Final

Remedial Investigation Report for

Fort Clinton West Munitions Response Site
Siege Battery Munitions Response Site
Lusk Reservoir Munitions Response Site
Artillery Firing Range Munitions Response Site

U.S. Army Garrison West Point
West Point, New York

March 2015

Prepared for:

U.S. Army Corps of Engineers
Baltimore District

Prepared by:

Weston Solutions, Inc.

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FINAL
REMEDIAL INVESTIGATION REPORT
FOR
FORT CLINTON WEST MUNITIONS RESPONSE SITE
SIEGE BATTERY MUNITIONS RESPONSE SITE
LUSK RESERVOIR MUNITIONS RESPONSE SITE
ARTILLERY FIRING RANGE MUNITIONS RESPONSE SITE

U.S. ARMY GARRISON WEST POINT
WEST POINT, NEW YORK

Contract No.: W912DR-09-D-0006
DELIVERY ORDER NO.: 0001

Prepared For:

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LIST OF ACRONYMS

ºF	degrees Fahrenheit
µg/kg	microgram per kilogram
2,4-DNT	2,4-dinitrotoluene
2,6-DNT	2,6-dinitrotoluene
2-Am-DNT	2-amino-4,6-dinitrotoluene
4-Am-DNT	4-amino-2,6-dinitrotoluene
amsl	above mean sea level
APC-T	armor-piercing capped tracer
APP	Accident Prevention Plan
ARAR	applicable or relevant and appropriate requirement
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BIP	blown in place
CENAB	United States Army Corps of Engineers, Baltimore District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	cultural feature
CFR	Code of Federal Regulations
CHE	Chemical Warfare Materiel Hazard Evaluation
CLP	Contract Laboratory Program
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
CTT	closed, transferred, and transferring
CWM	chemical warfare materiel
DGM	digital geophysical mapping
DMM	discarded military munitions
DoD	Department of Defense
DQO	data quality objective
DVP	Data Validation Procedure
ECBC	Edgewood Chemical Biological Center
Eco-SSL	ecological soil screening level
EE/CA	Engineering Evaluation/Cost Analysis
EHE	Explosives Hazard Evaluation
ELAP	Environmental Laboratory Accreditation Program
EM	Engineering Manual
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency
ERT	Earth Resources Technology, Inc.
ESL	ecological screening level
ESP	Explosives Site Plan
ESRI	Environmental Systems Research Institute
ESV	ecological screening value
FS	feasibility study
ft	feet
GIS	Geographic Information System
gpm	gallons per minute
GPS	Global Positioning System
GSV	Geophysical System Verification
HE	high explosive
HHE	health hazard evaluation
HHRA	human health risk assessment
HPLC	high performance liquid chromatography

LIST OF ACRONYMS (Continued)

HRR	Historical Records Review
IDW	investigation derived waste
ISO	industry standard object
IVS	Instrument Verification Strip
LANL	Los Alamos National Laboratory
LUC	land use control
MC	munitions constituents
MD	munitions debris
MDAS	material documented as safe
MDEH	material documented as an explosive hazard
MEC HA	munitions and explosives of concern hazard assessment
MEC	munitions and explosives of concern
MIST	Multi-Incremental Sampling Tool
mg/kg	milligram per kilogram
mm	millimeter
MMRP	Military Munitions Response Program
MP	Military Police
mph	miles per hour
MPPEH	material potentially presenting an explosive hazard
MQO	measurement quality objective
MRS	munitions response site
MRSPP	Munitions Response Site Prioritization Protocol
MS/MSD	matrix spike/matrix spike duplicate
MSD	minimum separation distance
mV	millivolt
NAD 83	North American Datum 1983
NAD	North American Datum
NBA	no benchmark available
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NELAC	National Environmental Laboratory Accreditation Conference
NFA	no further action
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NYCRR	New York Codes, Rules and Regulations
NYNHP	New York Natural Heritage Program
NYSDEC	New York State Department of Environmental Conservation
OB/OD	open burning/open detonation
OESS	Ordnance and Explosive Safety Specialist
ORNL	Oak Ridge National Laboratory
PA	preliminary assessment
PETN	pentaerythritol tetranitrate
PRG	preliminary remediation goal
PTTF	powder train time fuze
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
QSM	Quality System Manual
RCRA	Resource Conservation and Recovery Act
RDX	hexahydro-1,3,5-trinitro-1,3,5-triazine
RI	remedial investigation
RI/FS	remedial investigation and feasibility study
RPD	relative percent difference
RSD	relative standard deviation
RSL	regional screening level

LIST OF ACRONYMS (Continued)

