents from using the trail or entering the MRS.
- Dig permits, on-call construction support, and site-specific MEC awareness/safety training would be required during maintenance work and road construction in the MRS, reducing the likelihood of energy being imparted from an item to maintenance workers or contractor personnel.

Based on the preceding information, the likelihood to impart energy is “Inconsequential”.

Matrix 3 Result, Likelihood of Detonation: 3

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**

Matrix 2 Result, Severity of Incident: D

Matrix 3 Result, Likelihood of Detonation: 3

Matrix 4 Result, Acceptable and Unacceptable Site Conditions: Acceptable

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APPENDIX B
INSTITUTIONAL ANALYSIS

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1.0 INTRODUCTION

This Institutional Analysis (IA) was prepared by Plexus Scientific Corporation (Plexus) in support of the United States Army Military Munitions Response Program at the United States Army Garrison (USAG) West Point located in West Point, New York. This IA was prepared in accordance with the *MMRP Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009) and *Engineer Pamphlet (EP) 1110-1-24* (U.S. Army Corps of Engineers [USACE], 2000) to be utilized during the development of Feasibility Studies (FSs) for seven Munitions Response Sites (MRSs).

The development of FSs was recommended based on potential explosive hazards identified during remedial investigation activities conducted at each of the seven MRSs. The seven MRSs consist of a mixture of developed (housing, commercial, and service support) and undeveloped areas located within the Main Post and on Constitution Island. The name, identification, and acreage of the seven MRSs are identified in **Table 1-1**, and the location and layout of the seven MRSs are presented in **Figure 1-1**.

Table 1-1: Munitions Response Sites Summary

MRS	Identification	Acreage
Artillery Firing Range North	WSTPT-001-R-02	143.3
Artillery Firing Range South	WSTPT-001-R-03	123.4
Grey Ghost Housing Area – Undeveloped	WSTPT-010-R-02	11
Seacoast Battery	WSTPT-013-R-01	2
Siege Battery – Constitution Island	WSTPT-015-R-02	52
North Athletic Field	WSTPT-011-R-01	14
Target Hill	WSTPT-017-R-01	14

1.1 Overview

Typical strategies for addressing the presence of munitions and explosives of concern (MEC) are physical removals and risk management through land use controls (LUCs). Physical removal actions are conducted to reduce the amount of MEC at an MRS, while LUCs are implemented to manage the residual hazard of MEC remaining at an MRS.

LUCs limit access or use of a property to protect people from hazards, or provide warnings of a potential hazard. LUCs may include legal mechanisms (e.g. zoning restrictions, easements, covenants), educational controls (e.g., public notification of residual MEC concerns), and engineering controls (e.g., fencing) to minimize the potential for human exposure to MEC.

1.2 Purpose

The overall purpose of this IA is to provide information on the capability of government agencies associated with the seven MRSs to take part in the implementation and maintenance of LUCs in order to minimize exposure to MEC. The IA will also document existing LUCs

currently in place for the protection of the community from MEC hazards to assist in the evaluation of LUCs during the FS process.

1.3 Hazard Review

Remedial investigations were conducted at each of the seven MRSs listed in **Table 1-1** to determine the nature and extent of MEC as well as the hazards and potential risks posed to human health and the environment by MEC. The remedial investigations concluded that there was no risk from munitions constituent contamination. Only MEC was identified as a potential hazard. The results of these investigations were utilized to develop Munitions and Explosives of Concern Hazard Assessment (MEC HA) Hazard Level and Hazard Scores which are summarized in **Table 1-2**. The data utilized to develop the MEC HA Hazard Level/Scores were presented in remedial investigation reports completed for each of the seven MRSs (Weston, 2014a; 2014b; 2014c; 2014d; 2015).

Table 1-2: Munitions and Explosives of Concern Hazard Assessment Results Summary

MRS	MEC HA Hazard Level	MEC HA Hazard Score
Artillery Firing Range North	1	860
Artillery Firing Range South	3	720
Grey Ghost Housing Area – Undeveloped	3	705
Seacoast Battery	3	620
Siege Battery – Constitution Island	3	690
North Athletic Field	3	595
Target Hill	*	*

* No MEC was identified at the Target Hill MRS (WSTPT-017-R-01); therefore, no MEC HA Hazard Level/Score was developed.

The MEC HA was developed to be utilized during the Comprehensive Environmental Restoration, Compensation, and Liability Act hazard assessment methodology for MRSs where an explosive hazard exists from the known or suspected presence of MEC (United States Environmental Protection Agency [USEPA], 2008). The MEC HA is structured around three components (severity, accessibility, and sensitivity) of a potential explosive hazard incident.

Each of these components was assessed in the MEC HA based on MRS-specific inputs. These inputs were utilized to create a MEC HA Hazard Score from 125 to 1000. The resulting MEC HA Hazard Score corresponds to a MEC HA Hazard Level from 1 to 4. The MEC HA Hazard Levels are summarized below:

- Hazard Level 1 – an MRS with the highest hazard potential. There might be instances where an imminent threat to human health exists from MEC; corresponds to a MEC HA hazard score of 840 to 1000.

The Artillery Firing Range North MRS received a Hazard Score of 860 and was assigned to Hazard Level 1.

- Hazard Level 2 – an MRS with a high hazard potential. An MRS with surface MEC or one undergoing intrusive activities such that MEC would be encountered in the subsurface. The site would also have moderate or greater accessibility by the public.

  No Hazard Level 2 MRSs were identified.

- Hazard Level 3 – an MRS with a moderate hazard potential. An MRS that would be considered safe for the current land use without further munitions responses, although not necessarily suitable for reasonable, anticipated future use. These MRSs would generally have restricted access, a low number of contact hours, and, typically, MEC only in the subsurface.

  The following MRSs were assigned Hazard Level 3: Artillery Firing Range South (Hazard Score of 720), Grey Ghost Housing Area – Undeveloped (Hazard Score of 705), Seacoast Battery (Hazard Score of 620), Siege Battery – Constitution Island (Hazard Score of 690), and North Athletic Field (Hazard Score of 595).

- Hazard Level 4 – An MRS with a low hazard potential. An MRS compatible with current and reasonably anticipated future use. These MRSs typically have had an MEC cleanup performed.

  No Hazard Level 4 MRSs were identified.

No MEC was identified at the Target Hill MRS; however, because munitions debris (MD) was found during investigation activities and undiscovered MEC may be present, the assessment of possible response action alternatives in an FS was recommended for the Target Hill MRS.

1.4 Institution Selection and Discussion

USAG West Point was selected as the sole entity to be evaluated in this IA because each of the seven MRSs are located on a federal military reserve managed by the United States Army Installation Management Command (IMCOM) – Atlantic Region. USAG West Point are further supported by the United States Army Environmental Command (USAEC), a subordinate command of IMCOM, whose mission is, "to lead and execute Army cleanup and environmental quality programs, providing technical expertise to enable soldier readiness, and sustainable military communities."

The following table (**Table 1-3**) summarizes the elements considered when assessing an institution's capacity to assist in the implementation or monitoring of a proposed LUC program.

Table 1-3: U. S. Army Garrison West Point Institutional Analysis

Origin of Institution	USAG West Point role in our nation's history dates back to the Revolutionary War. USAG West Point's mission is "to provide the services, programs, and infrastructure to sustain a community of excellence at West Point."
Basis of Authority	USAG West Point was authorized by the Department of Defense.
Geographic Jurisdiction	USAG West Point has jurisdiction over each of the seven MRSs.
Public Safety Function	It is the responsibility of USAG West Point to prevent or mitigate public safety impacts associated with MEC located at each of the seven MRSs.
Land Use Controls	USAG West Point, as the lead agency, will evaluate and develop the appropriate LUC program for each of the seven MRSs.
Financial Capability	Yes. Funding for the implementation and management of a LUC program for each of the seven MRSs may also be provided by the USAEC.
Desire to Participate	Yes.
Constraints to Institutional Effectiveness	None.

2.0 LAND USE CONTROLS

This section provides a summary of LUC options that are available for each of the seven MRSs. LUCs protect human receptors (e.g., contractor personnel, residents (adults and children), site visitors, etc.) from potential hazards present at the MRSs by warning of potential MEC hazards and/or limiting access to, or use of, the MRS. LUCs may include legal mechanisms, engineering controls, and educational controls.

2.1 Legal Mechanisms

Legal mechanisms limit or control the land use and/or activities that can occur on a property through actions such as restrictive covenants (also known as deed restrictions), easements (e.g., affirmative/negative), zoning restrictions, and permitting programs. The following legal mechanisms may be appropriate for each of the seven MRSs: zoning restrictions, permit programs, siting restrictions, and overlay zoning. Each of these legal mechanisms is further discussed below:

- Zoning Restrictions – used to control land use through the development of zoning ordinances (e.g., residential and commercial/industrial) and master plans.
- Permit Programs – permitting programs, through the permitting agency, determine specific conditions which must be met before a certain use or action is allowed on a property.
- Siting Restrictions – are used to limit land use in areas subject to natural hazards such as earthquakes and floods. This type of control is also used to protect natural resources from development, such as existing wetlands.
- Overlay Zoning – siting restrictions may be combined with zoning ordinances/master plans to establish an effective institutional control. When using overlay zoning, the specific siting restriction is used as an overlay on the local government's master plan, thereby highlighting any discrepancies between the two.

Legal mechanisms are commonly applied to property not owned by the Army; therefore, these general requirements/activities will be identified as administrative mechanisms for each of the seven MRSs because they are located on a federal military reserve managed by IMCOM.

2.2 Engineering Controls

Engineering controls are also known as physical controls and include fencing, signage, and caps. These physical controls may be utilized to limit or prevent human receptor (on-site workers, authorized personnel including residents, and unauthorized trespassers) exposure to MEC at each of the seven MRSs. Fencing, signage, and soil caps are further discussed below:

- Fencing – fencing provides the most direct means of limiting incidental exposure to a contaminated site. By providing access only at certain points, appropriate notice can be given to all users and uses incompatible with the existing site conditions may be avoided.