RTS	Robotic Total Station
SARA	Superfund Amendments and Reauthorization Act
SCO	soil cleanup objective
SHA	secure holding area
SI	site inspection
SLERA	screening level ecological risk assessment
SOP	standard operating procedure
SQL	sample quantitation limit
SSHP	site safety and health plan
SUXOS	Senior UXO Supervisor
TAL	Target Analyte List
TBC	to be considered
TCL	Target Compound List
TCRA	Time Critical Removal Action
THQ	target hazard quotient
TLI	TLI Solutions, Inc.
TNT	trinitrotoluene
TPP	Technical Project Planning
TR	target risk
U.S.C.	United States Code
UFP-QAPP	Uniform Federal Policy Quality Assurance Project Plan
USACE	United States Army Corps of Engineers
USACHPPM	U.S. Army Center for Health Promotion and Preventative Medicine
USAEC	U.S. Army Environmental Command
USAG	U. S. Army Garrison
USMAPS	U.S. Military Academy Preparatory School
UTM	Universal Transverse Mercator
UV	ultraviolet
UXO	unexploded ordnance
UXOQCS	UXO Quality Control Specialist
West Point	U.S. Army Garrison West Point
WESTON®	Weston Solutions, Inc.
WWTP	wastewater treatment plant

1. INTRODUCTION

1.1 PROJECT AUTHORIZATION

Weston Solutions, Inc. (WESTON®) was authorized to perform remedial investigations (RIs) at 11 munitions response sites (MRSs) under the United States Army Corps of Engineers (USACE), Baltimore District (CENAB) Multiple Award Military Munitions Services (MAMMS) Contract W912DR-09-D-006, Delivery Order 0001. The RI Report includes discussions of the RI activities and results for the following MRSs: Fort Clinton West (WSTPT-008-R-01), Siege Battery (WSTPT-015-R-01), Lusk Reservoir (WSTPT-019-R-01), and Artillery Firing Range (WSTPT-001-R-01). The RI was completed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) process outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Some of the specific NCP processes that were followed include:

- 40 CFR 300.430(a) - Purpose of the remedy selection process, which is to implement remedies that eliminate, reduce, or control risk to human health and the environment.
- 40 CFR 300.430(b) – Scoping, which involves assembling and evaluating site-specific data and information.
- 40 CFR 300.430(d)(2) – Characterization of the nature of and the threat posed by the hazardous substances.
- 40 CFR 300.800 - The requirement for an administrative record made available to the public.

In accordance with Executive Order 12580, the U.S. Army is the lead agency with support from the State of New York. The RI Report is consistent with the U.S. Environmental Protection Agency (EPA) October 1988 document *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), and the U.S. Army Military Munitions Response Program (MMRP) document, *Final Munitions Response Remedial Investigation/Feasibility Study Guidance* (U.S. Army, 2009).

1.2 PURPOSE AND SCOPE

The U.S. Congress established the MMRP under the Defense Environmental Restoration Program (DERP) to address munitions and explosives of concern (MEC), including unexploded ordnance

(UXO), discarded military munitions (DMM), and munitions constituents (MC) located on current and former defense sites. MMRP-eligible sites include locations other than operational ranges where UXO, DMM, or MC are known or suspected to be present and where the release occurred prior to September 30, 2002. Properties classified as operational military ranges, permitted munitions disposal facilities, or operating munitions storage facilities are not eligible for the MMRP. The DERP, including the MMRP, typically follows CERCLA and the NCP.

The U.S. Army conducted an inventory of closed, transferred, and transferring (CTT) military ranges and defense sites (also known as the Phase 3 CTT), which meets the requirements of a CERCLA Preliminary Assessment (PA). In the Phase 3 CTT inventory for the U.S. Army Garrison West Point, New York (West Point), 10 closed ranges and 2 transferred areas with the potential for MEC, which includes both UXO and DMM and/or MC, were identified as eligible for action under the MMRP. The Phase 3 CTT Range Inventory Report for West Point (Malcolm Pirnie, 2004) was completed in August 2004.

The next phase of the CERCLA process at West Point was the site inspection (SI). The SI was completed in a two-step approach. The Historical Records Review (HRR) was the initial step in the MMRP SI process. During the HRR, records searches were performed to supplement the information gathered during the Phase 3 CTT and to facilitate the decision-making processes to determine the next step for the SI. The Final HRR Report was presented to the Army and the stakeholders in March 2006 (TLI Solutions, Inc. [TLI], 2006). Based on the HRR results, one MRS was determined to require no further action (NFA). All other MRSs in the Phase 3 CTT were determined to require a field inspection. These field inspections were performed in April, May, and September 2006. The results of the SI (TLI, 2007) indicated that multiple MRSs required further investigation through an RI. The SI report identified 11 MRSs at West Point to be evaluated in the RI phase of the CERCLA process. The April and May 2006 SI field activities applicable to each MRS are discussed in more detail in Sections 2 through 5. As part of the SI, a preliminary conceptual site model (CSM) was developed for West Point in its entirety. Individual CSMs were also developed for each of the MRSs.

The purpose of the MMRP RI was to determine whether further response action pursuant to CERCLA and the NCP is warranted at the Fort Clinton West MRS (WSTPT-008-R-01), Siege Battery MRS (WSTPT-015-R-01), Lusk Reservoir MRS (WSTPT-019-R-01), and Artillery

Firing Range MRS (WSTPT-001-R-01). The RI was designed to determine the nature and extent of MEC and MC and to determine the hazards and potential risks posed to human health and the environment by MEC and MC.

1.3 PROPERTY DESCRIPTION AND PROBLEM IDENTIFICATION

1.3.1 Project Location and Site Description

West Point is located in Orange and Putnam Counties, New York, on the west bank of the Hudson River. West Point is approximately 50 miles north of New York City and approximately 13 miles south of Newburgh. West Point is an active U.S. Army installation. The West Point installation consists of three parts: (1) Main Post, (2) West Point Military Reservation (WPMR), and (3) Constitution Island. Main Post, or the cantonment, is approximately 2,500 acres and is the academic, administrative, and community area along the Hudson River. The WPMR is generally considered to be the 14,000-acre area to the west of Main Post that serves as the field training facility for U.S. Army Garrison West Point. The Main Post and the WPMR are separated by Route 9W (Tetra Tech, Inc., 2011).

Both the Main Post and WPMR lie entirely in Orange County, New York. Directly across the Hudson River from the Main Post is Constitution Island, located in the township of Philipstown, Putnam County, New York. Constitution Island is bounded by the Hudson River on three sides except the eastern border, where it is bounded by the Metro-North railroad tracks (Tetra Tech, Inc., 2011). **Figure 1-1** provides a regional view of West Point, and **Figure 1-2** shows the locations of the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs.

1.4 WEST POINT MMRP REMEDIAL INVESTIGATION RESULTS

During the MMRP RI at the 11 West Point MRSs, consistent findings indicative of a common CSM were observed across the boundaries of several MRSs, including the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. These MRSs consist of abutting or overlapping ranges that terminate in the direction of the Crows Nest mountain at West Point. The Crows Nest demarcates the northern extent of the West Point installation boundary and is a topographic high point above the remainder of West Point. Crows Nest was a former target area used for range activities at West Point and for weapons testing from the West

Point Foundry (also referred to as the Cold Springs Foundry) situated on the east side of the Hudson River.

During the RI, areas with concentrations of MEC and/or MD were identified in portions of the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. Collectively, these areas with concentrations of MEC and/or MD are referred to as the Crows Nest impact area. The investigation activities and the results for the four MRSs are reported independently in separate sections of the RI Report. The Crows Nest impact area delineated within each MRS is also discussed. Based on the RI results and the conclusions for the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs, it was recommended that a new Artillery Firing Range North MRS (WSTPT-001-R-02) be delineated to aid in the characterization of the Crows Nest impact area.

The sections of the RI Report are as follows:

- Section 1 – Introduction
- Section 2 – Fort Clinton West MRS
- Section 3 – Siege Battery MRS
- Section 4 – Lusk Reservoir MRS
- Section 5 – Artillery Firing Range MRS
- Section 6 – Artillery Firing Range North MRS (addresses the Crows Nest impact area)
- Section 7 – Summary and Conclusions
- Section 8 – References

West Point has an existing installation-wide land use controls (LUCs) requirement involving dig permitting whenever ground is broken. The Department of Public Works reviews all dig permits and requires construction support for areas known to contain or having the potential to contain MEC. West Point uses a Probability Assessment (U.S. Army Garrison [USAG] West Point, 2010) to determine which areas on the installation require construction support for ground disturbing activities. The areas considered in the Probability Assessment are divided into Group A and Group B. Group A areas have a low probability of encountering MEC, and workers in these areas are provided a safety brochure with instructions in the event a munitions item is encountered. Group B areas require construction support for ground disturbing activities. The Department of Public Works reviews dig permit requests and compares them to the map in the

Probability Assessment and provides guidance to the dig permit requestor. The existing installation-wide LUCs were taken into consideration in determining the conclusions and recommendations for each MRS and are not considered a remedial action.

Recommendations for the individual MRSs are as follows:

- Fort Clinton West MRS
  - Transfer the 12.7-acre northwestern portion of the Fort Clinton West MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02).
  - Revise the Fort Clinton West MRS from 14.4 acres to 1.7 acres and maintain tracking under WSTPT-008-R-01.
- Siege Battery MRS
  - Transfer the 66.3-acre northwestern portion of the Siege Battery MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02).
  - Designate the 52 acres of the Siege Battery MRS located east of the Hudson River on Constitution Island as a separate MRS, known as Siege Battery Constitution Island (WSTPT-015-R-02).
  - Revise the Siege Battery MRS from 167.1 acres to 48.8 acres and maintain tracking under WSTPT-015-R-01.
- Lusk Reservoir MRS
  - Transfer the 8.8-acre portion of the Lusk Reservoir MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02).
  - Revise the Lusk Reservoir MRS from 83.2 acres to 74.4 acres and maintain tracking under WSTPT-019-R-01.
- Artillery Firing Range MRS
  - Split the northeastern noncontiguous area into two separate MRSs.
  - Transfer the northern 42-acre portion of the Artillery Firing Range MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02).
  - Designate the southern 123.4-acre portion of the Artillery Firing Range MRS where a complete MEC exposure pathway to potential receptors is present, but which is not within the Crows Nest impact area, as a separate MRS, known as Artillery Firing Range South MRS (WSTPT-001-R-03).
  - Revise the Artillery Firing Range MRS from 172.4 acres to 7 acres associated with the Sacred Heart Cemetery Range firing point area and maintain tracking under WSTPT-001-R-01.