- Signage – warning signs can provide information regarding the nature of the hazard, how to avoid the hazard, and also provide a contact for additional information. Signs may be used to deter access to a site or to give notice so that inappropriate uses of the site are avoided.
- Caps – placing a cap on a contaminated site by covering it with concrete, asphalt, or soil/clay has been proven to be an effective physical barrier to public exposure to certain types of residual contamination. If the cap is combined with an excavation restriction (administrative mechanism), then such an engineering control could effectively mitigate the risk of receptor contact with MEC.

2.3 Educational Controls

Educational controls include formal education programs and public notices/advisories and are further discussed below:

- Formal Education Programs – educating the local community about the potential exposure risks associated with an MEC contaminated site may be done through a variety of methods. These include periodic classes, training seminars, and training materials. In order to be effective, educational efforts need to be continual so that people do not forget or become complacent about the hazards associated with MEC, as well as to inform newcomers.
- Public Notices – the community can also be educated through the implementation of a wide-ranging public notice campaign that may include mass mailings of brochures, public service announcements on local radio or television stations, or periodic notices in local newspapers.

3.0 EVALUATION OF LAND USE CONTROLS

3.1 Existing Land Use Controls

The *Action Memorandum, Land Use Controls, Military Munitions Response Program* dated June 2012 selected MMRP-specific interim LUCs as the appropriate alternative for the Non-Time-Critical Removal Action (NTCRA) at USAG West Point. These interim LUCs were detailed in the *Non-Time Critical Removal Action, Land Use Control Plan* (LUCP), *Military Munitions Response Program* dated October 2012, and are summarized below in **Table 3-1**.

Table 3-1: Existing Land Use Controls

MRS	Land Use Restriction	Master Plan Notation	Dig Permit	Public Advisories	Monitoring and Enforcement
Artillery Firing Range North	X	X	X	X	X
Artillery Firing Range South	X	X	X	X	X
Grey Ghost Housing Area – Undeveloped	X	X	X	X	X
Seacoast Battery	X	X	X	X	X
Siege Battery – Constitution Island	X	X	X	X	X
North Athletic Field	X	X	X	X	X
Target Hill	X	X	X	X	X

X = selected as an interim LUC.

The LUCs selected for interim implementation include a mixture of administrative mechanisms and educational controls. Engineering controls, including signage, fencing, and guards, were considered during the interim LUC evaluation but were not selected for implementation. The interim LUCs for the seven MRSs are described in greater detail below.

- Land Use Restrictions – use of an MRS for residential purposes, daycare facilities, hospitals, or schools is prohibited without prior approval from USAG West Point. Additionally, excavation activities require a dig permit; dig permits are discussed separately below.
- Master Plan Notation – the installation master plan includes a notation on each MRS to record all 911 calls involving MEC in a geographic information system database to facilitate explosive hazard delineation.
- Dig Permits – dig permits and construction support are required whenever ground is broken at each MRS. USAG West Point reviews all dig permits and requires either on-call construction support and worker training or on-site construction support during excavation activities. The determination to use on-call construction support and worker

training or on-site construction support is based on the *Probability Assessment for Determining the Probability of Encountering MEC during Site Activities at West Point, New York* (USAG West Point, 2016) which assigns each MRS to Group A or Group B based on the probability of encountering MEC. Group A MRSs present a low probability of encountering MEC and require on-call construction support and worker training (site-specific MEC awareness/safety). The site-specific MEC awareness/safety training would be provided to workers performing ground disturbing activities. The site-specific MEC awareness/safety training would identify explosives safety concerns/measures to be taken during ground disturbing activities, and the proper reporting procedures to be utilized in the highly unlikely event a MEC item is discovered. Group B MRSs present a moderate to high probability of encountering MEC and require on-site construction support for ground disturbing activities.

- Public Advisories – USAG West Point developed an unexploded ordnance (UXO) awareness program to educate various audiences regarding the potential dangers of MEC. Components of the comprehensive UXO awareness program include, brochures (e.g., 3Rs pamphlet) distributed to new residents and annually thereafter, and newspaper and website articles posted quarterly.
- Monitoring and Enforcement – LUCs are reviewed annually by USAG West Point. An annual review report is prepared based on division self-audits, document reviews, site visits, and interviews. The results of the annual review are presented to the Garrison Commander at the installation Environmental Quality Control Committee.

3.2 Potential Land Use Controls

The interim LUCs (administrative mechanisms and educational controls) were evaluated for effectiveness, implementability, and cost utilizing input from USAG West Point and determined to be viable with one exception. The monitoring and enforcement administrative mechanism was modified to remove the annual reporting component and include only an annual review of the LUC program for the purpose of collecting data for use during the Five-Year Review. If engineering controls are selected, then an annual inspection will be performed to maintain the engineering controls. The data, collected annually by USAG West Point, will be utilized during the Five-Year Review to determine the continued protectiveness of the LUC program. Additional engineering controls, including, signage, fencing, and caps, were also evaluated for effectiveness, implementability, and cost utilizing input from USAG West Point. The results of the engineering control evaluation determined that fencing and signage may be viable for implementation at each of the seven MRSs; however, MRS-specific determinations will be made within each FS.

4.0 REFERENCES

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Weston, 2014b. *Final Remedial Investigation Report North Athletic Field Munitions Response Site.* Prepared for the USACE and USAG West Point. June.

Weston, 2014c. *Final Remedial Investigation Report Target Hill Munitions Response Site.* Prepared for the USACE and USAG West Point. June.

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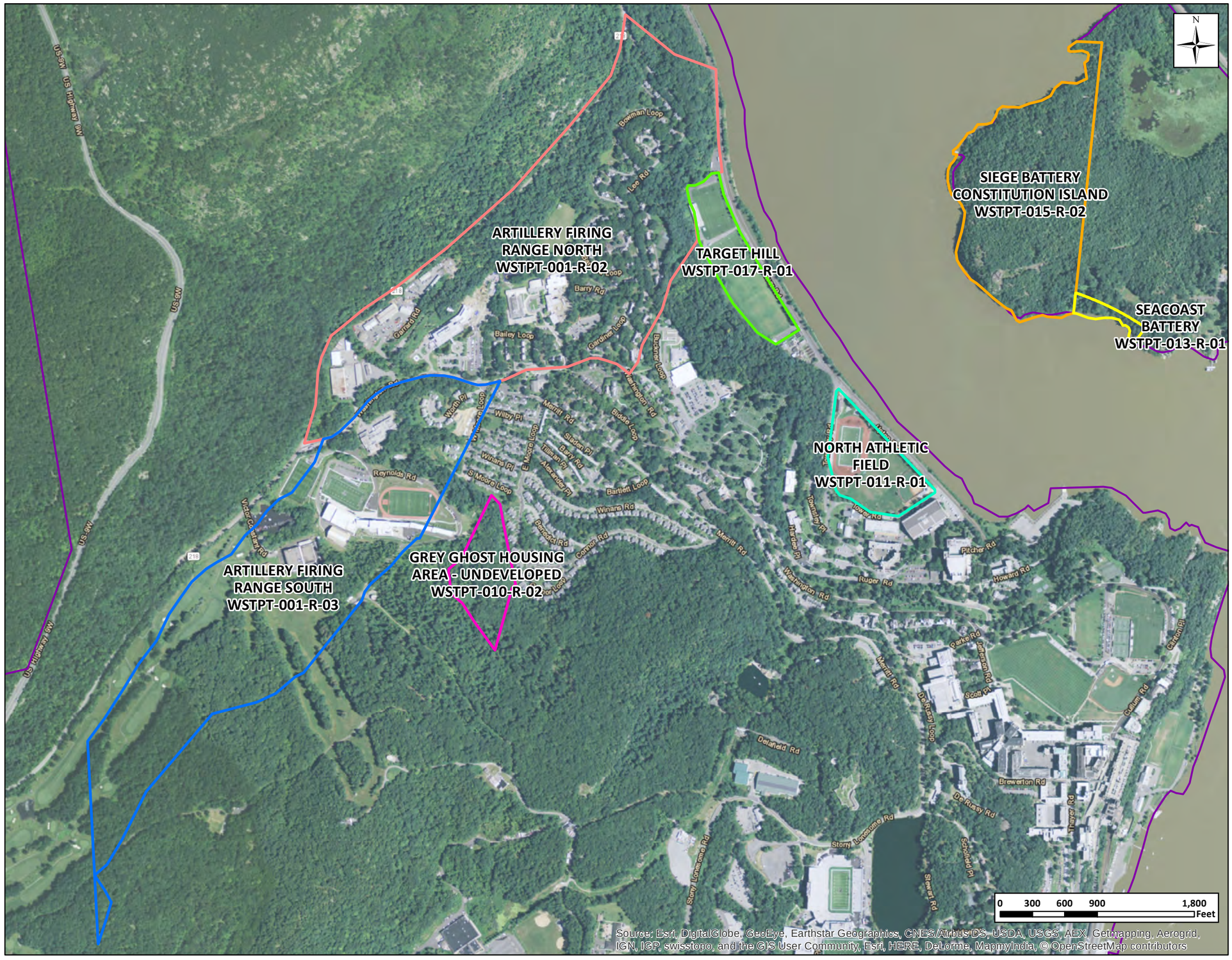

Map Key:

- West Point Boundary
- Artillery Firing Range North
- Artillery Firing Range South
- Grey Ghost Housing Area - Undeveloped
- North Athletic Field
- Seacoast Battery
- Siege Battery Constitution Island
- Target Hill

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FIGURE 1-1

Munitions Response Sites (MRS)

Institutional Analysis
U.S. Army Garrison West Point
West Point, NY

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APPENDIX C
COST ESTIMATES

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Alternative 2: Risk Management
Alternative Costs Summary
Grey Ghost Housing Area - Undeveloped MRS

Five-Year Review Costs				
RACER Technology	**RACER Element**	**RACER Cost**		**Assumptions**
Five-Year Review	Document Review	$	415.92	five-year review checklist, operation and maintenance records, previous five-year review reports
	Site Inspection	$	757.80	general site inspection, site visit documentation (photos, sketches, etc.)
	Report	$	5,294.28	comprehensive (all components of a five-year review report)
	Occurrence Total:	$	6,468.00	
	30-Year Total (5 Occurrences):	$	32,340.00	