The delineation of the MRSs is summarized in **Table 1-1.** The revised boundaries of the MRSs based on the results of the RI characterization are presented in **Figure 1-3**. Discussions of the RI results and the conclusions for each MRS are provided in Sections 2 through 6 and are presented in an overall summary in Section 7.

Table 1-1 Recommended West Point MMRP RI MRS Delineation Summary

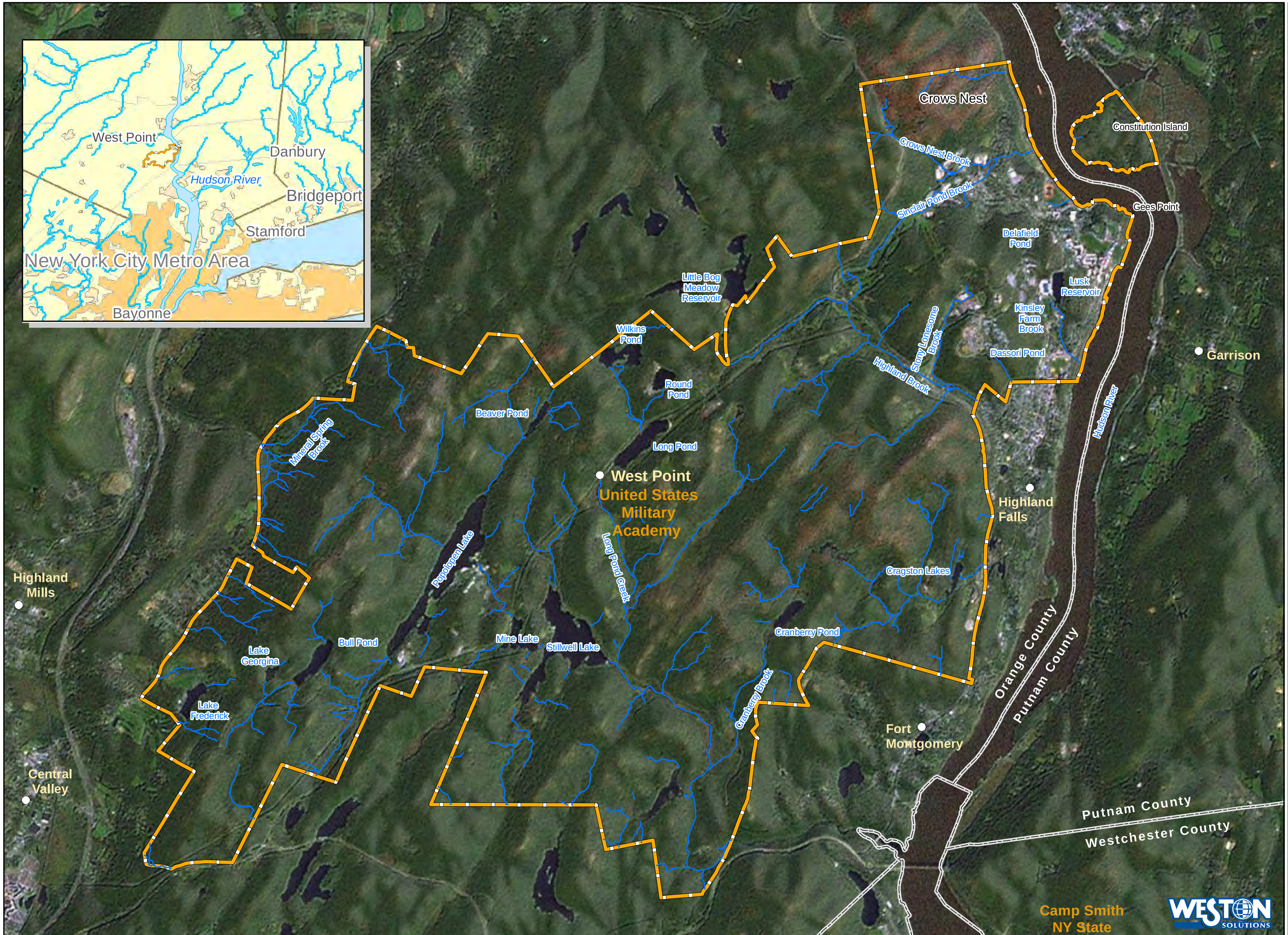
<table>
<tr><th colspan="2">Original Configuration</th><th colspan="2">Configuration Following Recommended Delineation</th></tr>
<tr><th>MRS Identifier</th><th>Area (acres)</th><th>MRS Identifier</th><th>Area (acres)</th></tr>
<tr><td>Fort Clinton West (WSTPT-008-R-01)</td><td>14.4</td><td>Fort Clinton West (WSTPT-008-R-01)</td><td>1.7</td></tr>
<tr><td rowspan="2">Siege Battery (WSTPT-015-R-01)</td><td rowspan="2">167.1[a]</td><td>Siege Battery (WSTPT-015-R-01)</td><td>48.8</td></tr>
<tr><td>Siege Battery Constitution Island (WSTPT-015-R-02)</td><td>52</td></tr>
<tr><td>Lusk Reservoir (WSTPT-019-R-01)</td><td>83.2</td><td>Lusk Reservoir (WSTPT-019-R-01)</td><td>74.4</td></tr>
<tr><td rowspan="3">Artillery Firing Range (WSTPT-001-R-01)</td><td rowspan="3">172.4</td><td>Artillery Firing Range (WSTPT-001-R-01)</td><td>7</td></tr>
<tr><td>Artillery Firing Range South (WSTPT-001-R-03)</td><td>123.4</td></tr>
<tr><td>Artillery Firing Range North (WSTPT-001-R-02)</td><td>143.3[b]</td></tr>
<tr><td>Total area</td><td>437.1</td><td></td><td>450.6</td></tr>
</table>