Capital Costs				
RACER Technology	**RACER Element**	**RACER Cost**		**Assumptions**
Land Use Controls	Planning Docs	$	18,987.73	one low complexity land use control implementation plan
	Planning Meetings	$	3,514.67	one meeting, one attendant, one day duration, limited travel
	Implementation	$	28,898.21	coordinate data collection and processing, one low complexity master plan modification
	30-Year Total:	$	51,400.61	

Operation and Maintenance (O&M) Costs				
RACER Technology	**RACER Element**	**RACER Cost**		**Assumptions**
Land Use Controls	Monitoring & Enforcement	$	3,930.01	one site visit per year, two individuals (one UXO TII), one day duration, limited travel, checklist completion
	Annual Total:	$	3,930.01	
	30-Year Total:	$	117,900.30	

Periodic Costs				
RACER Technology	**RACER Element**	**RACER Cost**		**Assumptions**
Construction Support	Construction Support	$	8,982.23	one instance every six years, one UXO TII, two week duration with handheld detector, per diem, one rental vehicle
Permitting	Permitting	$	171.60	one instance every six years, one individual, two hours per occurrence
	Occurrence Total:	$	9,153.83	
	30-Year Total (5 Occurrences):	$	45,769.15	

Alternative 2: Risk Management
Present Value Analysis
Grey Ghost Housing Area - Undeveloped MRS

30-Year Five-Year Review Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019			2029	$6,468.00	$5,573.26	2039	$6,468.00	$4,802.30
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024	$6,468.00	$6,003.99	2034	$6,468.00	$5,173.44	2044	$6,468.00	$4,457.78
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$32,340.00	$26,010.77

30-Year Capital Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$51,400.61	$51,400.61	2029			2039		
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024			2034			2044		
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$51,400.61	$51,400.61

30-Year Operation and Maintenance (O&M) Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$3,930.01	$3,930.01	2029	$3,930.01	$3,386.36	2039	$3,930.01	$2,917.92
2020	$3,930.01	$3,871.93	2030	$3,930.01	$3,336.32	2040	$3,930.01	$2,874.79
2021	$3,930.01	$3,814.71	2031	$3,930.01	$3,287.01	2041	$3,930.01	$2,832.31
2022	$3,930.01	$3,758.34	2032	$3,930.01	$3,238.43	2042	$3,930.01	$2,790.45
2023	$3,930.01	$3,702.79	2033	$3,930.01	$3,190.58	2043	$3,930.01	$2,749.21
2024	$3,930.01	$3,648.07	2034	$3,930.01	$3,143.42	2044	$3,930.01	$2,708.59
2025	$3,930.01	$3,594.16	2035	$3,930.01	$3,096.97	2045	$3,930.01	$2,668.56
2026	$3,930.01	$3,541.04	2036	$3,930.01	$3,051.20	2046	$3,930.01	$2,629.12
2027	$3,930.01	$3,488.71	2037	$3,930.01	$3,006.11	2047	$3,930.01	$2,590.27
2028	$3,930.01	$3,437.16	2038	$3,930.01	$2,961.68	2048	$3,930.01	$2,551.99
						Total:	$117,900.30	$95,798.22

Alternative 2: Risk Management
Present Value Analysis
Grey Ghost Housing Area - Undeveloped MRS

30-Year Periodic Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$9,153.83	$9,153.83	2029			2039		
2020			2030			2040		
2021			2031	$9,153.83	$7,656.15	2041		
2022			2032			2042		
2023			2033			2043	$9,153.83	$6,403.51
2024			2034			2044		
2025	$9,153.83	$8,371.56	2035			2045		
2026			2036			2046		
2027			2037	$9,153.83	$7,001.87	2047		
2028			2038			2048		
						Total:	$45,769.15	$38,586.92

30-Year Present Value (Capital, O&M, and Periodic) Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$64,484.45	$64,484.45	2029	$3,930.01	$3,386.36	2039	$3,930.01	$2,917.92
2020	$3,930.01	$3,871.93	2030	$3,930.01	$3,336.32	2040	$3,930.01	$2,874.79
2021	$3,930.01	$3,814.71	2031	$13,083.84	$10,943.16	2041	$3,930.01	$2,832.31
2022	$3,930.01	$3,758.34	2032	$3,930.01	$3,238.43	2042	$3,930.01	$2,790.45
2023	$3,930.01	$3,702.79	2033	$3,930.01	$3,190.58	2043	$13,083.84	$9,152.72
2024	$3,930.01	$3,648.07	2034	$3,930.01	$3,143.42	2044	$3,930.01	$2,708.59
2025	$13,083.84	$11,965.72	2035	$3,930.01	$3,096.97	2045	$3,930.01	$2,668.56
2026	$3,930.01	$3,541.04	2036	$3,930.01	$3,051.20	2046	$3,930.01	$2,629.12
2027	$3,930.01	$3,488.71	2037	$13,083.84	$10,007.98	2047	$3,930.01	$2,590.27
2028	$3,930.01	$3,437.16	2038	$3,930.01	$2,961.68	2048	$3,930.01	$2,551.99
						Total:	$215,070.06	$185,785.75

Total 30-Year Non-Discounted Capital Costs:	**$**	**51,400.61**
Total 30-Year Non-Discounted O&M Costs:	**$**	**117,900.30**
Total 30-Year Non-Discounted Periodic Costs:	**$**	**45,769.15**
Total 30-Year Present Value (Capital, O&M, and Periodic) Costs:	**$**	**185,785.75**
Total Non-Discounted (Capital, O&M, and Periodic) Costs:	**$**	**215,070.06**
Total 30-Year Five-Year Review Non-Discounted Costs:	**$**	**32,340.00**

Alternative 2: Risk Management
Phase Technology Cost Detail Report (with Markups)

System:

RACER Version: RACER® Version 11.4.63.0
Database Location: C:\Users\e.rgshare\Documents\RACER 11.4\Racer.mdb

Folder:

Folder Name: New Folder

Project:

ID: 8255-5AC
Name: West Point MMRP Feasibility Studies
Category: None

Location
State / Country: NEW YORK
City: WEST POINT MILITARY RESERV

Location Modifier	Default	User	Reason for changes
	1.220	1.220	

Options
Database: Modified System Costs
Cost Database Date: 2017
Report Option: Fiscal

Description Includes the development of FSs for seven MRSs located at West Point

Military Reserve in New York.

Site:

ID: WSTPT-010-R-02
Name: Grey Ghost Housing Area - Undeveloped MRS
Type: MMRP

Media/Waste Type

Primary: Ordnance (not residual)
Secondary: Soil

Contaminant

Primary: Ordnance (not residual)
Secondary: Ordnance (residual)

Phase Names

- **Pre-Study** ☐
- **Study** ☐
- **Design** ☐
- **Removal/Interim Action** ☐
- **Remedial Action** ☑
- **Operations & Maintenance** ☑
- **Long Term Monitoring** ☑
- **Site Closeout** ☐

Documentation

Description:
1. Alternative 1: No Action
2. Alternative 2: Risk Management
3. Alternative 3: MEC Removal to Qualify for UU/UE
4. Alternative 4: Partial MEC Removal with Risk Management

Support Team: Patrick Reilley: Project Manager
Ali Sadrieh: Program Manager

References: The Remedial Investigation Report (Weston, 2014) and USAG West Point were used to develop the costs included in this report.

Estimator Information

Estimator Name: Jeffrey S. Miller
Estimator Title: Environmental Scientist
Agency/Org./Office: Plexus Scientific Corporation
Business Address: 5510 Cherokee Avenue - Suite 350
Alexandria, VA 22312
Telephone Number: 571.527.1224
Email Address: jmiller@plexsci.com

Estimate Prepared Date: 07/18/2018

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Patrick Reilley
Reviewer Title: Project Manager
Agency/Org./Office: Plexus Scientific Corporation
Business Address: 5510 Cherokee Avenue - Suite 350
Alexandria, VA 22312
Telephone Number: 571.527.1225
Email Address: preilley@plexsci.com

Date Reviewed: 07/18/2018

Reviewer Signature: _____ **Date:** _____

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: Alt.2: Risk Management
Description: Land Use Controls (administrative mechanisms and educational controls)

Approach: Ex Situ
Start Date: January, 2019
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markup Template: System Defaults

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	False	0	0
Land Use Controls	False	0	0
Construction Support	False	0	0
Permitting	False	0	0

Total Marked-up Cost: $247,409.91

Because of rounding, the total marked-up cost presented here is slightly different ($0.15) than the sum of the tasks presented earlier in the Alternative Costs Summary and Present Value Analysis.

Technologies:

Technology: Five-Year Review

Element: Document Review

	Unit of	Material	Labor	Unit	Equipment	Sub Bid	Cost

Technology: Five-Year Review

Assembly	Description	Quantity	Measure	Unit Cost	Cost	Unit Cost	Cost	Extended Cost	Override
33220105	Project Engineer	2.00	HR	0.00	85.80	0.00	0.00	$171.60	False
33220108	Project Scientist	1.00	HR	0.00	93.42	0.00	0.00	$93.42	False
33220109	Staff Scientist	2.00	HR	0.00	75.45	0.00	0.00	$150.89	False

Total Element Cost: $415.92

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Override
33220102	Project Manager	2.00	HR	0.00	124.23	0.00	0.00	$248.46	False
33220105	Project Engineer	2.00	HR	0.00	85.80	0.00	0.00	$171.60	False
33220108	Project Scientist	2.00	HR	0.00	93.42	0.00	0.00	$186.84	False
33220109	Staff Scientist	2.00	HR	0.00	75.45	0.00	0.00	$150.89	False

Total Element Cost: $757.80

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Override
33220102	Project Manager	6.00	HR	0.00	124.23	0.00	0.00	$745.39	False
33220105	Project Engineer	16.00	HR	0.00	85.80	0.00	0.00	$1,372.83	False
33220108	Project Scientist	13.00	HR	0.00	93.42	0.00	0.00	$1,214.45	False
33220109	Staff Scientist	26.00	HR	0.00	75.45	0.00	0.00	$1,961.61	False

Total Element Cost:	$5,294.28
Total 1st Year Tech Cost:	$6,467.99

Technology: Land Use Controls

Element: Planning Docs

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	22.00	HR	0.00	101.87	0.00	0.00	$2,241.14	False
33220105	Project Engineer	30.00	HR	0.00	85.80	0.00	0.00	$2,574.05	False
33220106	Staff Engineer	45.00	HR	0.00	92.63	0.00	0.00	$4,168.56	False
33220110	QA/QC Officer	11.00	HR	0.00	72.64	0.00	0.00	$799.03	False
33220114	Word Processing/Clerical	60.00	HR	0.00	47.68	0.00	0.00	$2,860.66	False
33220115	Draftsman/CADD	30.00	HR	0.00	45.36	0.00	0.00	$1,360.79	False
33220503	Attorney, Partner, Real Estate	22.00	HR	0.00	205.47	0.00	0.00	$4,520.39	False
33240101	Other Direct Costs	1.00	LS	463.12	0.00	0.00	0.00	$463.12	True

Total Element Cost:	$18,987.73

Element: Planning Meetings

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Vehicle mileage charge, car or van	10.00	MI	0.00	0.00	0.00	0.56	$5.60	True
33010202	Per Diem (per person)	1.00	DAY	0.00	0.00	0.00	165.00	$165.00	True
33220102	Project Manager	21.00	HR	0.00	101.87	0.00	0.00	$2,139.27	False

Technology: Land Use Controls

33220114	Word Processing/Clerical	16.00	HR	0.00	47.68	0.00	0.00	$762.84	False
33220115	Draftsman/CADD	8.00	HR	0.00	45.36	0.00	0.00	$362.88	False
33240101	Other Direct Costs	1.00	LS	79.08	0.00	0.00	0.00	$79.08	True

Total Element Cost: $3,514.67

Element: Implementation

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33022037	Overnight Delivery, 8 oz Letter	8.00	EA	0.00	0.00	0.00	34.44	$275.52	False
33040671	Portable GPS Set with Mapping, 5 cm Accuracy	1.00	MO	6,403.48	0.00	0.00	0.00	$6,403.48	False
33220102	Project Manager	30.00	HR	0.00	101.87	0.00	0.00	$3,056.10	False
33220105	Project Engineer	45.00	HR	0.00	70.36	0.00	0.00	$3,166.08	False
33220106	Staff Engineer	60.00	HR	0.00	92.63	0.00	0.00	$5,558.08	False
33220110	QA/QC Officer	13.00	HR	0.00	88.58	0.00	0.00	$1,151.59	False
33220114	Word Processing/Clerical	30.00	HR	0.00	47.68	0.00	0.00	$1,430.33	False
33220115	Draftsman/CADD	90.00	HR	0.00	45.36	0.00	0.00	$4,082.36	False
33220212	Surveying - 2-man Crew	3.00	DAY	0.00	1,061.58	16.40	0.00	$3,233.94	False
33240101	Other Direct Costs	1.00	LS	540.73	0.00	0.00	0.00	$540.73	True

Total Element Cost: $28,898.21

Element: Monitoring & Enforcement

			Unit of	Material	Labor Unit	Equipment	Sub Bid		Cost

Technology: Land Use Controls

Assembly	Description	Quantity	Measure	Unit Cost	Cost	Unit Cost	Cost	Extended Cost	Override
33010104	Vehicle mileage charge, car or van	15.00	MI	0.00	0.00	0.00	0.56	$8.40	True
33010108	Sedan, Automobile, Rental	2.00	DAY	0.00	0.00	0.00	58.28	$116.56	False
33010202	Per Diem (per person)	4.00	DAY	0.00	0.00	0.00	165.00	$660.00	True
33040213	White's All Metals, weekly rental	0.67	WK	0.00	0.00	0.00	300.00	$201.00	False
33040934	UXO Technician II	10.00	HR	0.00	47.98	0.00	0.00	$479.83	False
33041101	Airfare	1.00	LS	0.00	0.00	0.00	750.00	$750.00	True
33220102	Project Manager	13.00	HR	0.00	124.23	0.00	0.00	$1,615.01	False
33220114	Word Processing/Clerical	1.00	HR	0.00	58.14	0.00	0.00	$58.14	False
33240101	Other Direct Costs	1.00	LS	41.06	0.00	0.00	0.00	$41.06	True

Total Element Cost:	$3,930.01
Total 1st Year Tech Cost:	$55,330.61

Technology: Construction Support

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	50.00	DAY	0.00	0.00	0.00	58.28	$2,913.97	False
33010202	Per Diem (per person)	50.00	DAY	0.00	0.00	0.00	119.79	$5,989.50	True
33040213	White's All Metals, weekly rental	10.00	WK	0.00	0.00	0.00	300.00	$3,000.00	False
33040934	UXO Technician II	500.00	HR	0.00	58.52	0.00	0.00	$29,257.68	False
33041101	Airfare	5.00	LS	0.00	0.00	0.00	750.00	$3,750.00	True

Total Element Cost:	$44,911.15
Total 1st Year Tech Cost:	$44,911.15

Technology: Permitting

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220105	Project Engineer	10.00	HR	0.00	85.80	0.00	0.00	$858.02	False

Total Element Cost:	$858.02
Total 1st Year Tech Cost:	$858.02

Total Phase Element Cost	**$107,567.78**

Alternative 3: MEC Removal to Qualify for UU/UE
Alternative Costs Summary
Grey Ghost Housing Area - Undeveloped MRS

Five-Year Review Costs			
RACER Technology	**RACER Element**	**RACER Cost**	**Assumptions**
None	None	$ -	--
	Occurrence Total:	$ -	
	30-Year Total (0 Occurrences):	$ -	

Capital Costs			
RACER Technology	**RACER Element**	**RACER Cost**	**Assumptions**
Clear and Grub	Clear and Grub	$ 174,991.02	100% dry soil, grubbing depth 12", cleared material to be chipped/stockpiled for use by West Point, three week duration, one UXO TII with handheld detector
MEC Removal	Site Visit	$ 83,777.54	one work plan, one ESS, one site visit (3 individuals), one day duration, some travel per diem, rental vehicles
	Surveying	$ 18,908.67	UXO escort, automated with recording mapping system, hand held units
	UXO Mapping	$ 59,373.45	mag and dig removal (one team, five days), surface removal (one team, two days)
	UXO Removal	$ 111,669.82	100% perforator disposal, one removal team, 14 days duration
	Site Management	$ 286,153.66	35 days, five individuals
	Stakeholder Involvement	$ 870,465.45	two community meetings, final report, evacuation plan, relocation allowance for 53 families, hotel accomodations for 53 families for seven weeks, yard maintenance every two weeks for 53 families
Cleanup & Landscaping	Cleanup & Landscaping	$ 169,133.76	100% area cleanup, 100% seeded
	30-Year Total:	$ 1,774,473.37	

Operation and Maintenance (O&M) Costs			
RACER Technology	**RACER Element**	**RACER Cost**	**Assumptions**
None	None	$ -	--
	Annual Total:	$ -	
	30-Year Total:	$ -	

Periodic Costs			
RACER Technology	**RACER Element**	**RACER Cost**	**Assumptions**
None	None	$ -	--
	Occurrence Total:	$ -	
	30-Year Total (0 Occurrences):	$ -	

Alternative 3: MEC Removal to Qualify for UU/UE
Present Value Analysis
Grey Ghost Housing Area - Undeveloped MRS

30-Year Five-Year Review Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019			2029			2039		
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024			2034			2044		
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$0.00	$0.00

30-Year Capital Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$1,774,473.37	$1,774,473.37	2029			2039		
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024			2034			2044		
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$1,774,473.37	$1,774,473.37

30-Year Operation and Maintenance (O&M) Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019			2029			2039		
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024			2034			2044		
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$0.00	$0.00

Alternative 3: MEC Removal to Qualify for UU/UE
Present Value Analysis
Grey Ghost Housing Area - Undeveloped MRS

30-Year Periodic Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019			2029			2039		
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024			2034			2044		
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$0.00	$0.00

30-Year Present Value (Capital, O&M, and Periodic) Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$1,774,473.37	$1,774,473.37	2029	$0.00	$0.00	2039	$0.00	$0.00
2020	$0.00	$0.00	2030	$0.00	$0.00	2040	$0.00	$0.00
2021	$0.00	$0.00	2031	$0.00	$0.00	2041	$0.00	$0.00
2022	$0.00	$0.00	2032	$0.00	$0.00	2042	$0.00	$0.00
2023	$0.00	$0.00	2033	$0.00	$0.00	2043	$0.00	$0.00
2024	$0.00	$0.00	2034	$0.00	$0.00	2044	$0.00	$0.00
2025	$0.00	$0.00	2035	$0.00	$0.00	2045	$0.00	$0.00
2026	$0.00	$0.00	2036	$0.00	$0.00	2046	$0.00	$0.00
2027	$0.00	$0.00	2037	$0.00	$0.00	2047	$0.00	$0.00
2028	$0.00	$0.00	2038	$0.00	$0.00	2048	$0.00	$0.00
						Total:	$1,774,473.37	$1,774,473.37

Total 30-Year Non-Discounted Capital Costs:	**$**	**1,774,473.37**
Total 30-Year Non-Discounted O&M Costs:	**$**	**-**
Total 30-Year Non-Discounted Periodic Costs:	**$**	**-**
Total 30-Year Present Value (Capital, O&M, and Periodic) Costs:	**$**	**1,774,473.37**
Total Non-Discounted (Capital, O&M, and Periodic) Costs:	**$**	**1,774,473.37**
Total 30-Year Five-Year Review Non-Discounted Costs:	**$**	**-**

Alternative 3: MEC Removal to Qualify for UU/UE
Phase Technology Cost Detail Report (with Markups)

System:

RACER Version: RACER® Version 11.4.63.0
Database Location: C:\Users\e.rgshare\Documents\RACER 11.4\Racer.mdb

Folder:

Folder Name: New Folder

Project:

ID: 8255-5AC
Name: West Point MMRP Feasibility Studies
Category: None

Location
State / Country: NEW YORK
City: WEST POINT MILITARY RESERV

Location Modifier	Default	User	Reason for changes
	1.220	1.220	

Options
Database: Modified System Costs
Cost Database Date: 2017
Report Option: Fiscal

Description Includes the development of FSs for seven MRSs located at West Point

Military Reserve in New York.