Notes:

[a] The area for the Siege Battery MRS (WSTPT-015-R-01) reported in the SI was 179.3 acres (TLI, 2007), which was subsequently used in the Final Work Plan (WESTON, 2011a). During the RI, the area of the MRS was determined to include portions of the Hudson River and was adjusted to 167.1 acres to align with the current land boundary. The 12.2 acres removed are assumed to be associated with the Siege Battery – TD – River MRS (WSTPT-016-R-01).

[b] The Artillery Firing Range North MRS acreage represents the Crows Nest impact area characterized within portions of the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and 13.5 additional acres previously not included within an MRS boundary at West Point.

SECTION 1
FIGURES



Legend

Installation Boundary

Streams

Imagery Source: ESRI, World Imagery
USAD FSA, NAIP 2009

N
W E
S

0 1 2
Miles

Figure 1-1
Regional Location Map
U.S. Army Garrison West Point

WESTON SOLUTIONS

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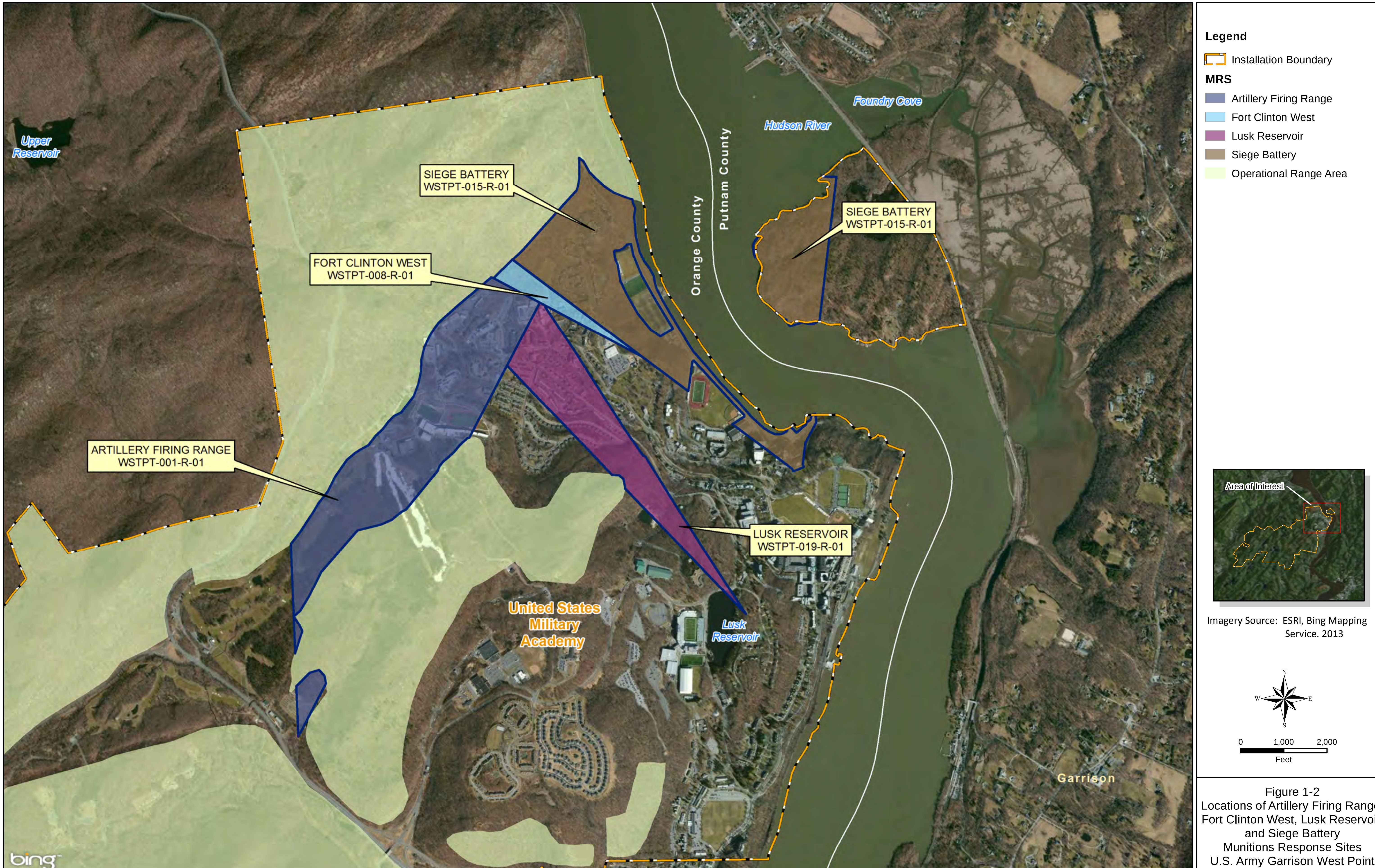

Figure 1-2
Locations of Artillery Firing Range, Fort Clinton West, Lusk Reservoir, and Siege Battery Munitions Response Sites
U.S. Army Garrison West Point

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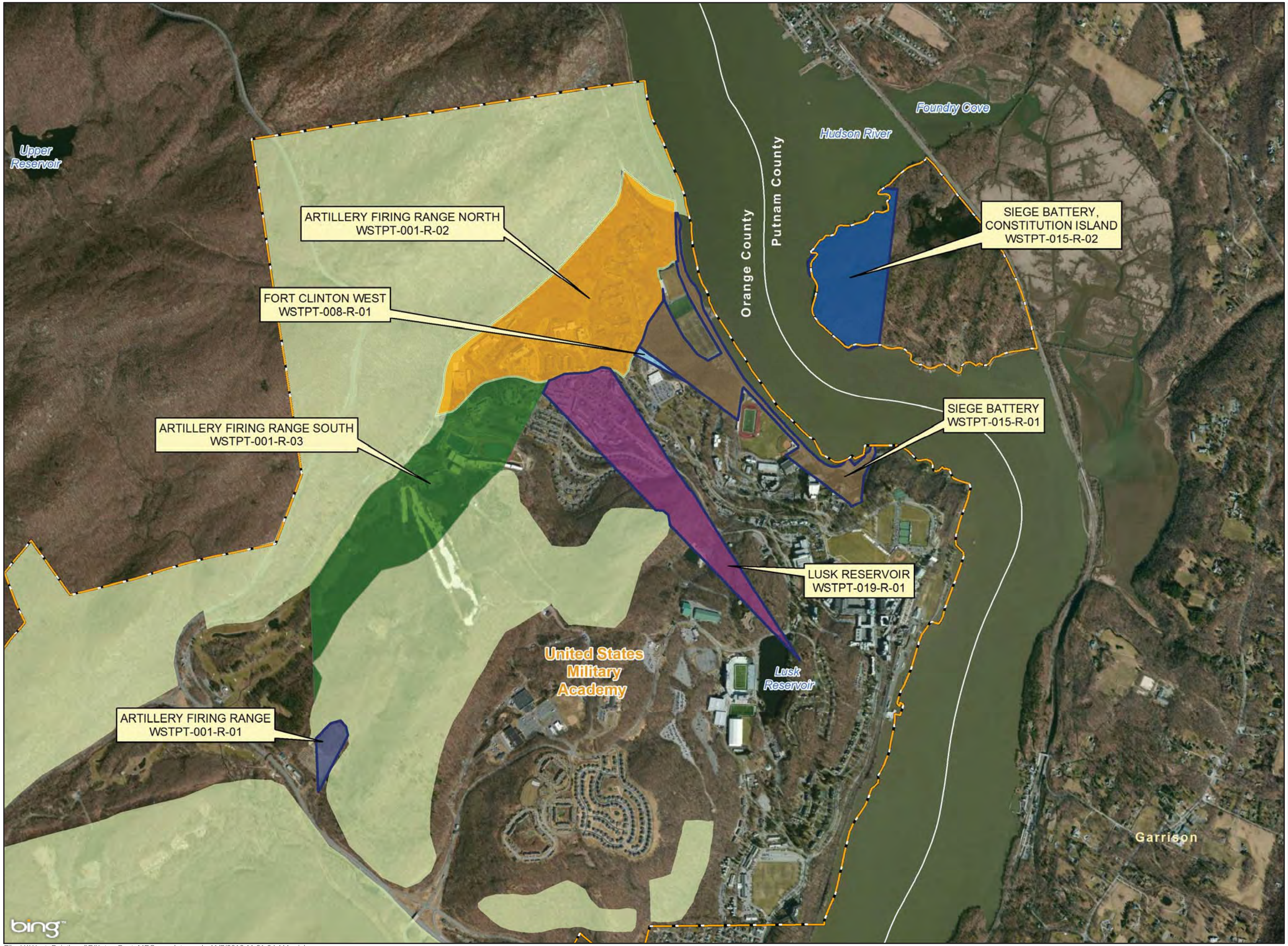
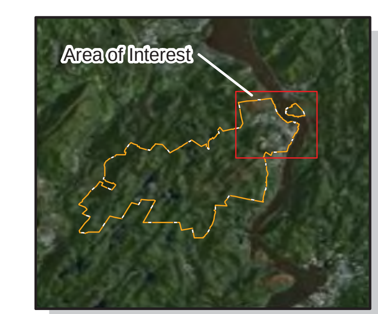