Site:

ID: WSTPT-010-R-02
Name: Grey Ghost Housing Area - Undeveloped MRS
Type: MMRP

Media/Waste Type

Primary: Ordnance (not residual)
Secondary: Soil

Contaminant

Primary: Ordnance (not residual)
Secondary: Ordnance (residual)

Phase Names

- **Pre-Study** ☐
- **Study** ☐
- **Design** ☐
- **Removal/Interim Action** ☐
- **Remedial Action** ☑
- **Operations & Maintenance** ☑
- **Long Term Monitoring** ☑
- **Site Closeout** ☐

Documentation

Description:
1. Alternative 1: No Action
2. Alternative 2: Risk Management
3. Alternative 3: MEC Removal to Qualify for UU/UE
4. Alternative 4: Partial MEC Removal with Risk Management

Support Team: Patrick Reilley: Project Manager
Ali Sadrieh: Program Manager

References: The Remedial Investigation Report (Weston, 2014) and USAG West Point were used to develop the costs included in this report.

Estimator Information

Estimator Name: Jeffrey S. Miller
Estimator Title: Environmental Scientist
Agency/Org./Office: Plexus Scientific Corporation
Business Address: 5510 Cherokee Avenue - Suite 350
Alexandria, VA 22312
Telephone Number: 571.527.1224
Email Address: jmiller@plexsci.com

Estimate Prepared Date: 04/03/2018

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Patrick Reilley
Reviewer Title: Project Manager
Agency/Org./Office: Plexus Scientific Corporation
Business Address: 5510 Cherokee Avenue - Suite 350
Alexandria, VA 22312
Telephone Number: 571.527.1225
Email Address: preilley@plexsci.com

Date Reviewed: 04/03/2018

Reviewer Signature: _____ **Date:** _____

Phase Documentation:

Phase Type: Remedial Action
Phase Name: Alt.3: MEC Removal to Qualify for UU/UE
Description: Removal of surface/subsurface MEC from the entire 11-acre MRS.

Approach: Ex Situ
Start Date: January, 2019
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate

Phase Markup Template: System Defaults

Technology Markups	Markup	% Prime	% Sub.
Clear and Grub	True	20	80
MEC Removal Action	True	20	80
Cleanup and Landscaping	True	20	80

Total Marked-up Cost: $1,774,473.37

Technologies:

Technology: Clear and Grub

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override

Technology: Clear and Grub

17010210	Site clearing trees, with 335 H.P. dozer, to 6" diameter	1,100.00	EA	0.00	6.25	9.15	0.00	$16,941.38	False
17010211	Site clearing trees, with 335 H.P. dozer, to 12" diameter	275.00	EA	0.00	11.67	17.08	0.00	$7,906.02	False
17010212	Site clearing trees, with 335 H.P. dozer, to 24" diameter	55.00	EA	0.00	17.50	25.62	0.00	$2,371.81	False
17010213	Site clearing trees, with 335 H.P. dozer, to 36" diameter	11.00	EA	0.00	35.00	51.24	0.00	$948.72	False
17010314	Grub stumps, with 335 H.P. dozer, to 6" diameter	1,100.00	EA	0.00	4.38	6.41	0.00	$11,859.13	False
17010315	Grub stumps, with 335 H.P. dozer, to 12" diameter	275.00	EA	0.00	7.00	12.32	0.00	$5,313.95	False
17010316	Grub stumps, with 335 H.P. dozer, to 24" diameter	55.00	EA	0.00	70.01	123.23	0.00	$10,627.85	False
17010317	Grub stumps, with 335 H.P. dozer, to 36" diameter	11.00	EA	0.00	175.02	308.06	0.00	$5,313.92	False
17010402	Chipping brush, medium brush	11.00	ACR	0.00	3,548.68	876.37	0.00	$48,675.57	False
17010501	Grub and stack, 140 H.P. dozer	2,662.00	CY	0.00	7.00	3.91	0.00	$29,039.86	False
17030226	988, 7.0 CY, Wheel Loader	19.00	HR	0.00	157.14	208.34	0.00	$6,944.19	False
17030296	50 Ton, 773, Off-highway Truck	37.00	HR	0.00	137.45	287.70	0.00	$15,730.41	False
33010118	Mobilize/Demobilize Dozer, Loader, Backhoe or Excavator, 70 H.P. to 150 H.P., up to 50 miles	2.00	LS	0.00	257.20	203.36	0.00	$921.11	False
33029501	Shipping	2.00	LS	79.46	0.00	0.00	0.00	$158.92	False
33040213	White's All Metals, weekly rental	3.00	WK	0.00	0.00	0.00	359.64	$1,078.92	False
33040934	UXO Technician II	120.00	HR	0.00	92.99	0.00	0.00	$11,159.26	False

Total Element Cost:	$174,991.02
Total 1st Year Tech Cost:	$174,991.02

Technology: MEC Removal Action

Element: Site Visit

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	3.00	DAY	0.00	0.00	0.00	69.87	$209.60	False
33010202	Per Diem (per person)	3.00	DAY	0.00	0.00	0.00	165.00	$495.00	True
33040921	Senior UXO Supervisor (SUXOS)	8.00	HR	0.00	119.30	0.00	0.00	$954.38	False
33040923	UXO Project Manager	8.00	HR	0.00	189.06	0.00	0.00	$1,512.46	False
33040925	UXO Staff Engineer	8.00	HR	0.00	111.25	0.00	0.00	$890.01	False
33041101	Airfare	3.00	LS	0.00	0.00	0.00	750.00	$2,250.00	True
33041303	Munitions Response Workplan (High Complexity)	1.00	EA	155.11	27,235.84	0.00	0.00	$27,390.95	False
33041306	Explosive Safety Submission (High Complexity)	1.00	EA	310.22	48,970.32	0.00	0.00	$49,280.54	False
33240101	Other Direct Costs	1.00	LS	794.61	0.00	0.00	0.00	$794.61	True

Total Element Cost:	$83,777.54

Element: Surveying

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010202	Per Diem (per person)	9.00	DAY	0.00	0.00	0.00	165.00	$1,485.00	True
33040673	GPS, Real Time Kinematic	1.00	WK	0.00	0.00	0.00	2,877.54	$2,877.54	False

Technology: MEC Removal Action

	Survey Grade, Weekly Rental								
33040695	GPS, Hand Held Mapping Grade, Weekly Rental with External Antenna	1.00	WK	0.00	0.00	0.00	771.49	$771.49	False
33040934	UXO Technician II	60.00	HR	0.00	76.25	0.00	0.00	$4,575.30	False
33041101	Airfare	2.00	LS	0.00	0.00	0.00	500.00	$1,000.00	True
33220213	Surveying - 3-man Crew	3.00	DAY	0.00	2,548.01	26.06	0.00	$7,722.22	False
33240101	Other Direct Costs	1.00	LS	0.00	0.00	0.00	477.13	$477.13	True

Total Element Cost: $18,908.67

Element: UXO Mapping - Land

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	6.00	DAY	0.00	0.00	0.00	69.87	$419.19	False
33010202	Per Diem (per person)	73.00	DAY	0.00	0.00	0.00	165.00	$12,045.00	True
33021530	Differential GPS Unit Rental	1.00	MO	848.04	0.00	0.00	0.00	$848.04	False
33040149	Nonsparking UXO Shovels	2.00	EA	154.57	0.00	0.00	0.00	$309.13	False
33040267	Schonstedt GA-52Cx Daily Rental	12.00	DAY	0.00	0.00	0.00	37.73	$452.80	False
33040268	Schonstedt GA-52Cx Weekly Rental	6.00	WK	0.00	0.00	0.00	120.22	$721.32	False
33040651	4 X 4 Truck- Rental/Lease	35.00	DAY	0.00	0.00	158.32	0.00	$5,541.04	False
33040695	GPS, Hand Held Mapping Grade, Weekly Rental with External Antenna	1.00	WK	0.00	0.00	0.00	771.49	$771.49	False
33040933	UXO Technician I	60.00	HR	0.00	63.26	0.00	0.00	$3,795.88	False

Technology: MEC Removal Action

33040934	UXO Technician II	106.00	HR	0.00	76.25	0.00	0.00	$8,083.02	False
33040935	UXO Technician III (UXO Supervisor)	25.00	HR	0.00	90.08	0.00	0.00	$2,251.97	False
33040936	Geophysicist (UXO)	24.00	HR	0.00	152.74	0.00	0.00	$3,665.82	False
33041101	Airfare	16.00	LS	0.00	0.00	0.00	750.00	$12,000.00	True
33220212	Surveying - 2-man Crew	1.00	DAY	0.00	1,687.09	26.06	0.00	$1,713.15	False
33240101	Other Direct Costs	1.00	LS	6,755.58	0.00	0.00	0.00	$6,755.58	True

Total Element Cost: $59,373.45

Element: UXO Removal - Land

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010115	Demobilize Equipment (Soils)	1.00	LS	0.00	3,155.75	3,608.33	0.00	$6,764.08	False
33010202	Per Diem (per person)	98.00	DAY	0.00	0.00	0.00	165.00	$16,170.00	True
33040157	Non-electrical Blasting Caps	11.00	EA	12.12	0.00	0.00	0.00	$133.30	False
33040646	Backhoe - Rental/Lease	21.00	DAY	0.00	990.29	212.57	0.00	$25,259.98	False
33040651	4 X 4 Truck- Rental/Lease	5.00	DAY	0.00	0.00	158.32	0.00	$791.58	False
33040934	UXO Technician II	560.00	HR	0.00	76.25	0.00	0.00	$42,702.76	False
33040935	UXO Technician III (UXO Supervisor)	140.00	HR	0.00	90.08	0.00	0.00	$12,611.05	False
33041002	50 gr/ft Det -Cord (1000 ft roll)	2.00	EA	668.90	0.00	0.00	0.00	$1,337.81	False
33041005	Perforator Explosive Charge	11.00	EA	11.63	0.00	0.00	0.00	$127.96	False
33240101	Other Direct Costs	1.00	LS	5,771.31	0.00	0.00	0.00	$5,771.31	True