Legend

Installation Boundary

MRS

- Artillery Firing Range
- Artillery Firing Range North Crows Nest Impact Area
- Artillery Firing Range South
- Fort Clinton West
- Lusk Reservoir
- Siege Battery
- Siege Battery, Constitution Island
- Operational Range Area



Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 1,000 2,000
Feet

Figure 1-3
Post-RI MRS Boundaries
U.S. Army Garrison West Point

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2. FORT CLINTON WEST MRS

2.1 INTRODUCTION

Section 2 presents the activities, results, and conclusions from the Military Munitions Response Program (MMRP) remedial investigation (RI) performed to characterize the Fort Clinton West munitions response site (MRS) tracked under WSTPT-008-R-01 in the Army Environmental Database – Restoration Module.

2.1.1 Site Description

The Fort Clinton West MRS (WSTPT-008-R-01), which is 14.4 acres (see **Figure 2-1**), is part of a much larger former artillery range fan that extended across Main Post from Gees Point to Crows Nest mountain. The firing point for the former range was not located within the Fort Clinton West MRS boundaries. Approximately 17 structures are located within the boundaries of the Fort Clinton West MRS. Residential housing and a portion of a Child Development Center and of a solid waste landfill (Post School Landfill) are located in the MRS (**Figure 2-2**).

2.1.1.1 Climate

The climate of the region that includes West Point is characterized as a humid, continental climate. Summers are warm and have periods of high humidity. The semi-permanent Bermuda High brings south to southwest warm and humid air to the area. July is the hottest month, with a mean temperature of 86 degrees Fahrenheit (ºF); and the coldest month of the year is January, which has a mean temperature of 27 ºF. Winters are cold with extended periods of snow cover and are influenced by the cold Hudson Bay air masses. Most winters are characterized by one or more warm periods when soils nearly or completely thaw (Tetra Tech, Inc., 2011).

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 (Tetra Tech, Inc., 2011).

Thunderstorms occur approximately 20 times per year. Tornadoes occur at a frequency of 3 to 4 times a 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 the least amount (approximately 3.5 inches each month) occurring in January and February, and the most precipitation occurring in May (approximately 4.9 inches) (Tetra Tech, Inc., 2011).

2.1.1.2 Geology

West Point lies in the Hudson Highlands, a low, rugged mountain range, that forms a zone of folded and faulted metamorphic and igneous rocks subjected to extensive weathering and erosion. Precambrian-age granite, diorite, gneiss, and schist compose the majority of the crystalline bedrock underlying West Point. Granite, the most prevalent rock type in the bedrock, is typically medium-grained and composed of quartz, feldspar, and mica. Granite and pegmatite are igneous rocks that occur as dikes and sills within the gneiss. Igneous rocks on the West Point installation consist of plagioclase feldspar, hornblende, pyroxene, and biotite mica and quartz (Tetra Tech, Inc., 2011).

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 (Tetra Tech, Inc., 2011).

The faults mapped at the surface near and within the habitation area at West Point include the Long Pond, the Crown Ridge, and the Highland Brook faults. 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 (NY 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 between the Long Pond and Crown Ridge faults (Tetra Tech, Inc., 2011).

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 features are 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 (Tetra Tech, Inc., 2011).

Site-specific geologic investigations were not conducted for the Fort Clinton West MRS, and information regarding site-specific geology is not available for the MRS**.** Regional geologic maps (Cadwell, 1989; Fisher et al., 1970) indicate that the bedrock geology of the Fort Clinton West MRS is leucogranitic gneiss, rusty and gray biotite-quartz-feldspar gneisses, and quartz plagioclase gneiss.

2.1.1.3 Topography

The topography of West Point is best described as having moderately steep hills and numerous escarpments. Slopes from 10 to 60% are common on the West Point 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 (Tetra Tech, Inc., 2011). The elevation of the Fort Clinton West MRS ranges between 118 feet (36 meters) and 385 feet (117 meters) above mean sea level (amsl).