Total Element Cost: $111,669.82

Element: Site Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010202	Per Diem (per person)	222.00	DAY	0.00	0.00	0.00	165.00	$36,630.00	True
33040651	4 X 4 Truck- Rental/Lease	222.00	DAY	0.00	0.00	158.32	0.00	$35,146.05	False
33040921	Senior UXO Supervisor (SUXOS)	350.00	HR	0.00	119.30	0.00	0.00	$41,754.08	False
33040922	UXO Program Manager	350.00	HR	0.00	211.97	0.00	0.00	$74,191.02	False
33040930	UXO QC Specialist	350.00	HR	0.00	106.17	0.00	0.00	$37,159.98	False
33040931	UXO Safety Officer	350.00	HR	0.00	106.77	0.00	0.00	$37,370.34	False
33040940	GIS Manager (UXO)	180.00	HR	0.00	128.62	0.00	0.00	$23,152.18	False
33041101	Airfare	1.00	LS	0.00	0.00	0.00	750.00	$750.00	True

Total Element Cost: $286,153.66

Element: Stakeholder Involvement

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33040923	UXO Project Manager	12.00	HR	0.00	189.06	0.00	0.00	$2,268.69	False
33040935	UXO Technician III (UXO Supervisor)	12.00	HR	0.00	90.08	0.00	0.00	$1,080.95	False
33041105	Full Per Diem Rate - Relocation Allowance	53.00	LS	4,290.90	0.00	0.00	0.00	$227,417.44	False
33041107	Local Hotel- Billeting	2,968.00	LS	173.23	0.00	0.00	0.00	$514,131.87	False
33041315	Site Specific Final Report	1.00	EA	381.41	30,198.59	0.00	0.00	$30,580.00	False
33041318	Evacuation Plan (High	1.00	EA	953.53	85,610.11	0.00	0.00	$86,563.64	False

Technology: MEC Removal Action

	Complexity)								
33240107	Yard Maintenance	212.00	LS	39.73	0.00	0.00	0.00	$8,422.87	False

Total Element Cost:	$870,465.45
Total 1st Year Tech Cost:	$1,430,348.59

Technology: Cleanup and Landscaping

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
18050101	Area Preparation, 67% Level & 33% Slope	11.00	ACR	0.00	43.75	44.24	0.00	$967.93	False
18050401	Seeding, 67% Level & 33% Slope, Hydroseeding	11.00	ACR	2,998.20	1,820.14	852.37	0.00	$62,377.78	False
18050408	Fertilizer, Hydro Spread	22.00	ACR	1,689.13	175.35	95.60	0.00	$43,121.75	False
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	88.00	ACR	375.83	95.79	101.15	0.00	$50,403.70	False
18050415	Mowing	22.00	ACR	0.00	557.39	0.00	0.00	$12,262.60	False

Total Element Cost:	$169,133.76
Total 1st Year Tech Cost:	$169,133.76

	Total Phase Element Cost	**$1,774,473.37**

Alternative 4: Partial Surface and Subsurface MEC Removal with Risk Management
Alternative Costs Summary
Grey Ghost Housing Area - Undeveloped MRS

Five-Year Review Costs				
RACER Technology	**RACER Element**		**RACER Cost**	**Assumptions**
Five-Year Review	Document Review	$	415.92	five-year review checklist, operation and maintenance records, previous five-year review reports
	Site Inspection	$	757.80	general site inspection, site visit documentation (photos, sketches, etc.)
	Report	$	5,294.28	comprehensive (all components of a five-year review report)
	Occurrence Total:	$	6,468.00	
	30-Year Total (5 Occurrences):	$	32,340.00	

Capital Costs				
RACER Technology	**RACER Element**		**RACER Cost**	**Assumptions**
Land Use Controls	Planning Docs	$	18,987.73	one low complexity land use control implementation plan
	Planning Meetings	$	3,514.67	one meeting, one attendant, one day duration, limited travel
	Implementation	$	28,898.21	coordinate data collection and processing, one low complexity master plan modification
MEC Removal	Site Visit	$	83,777.54	one work plan, one ESS, one site visit (3 individuals), one day duration, some travel per diem, rental vehicles
	Surveying	$	18,908.67	UXO escort, automated with recording mapping system, hand held units
	Vegetation Removal	$	77,445.51	5.5 acres of heavy removal, 2.8 acres of moderate removal, 2.7 acres of light removal
	UXO Mapping	$	59,373.45	mag and dig removal (one team, five days), surface removal (one team, two days)
	UXO Removal	$	111,669.82	100% perforator disposal, one removal team, 14 days duration
	Site Management	$	325,636.37	40 days, five individuals
	Stakeholder Involvement	$	806,198.96	two community meetings, final report, evacuation plan, relocation allowance for 53 families, hotel accomodations for 53 families for seven weeks, yard maintenance every two weeks for 53 families
Cleanup & Landscaping	Cleanup & Landscaping	$	169,133.76	100% area cleanup, 100% seeded
	30-Year Total:	$	1,703,544.69	

Operation and Maintenance (O&M) Costs				
RACER Technology	**RACER Element**		**RACER Cost**	**Assumptions**
Land Use Controls	Monitoring & Enforcement	$	3,930.01	one site visit per year, two individuals (one UXO TII with handheld detector), one day duration, limited travel, checklist completion
	Annual Total:	$	3,930.01	
	30-Year Total:	$	117,900.30	

Alternative 4: Partial Surface and Subsurface MEC Removal with Risk Management
Alternative Costs Summary
Grey Ghost Housing Area - Undeveloped MRS

Periodic Costs				
RACER Technology	**RACER Element**	**RACER Cost**		**Assumptions**
Construction Support	Construction Support	$	8,982.23	one instance every six years, one UXO TII, two week duration with handheld detector, per diem, one rental vehicl
Permitting	Permitting	$	171.60	one instance every six years, one individual, two hours per occurrence
	Occurrence Total:	$	9,153.83	
	30-Year Total (5 Occurrences):	$	45,769.15	

Alternative 4: Partial Surface and Subsurface MEC Removal with Risk Management
Present Value Analysis
Grey Ghost Housing Area - Undeveloped MRS

30-Year Five-Year Review Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019			2029	$6,468.00	$5,573.26	2039	$6,468.00	$4,802.30
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024	$6,468.00	$6,003.99	2034	$6,468.00	$5,173.44	2044	$6,468.00	$4,457.78
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$32,340.00	$26,010.77

30-Year Capital Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$1,703,544.69	$1,703,544.69	2029			2039		
2020			2030			2040		
2021			2031			2041		
2022			2032			2042		
2023			2033			2043		
2024			2034			2044		
2025			2035			2045		
2026			2036			2046		
2027			2037			2047		
2028			2038			2048		
						Total:	$1,703,544.69	$1,703,544.69

30-Year Operation and Maintenance (O&M) Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$3,930.01	$3,930.01	2029	$3,930.01	$3,386.36	2039	$3,930.01	$2,917.92
2020	$3,930.01	$3,871.93	2030	$3,930.01	$3,336.32	2040	$3,930.01	$2,874.79
2021	$3,930.01	$3,814.71	2031	$3,930.01	$3,287.01	2041	$3,930.01	$2,832.31
2022	$3,930.01	$3,758.34	2032	$3,930.01	$3,238.43	2042	$3,930.01	$2,790.45
2023	$3,930.01	$3,702.79	2033	$3,930.01	$3,190.58	2043	$3,930.01	$2,749.21
2024	$3,930.01	$3,648.07	2034	$3,930.01	$3,143.42	2044	$3,930.01	$2,708.59
2025	$3,930.01	$3,594.16	2035	$3,930.01	$3,096.97	2045	$3,930.01	$2,668.56
2026	$3,930.01	$3,541.04	2036	$3,930.01	$3,051.20	2046	$3,930.01	$2,629.12
2027	$3,930.01	$3,488.71	2037	$3,930.01	$3,006.11	2047	$3,930.01	$2,590.27
2028	$3,930.01	$3,437.16	2038	$3,930.01	$2,961.68	2048	$3,930.01	$2,551.99
						Total:	$117,900.30	$95,798.22

Alternative 4: Partial Surface and Subsurface MEC Removal with Risk Management
Present Value Analysis
Grey Ghost Housing Area - Undeveloped MRS

30-Year Periodic Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$9,153.83	$9,153.83	2029			2039		
2020			2030			2040		
2021			2031	$9,153.83	$7,656.15	2041		
2022			2032			2042		
2023			2033			2043	$9,153.83	$6,403.51
2024			2034			2044		
2025	$9,153.83	$8,371.56	2035			2045		
2026			2036			2046		
2027			2037	$9,153.83	$7,001.87	2047		
2028			2038			2048		
						Total:	$45,769.15	$38,586.92

30-Year Present Value (Capital, O&M, and Periodic) Costs								
Year	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**	**Year**	**Non-Discounted**	**Present Value**
2019	$1,716,628.53	$1,716,628.53	2029	$3,930.01	$3,386.36	2039	$3,930.01	$2,917.92
2020	$3,930.01	$3,871.93	2030	$3,930.01	$3,336.32	2040	$3,930.01	$2,874.79
2021	$3,930.01	$3,814.71	2031	$13,083.84	$10,943.16	2041	$3,930.01	$2,832.31
2022	$3,930.01	$3,758.34	2032	$3,930.01	$3,238.43	2042	$3,930.01	$2,790.45
2023	$3,930.01	$3,702.79	2033	$3,930.01	$3,190.58	2043	$13,083.84	$9,152.72
2024	$3,930.01	$3,648.07	2034	$3,930.01	$3,143.42	2044	$3,930.01	$2,708.59
2025	$13,083.84	$11,965.72	2035	$3,930.01	$3,096.97	2045	$3,930.01	$2,668.56
2026	$3,930.01	$3,541.04	2036	$3,930.01	$3,051.20	2046	$3,930.01	$2,629.12
2027	$3,930.01	$3,488.71	2037	$13,083.84	$10,007.98	2047	$3,930.01	$2,590.27
2028	$3,930.01	$3,437.16	2038	$3,930.01	$2,961.68	2048	$3,930.01	$2,551.99
						Total:	$1,867,214.14	$1,837,929.83

Total 30-Year Non-Discounted Capital Costs: $ 1,703,544.69
Total 30-Year Non-Discounted O&M Costs: $ 117,900.30
Total 30-Year Non-Discounted Periodic Costs: $ 45,769.15
Total 30-Year Present Value (Capital, O&M, and Periodic) Costs: $ 1,837,929.83
Total Non-Discounted (Capital, O&M, and Periodic) Costs: $ 1,867,214.14
Total 30-Year Five-Year Review Non-Discounted Costs: $ 32,340.00

Alternative 4: Partial MEC Removal with Risk Management
Phase Technology Cost Detail Report (with Markups)

System:

RACER Version: RACER® Version 11.4.63.0
Database Location: C:\Users\e.rgshare\Documents\RACER 11.4\Racer.mdb

Folder:

Folder Name: New Folder

Project:

ID: 8255-5AC
Name: West Point MMRP Feasibility Studies
Category: None

Location
State / Country: NEW YORK
City: WEST POINT MILITARY RESERV

Location Modifier	Default	User	Reason for changes
	1.220	1.220	

Options
Database: Modified System Costs
Cost Database Date: 2017
Report Option: Fiscal

Description Includes the development of FSs for seven MRSs located at West Point

Military Reserve in New York.

Site:

ID: WSTPT-010-R-02
Name: Grey Ghost Housing Area - Undeveloped MRS
Type: MMRP

Media/Waste Type

Primary: Ordnance (not residual)
Secondary: Soil

Contaminant

Primary: Ordnance (not residual)
Secondary: Ordnance (residual)

Phase Names

- **Pre-Study** ☐
- **Study** ☐
- **Design** ☐
- **Removal/Interim Action** ☐
- **Remedial Action** ☑
- **Operations & Maintenance** ☑
- **Long Term Monitoring** ☑
- **Site Closeout** ☐

Documentation

Description: 1. Alternative 1: No Action
2. Alternative 2: Risk Management
3. Alternative 3: MEC Removal to Qualify for UU/UE
4. Alternative 4: Partial MEC Removal with Risk Management

Support Team: Patrick Reilley: Project Manager
Ali Sadrieh: Program Manager

References: The Remedial Investigation Report (Weston, 2014) and USAG West Point were used to develop the costs included in this report.

Estimator Information

Estimator Name: Jeffrey S. Miller
Estimator Title: Environmental Scientist
Agency/Org./Office: Plexus Scientific Corporation
Business Address: 5510 Cherokee Avenue - Suite 350
Alexandria, VA 22312
Telephone Number: 571.527.1224
Email Address: jmiller@plexsci.com

Estimate Prepared Date: 07/18/2018

Estimator Signature: _____ **Date:** _____

Reviewer Information

Reviewer Name: Patrick Reilley
Reviewer Title: Project Manager
Agency/Org./Office: Plexus Scientific Corporation
Business Address: 5510 Cherokee Avenue - Suite 350
Alexandria, VA 22312
Telephone Number: 571.527.1225
Email Address: preilley@plexsci.com

Date Reviewed: 07/18/2018

Reviewer Signature: _____ **Date:** _____

Phase Documentation:

Phase Type: Remedial Action
Phase Name: Alt.4: Partial MEC Removal with Risk Management
Description: Removal of surface/subsurface MEC from approximately 10.5 acres of the MRS and land use control (administrative mechanisms and educational controls) implementation.
Approach: Ex Situ
Start Date: January, 2019
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Markup	% Prime	% Sub.
Construction Support	False	0	0
Land Use Controls	False	0	0
Permitting	False	0	0
MEC Removal Action	True	20	80
Cleanup and Landscaping	True	20	80
Five-Year Review	False	0	0

Total Marked-up Cost: $1,899,553.99

Because of rounding, the total marked-up cost presented here is slightly different ($0.15) than the sum of the tasks presented earlier in the Alternative Costs Summary and Present Value Analysis.

Technologies:

Technology: Permitting

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220105	Project Engineer	10.00	HR	0.00	85.80	0.00	0.00	$858.02	False

Total Element Cost: $858.02

Total 1st Year Tech Cost: $858.02

Technology: MEC Removal Action

Element: Site Visit

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	3.00	DAY	0.00	0.00	0.00	69.87	$209.60	False
33010202	Per Diem (per person)	3.00	DAY	0.00	0.00	0.00	165.00	$495.00	True
33040921	Senior UXO Supervisor (SUXOS)	8.00	HR	0.00	119.30	0.00	0.00	$954.38	False
33040923	UXO Project Manager	8.00	HR	0.00	189.06	0.00	0.00	$1,512.46	False
33040925	UXO Staff Engineer	8.00	HR	0.00	111.25	0.00	0.00	$890.01	False
33041101	Airfare	3.00	LS	0.00	0.00	0.00	750.00	$2,250.00	True
33041303	Munitions Response Workplan (High Complexity)	1.00	EA	155.11	27,235.84	0.00	0.00	$27,390.95	False
33041306	Explosive Safety Submission (High Complexity)	1.00	EA	310.22	48,970.32	0.00	0.00	$49,280.54	False
33240101	Other Direct Costs	1.00	LS	794.61	0.00	0.00	0.00	$794.61	True

Total Element Cost: $83,777.54

Element: Surveying

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010202	Per Diem (per person)	9.00	DAY	0.00	0.00	0.00	165.00	$1,485.00	True
33040673	GPS, Real Time Kinematic Survey Grade, Weekly Rental	1.00	WK	0.00	0.00	0.00	2,877.54	$2,877.54	False
33040695	GPS, Hand Held Mapping Grade, Weekly Rental with External Antenna	1.00	WK	0.00	0.00	0.00	771.49	$771.49	False
33040934	UXO Technician II	60.00	HR	0.00	76.25	0.00	0.00	$4,575.30	False
33041101	Airfare	2.00	LS	0.00	0.00	0.00	500.00	$1,000.00	True
33220213	Surveying - 3-man Crew	3.00	DAY	0.00	2,548.01	26.06	0.00	$7,722.22	False
33240101	Other Direct Costs	1.00	LS	0.00	0.00	0.00	477.13	$477.13	True

Total Element Cost: $18,908.67

Element: Vegetation Removal

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17010401	Chipping brush, light brush	2.70	ACR	0.00	2,263.38	681.66	0.00	$7,951.61	False
17010402	Chipping brush, medium brush	2.80	ACR	0.00	2,909.92	876.37	0.00	$10,601.61	False
17010403	Chipping brush, heavy brush	5.50	ACR	0.00	5,659.47	1,704.45	0.00	$40,501.52	False
33010114	Mobilization Equipment (Soils)	1.00	LS	0.00	3,155.75	3,608.33	0.00	$6,764.08	False
33010202	Per Diem (per person)	14.00	DAY	0.00	0.00	0.00	165.00	$2,310.00	True
33040934	UXO Technician II	50.00	HR	0.00	76.25	0.00	0.00	$3,812.75	False

Technology: MEC Removal Action

33040935	UXO Technician III (UXO Supervisor)	50.00	HR	0.00	90.08	0.00	0.00	$4,503.95	False
33041101	Airfare	2.00	LS	0.00	0.00	0.00	500.00	$1,000.00	True

Total Element Cost: $77,445.51

Element: UXO Mapping - Land

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	6.00	DAY	0.00	0.00	0.00	69.87	$419.19	False
33010202	Per Diem (per person)	73.00	DAY	0.00	0.00	0.00	165.00	$12,045.00	True
33021530	Differential GPS Unit Rental	1.00	MO	848.04	0.00	0.00	0.00	$848.04	False
33040149	Nonsparking UXO Shovels	2.00	EA	154.57	0.00	0.00	0.00	$309.13	False
33040267	Schonstedt GA-52Cx Daily Rental	12.00	DAY	0.00	0.00	0.00	37.73	$452.80	False
33040268	Schonstedt GA-52Cx Weekly Rental	6.00	WK	0.00	0.00	0.00	120.22	$721.32	False
33040651	4 X 4 Truck- Rental/Lease	35.00	DAY	0.00	0.00	158.32	0.00	$5,541.04	False
33040695	GPS, Hand Held Mapping Grade, Weekly Rental with External Antenna	1.00	WK	0.00	0.00	0.00	771.49	$771.49	False
33040933	UXO Technician I	60.00	HR	0.00	63.26	0.00	0.00	$3,795.88	False
33040934	UXO Technician II	106.00	HR	0.00	76.25	0.00	0.00	$8,083.02	False
33040935	UXO Technician III (UXO Supervisor)	25.00	HR	0.00	90.08	0.00	0.00	$2,251.97	False
33040936	Geophysicist (UXO)	24.00	HR	0.00	152.74	0.00	0.00	$3,665.82	False
33041101	Airfare	16.00	LS	0.00	0.00	0.00	750.00	$12,000.00	True

Technology: MEC Removal Action

33220212	Surveying - 2-man Crew	1.00	DAY	0.00	1,687.09	26.06	0.00	$1,713.15	False
33240101	Other Direct Costs	1.00	LS	6,755.58	0.00	0.00	0.00	$6,755.58	True

Total Element Cost: $59,373.45

Element: UXO Removal - Land

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010115	Demobilize Equipment (Soils)	1.00	LS	0.00	3,155.75	3,608.33	0.00	$6,764.08	False
33010202	Per Diem (per person)	98.00	DAY	0.00	0.00	0.00	165.00	$16,170.00	True
33040157	Non-electrical Blasting Caps	11.00	EA	12.12	0.00	0.00	0.00	$133.30	False
33040646	Backhoe - Rental/Lease	21.00	DAY	0.00	990.29	212.57	0.00	$25,259.98	False
33040651	4 X 4 Truck- Rental/Lease	5.00	DAY	0.00	0.00	158.32	0.00	$791.58	False
33040934	UXO Technician II	560.00	HR	0.00	76.25	0.00	0.00	$42,702.76	False
33040935	UXO Technician III (UXO Supervisor)	140.00	HR	0.00	90.08	0.00	0.00	$12,611.05	False
33041002	50 gr/ft Det -Cord (1000 ft roll)	2.00	EA	668.90	0.00	0.00	0.00	$1,337.81	False
33041005	Perforator Explosive Charge	11.00	EA	11.63	0.00	0.00	0.00	$127.96	False
33240101	Other Direct Costs	1.00	LS	5,771.31	0.00	0.00	0.00	$5,771.31	True

Total Element Cost: $111,669.82

Element: Site Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override

Technology: MEC Removal Action

33010202	Per Diem (per person)	252.00	DAY	0.00	0.00	0.00	165.00	$41,580.00	True
33040651	4 X 4 Truck- Rental/Lease	252.00	DAY	0.00	0.00	158.32	0.00	$39,895.52	False
33040921	Senior UXO Supervisor (SUXOS)	400.00	HR	0.00	119.30	0.00	0.00	$47,718.95	False
33040922	UXO Program Manager	400.00	HR	0.00	211.97	0.00	0.00	$84,789.74	False
33040930	UXO QC Specialist	400.00	HR	0.00	106.17	0.00	0.00	$42,468.55	False
33040931	UXO Safety Officer	400.00	HR	0.00	106.77	0.00	0.00	$42,708.96	False
33040940	GIS Manager (UXO)	200.00	HR	0.00	128.62	0.00	0.00	$25,724.65	False
33041101	Airfare	1.00	LS	0.00	0.00	0.00	750.00	$750.00	True

Total Element Cost: $325,636.37

Element: Stakeholder Involvement

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33040923	UXO Project Manager	12.00	HR	0.00	189.06	0.00	0.00	$2,268.69	False
33040935	UXO Technician III (UXO Supervisor)	12.00	HR	0.00	90.08	0.00	0.00	$1,080.95	False
33041105	Full Per Diem Rate - Relocation Allowance	53.00	LS	4,290.90	0.00	0.00	0.00	$227,417.44	False
33041107	Local Hotel- Billeting	2,597.00	LS	173.23	0.00	0.00	0.00	$449,865.38	False
33041315	Site Specific Final Report	1.00	EA	381.41	30,198.59	0.00	0.00	$30,580.00	False
33041318	Evacuation Plan (High Complexity)	1.00	EA	953.53	85,610.11	0.00	0.00	$86,563.64	False
33240107	Yard Maintenance	212.00	LS	39.73	0.00	0.00	0.00	$8,422.87	False

Total Element Cost:	$806,198.96
Total 1st Year Tech Cost:	$1,483,010.32

Technology: Cleanup and Landscaping

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
18050101	Area Preparation, 67% Level & 33% Slope	11.00	ACR	0.00	43.75	44.24	0.00	$967.93	False
18050401	Seeding, 67% Level & 33% Slope, Hydroseeding	11.00	ACR	2,998.20	1,820.14	852.37	0.00	$62,377.78	False
18050408	Fertilizer, Hydro Spread	22.00	ACR	1,689.13	175.35	95.60	0.00	$43,121.75	False
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	88.00	ACR	375.83	95.79	101.15	0.00	$50,403.70	False
18050415	Mowing	22.00	ACR	0.00	557.39	0.00	0.00	$12,262.60	False

Total Element Cost:	$169,133.76
Total 1st Year Tech Cost:	$169,133.76

Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220105	Project Engineer	2.00	HR	0.00	85.80	0.00	0.00	$171.60	False
33220108	Project Scientist	1.00	HR	0.00	93.42	0.00	0.00	$93.42	False

Technology: Five-Year Review

33220109	Staff Scientist	2.00	HR	0.00	75.45	0.00	0.00	$150.89	False

Total Element Cost: $415.92

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	2.00	HR	0.00	124.23	0.00	0.00	$248.46	False
33220105	Project Engineer	2.00	HR	0.00	85.80	0.00	0.00	$171.60	False
33220108	Project Scientist	2.00	HR	0.00	93.42	0.00	0.00	$186.84	False
33220109	Staff Scientist	2.00	HR	0.00	75.45	0.00	0.00	$150.89	False

Total Element Cost: $757.80

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	6.00	HR	0.00	124.23	0.00	0.00	$745.39	False
33220105	Project Engineer	16.00	HR	0.00	85.80	0.00	0.00	$1,372.83	False
33220108	Project Scientist	13.00	HR	0.00	93.42	0.00	0.00	$1,214.45	False
33220109	Staff Scientist	26.00	HR	0.00	75.45	0.00	0.00	$1,961.61	False

Total Element Cost: $5,294.28

Total 1st Year Tech Cost: $6,467.99

Technology: Construction Support

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	50.00	DAY	0.00	0.00	0.00	58.28	$2,913.97	False
33010202	Per Diem (per person)	50.00	DAY	0.00	0.00	0.00	119.79	$5,989.50	True
33040213	White's All Metals, weekly rental	10.00	WK	0.00	0.00	0.00	300.00	$3,000.00	False
33040934	UXO Technician II	500.00	HR	0.00	58.52	0.00	0.00	$29,257.68	False
33041101	Airfare	5.00	LS	0.00	0.00	0.00	750.00	$3,750.00	True

Total Element Cost:	$44,911.15
Total 1st Year Tech Cost:	$44,911.15

Technology: Land Use Controls

Element: Planning Docs

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	22.00	HR	0.00	101.87	0.00	0.00	$2,241.14	False
33220105	Project Engineer	30.00	HR	0.00	85.80	0.00	0.00	$2,574.05	False
33220106	Staff Engineer	45.00	HR	0.00	92.63	0.00	0.00	$4,168.56	False
33220110	QA/QC Officer	11.00	HR	0.00	72.64	0.00	0.00	$799.03	False
33220114	Word Processing/Clerical	60.00	HR	0.00	47.68	0.00	0.00	$2,860.66	False
33220115	Draftsman/CADD	30.00	HR	0.00	45.36	0.00	0.00	$1,360.79	False

Technology: Land Use Controls

33220503	Attorney, Partner, Real Estate	22.00	HR	0.00	205.47	0.00	0.00	$4,520.39	False
33240101	Other Direct Costs	1.00	LS	463.12	0.00	0.00	0.00	$463.12	True

Total Element Cost: $18,987.73

Element: Planning Meetings

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Vehicle mileage charge, car or van	10.00	MI	0.00	0.00	0.00	0.56	$5.60	True
33010202	Per Diem (per person)	1.00	DAY	0.00	0.00	0.00	165.00	$165.00	True
33220102	Project Manager	21.00	HR	0.00	101.87	0.00	0.00	$2,139.27	False
33220114	Word Processing/Clerical	16.00	HR	0.00	47.68	0.00	0.00	$762.84	False
33220115	Draftsman/CADD	8.00	HR	0.00	45.36	0.00	0.00	$362.88	False
33240101	Other Direct Costs	1.00	LS	79.08	0.00	0.00	0.00	$79.08	True

Total Element Cost: $3,514.67

Element: Implementation

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33022037	Overnight Delivery, 8 oz Letter	8.00	EA	0.00	0.00	0.00	34.44	$275.52	False
33040671	Portable GPS Set with Mapping, 5 cm Accuracy	1.00	MO	6,403.48	0.00	0.00	0.00	$6,403.48	False
33220102	Project Manager	30.00	HR	0.00	101.87	0.00	0.00	$3,056.10	False

Technology: Land Use Controls

33220105	Project Engineer	45.00	HR	0.00	70.36	0.00	0.00	$3,166.08	False
33220106	Staff Engineer	60.00	HR	0.00	92.63	0.00	0.00	$5,558.08	False
33220110	QA/QC Officer	13.00	HR	0.00	88.58	0.00	0.00	$1,151.59	False
33220114	Word Processing/Clerical	30.00	HR	0.00	47.68	0.00	0.00	$1,430.33	False
33220115	Draftsman/CADD	90.00	HR	0.00	45.36	0.00	0.00	$4,082.36	False
33220212	Surveying - 2-man Crew	3.00	DAY	0.00	1,061.58	16.40	0.00	$3,233.94	False
33240101	Other Direct Costs	1.00	LS	540.73	0.00	0.00	0.00	$540.73	True

Total Element Cost: $28,898.21

Element: Monitoring & Enforcement

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Vehicle mileage charge, car or van	15.00	MI	0.00	0.00	0.00	0.56	$8.40	True
33010108	Sedan, Automobile, Rental	2.00	DAY	0.00	0.00	0.00	58.28	$116.56	False
33010202	Per Diem (per person)	4.00	DAY	0.00	0.00	0.00	165.00	$660.00	True
33040213	White's All Metals, weekly rental	0.67	WK	0.00	0.00	0.00	300.00	$201.00	False
33040934	UXO Technician II	10.00	HR	0.00	47.98	0.00	0.00	$479.83	False
33041101	Airfare	1.00	LS	0.00	0.00	0.00	750.00	$750.00	True
33220102	Project Manager	13.00	HR	0.00	124.23	0.00	0.00	$1,615.01	False
33220114	Word Processing/Clerical	1.00	HR	0.00	58.14	0.00	0.00	$58.14	False
33240101	Other Direct Costs	1.00	LS	41.06	0.00	0.00	0.00	$41.06	True

	Total Element Cost:	$3,930.01
	Total 1st Year Tech Cost:	$55,330.61
	Total Phase Element Cost	**$1,759,711.86**

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