2.1.1.4 Soils

Five soil types exist within the Fort Clinton West MRS based on the soils mapped within West Point (Tetra Tech Inc., 2011). Sloping Hollis soils are dominant within the MRS and exist primarily in undeveloped areas. The remaining soils include Swartswood gravelly loam, sloping and moderately steep Rock outcrop-Hollis complex, and smoothed Udorthents. The soil types in the Fort Clinton West MRS range from well drained to somewhat excessively well drained. With the exception of the smoothed Udorthents and Swartswood gravelly loam, the remainder of the soils are typically shallow. **Figure 2-3** presents the location of each of the specific soil types in the MRS.

2.1.1.5 Hydrology

2.1.1.5.1 Surface Water

No surface water bodies are located in the Fort Clinton West MRS. The following surface water bodies are located within a 3.0-mile radius of the MRS: the Hudson River, Crows Nest Brook, Sinclair Pond Brook, Delafield Pond, Lusk Reservoir, Kinsley Farm Brook, Stony Lonesome Brook, Highland Brook, Dassori Pond, Round Pond, Wilkins Pond, and Cragston Lakes (see **Figure 2-1**).

2.1.1.5.2 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 West Point installation, but the deposits are thin and generally have fairly small well yields that average about 40 gallons per minute (gpm). 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 (Tetra Tech, Inc., 2011; TLI Solutions, Inc. [TLI], 2007). However, an unconsolidated aquifer does not exist within the Fort Clinton West MRS based on the geology. Site-specific groundwater investigations were not conducted for the Fort Clinton West MRS.

2.1.1.6 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 in that five physiographic provinces—the Appalachian Plateaus, Folded Appalachians (Valley and Ridge), New England, Piedmont, and Coastal Plain—converge within a 35-mile radius of the West Point installation. West Point is located in the New England Province in an area known as the Hudson Highlands (Tetra Tech, Inc., 2011).

2.1.1.6.1 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 West Point installation. No specially managed sites exist within the Fort Clinton West MRS (Tetra Tech, Inc., 2011).

2.1.1.6.2 Wetlands

Approximately 1,010 acres of wetlands are located throughout West Point in association with streams, ponds, depressions, and seeps (Tetra Tech, Inc., 2011); however, there are no wetlands within the Fort Clinton West MRS.

2.1.1.6.3 Flora

Approximately 50% of the Fort Clinton West MRS is extensively disturbed with development, which includes a housing area and the Child Development Center. Vegetation within the developed areas of the MRS is primarily mowed lawn and trees that are characteristic of developed, landscaped areas. However, portions of the MRS are heavily forested.

2.1.1.6.4 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 species of fish and invertebrate species (Tetra Tech, Inc., 2011). A large portion of the Fort Clinton West MRS is extensively developed, and it is unlikely that most of these species would rely on the developed area for habitat. The undeveloped, forested areas may provide habitat for some of these species.

2.1.1.6.5 Ecological Receptors

Potential ecological receptors were provided by West Point and are presented in the overall conceptual site model (CSM) for West Point. The following list of ecological receptors was modified from the list of receptors in the overall CSM for West Point to include only those species that have the potential to exist within the Fort Clinton West 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.
- 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.
- 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 (5 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.

An MRS-specific inventory of floral and faunal species was not conducted in the Fort Clinton West MRS. The *Integrated Natural Resources Management Plan for the United States Army Garrison – West Point* (Tetra Tech, Inc., 2011) contains an extensive list of species that have been documented at West Point.

2.1.1.7 Sensitive Environmental Resources in the MRS

Weston Solutions, Inc. (WESTON®) submitted a request for review by the New York Natural Heritage Program (NYNHP) to determine whether there are records of any known rare, threatened, and endangered species or species of special concern located within or near the West Point MRSs. In response, the 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 the 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 remaining species have the potential to occur in the

Fort Clinton West MRS. The central and southern portions of the Fort Clinton West MRS are extensively developed, and it is unlikely that most of these species would rely on the developed areas for habitat. The undeveloped, forested areas in the northwestern portion of the MRS may provide habitat for some of these species. However, the NYNHP did not identify any federally threatened or endangered plant species within any of the West Point MRSs.

2.1.1.8 Cultural and Archaeological Resources

Because West Point is one of the older training grounds in the United States that is still intact, it contains numerous cultural, archaeological, and historical sites. Standard operating procedures to identify and report cultural and archaeological resources were put in place during the work planning phases. No cultural or archeological items or features of significance were observed during RI field activities.

2.1.1.9 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 four land use zones based on the functional categories that reflect the West Point missions (Tetra Tech, Inc., 2011):

- Cadet Use: Academic, intramural athletic, billeting, and parading.
- Cadet Support: Intercollegiate athletic fields and some cadet support facilities.
- Post Support: Housing, commercial, and service support to staff and faculty, non-West Point military personnel, and military retirees.
- Recreational, Industrial, Field Training: Building and storage area support for industrial operation, field training areas, recreation areas, and open space.

The Fort Clinton West MRS is located in two land use zones, (1) the Post Support and (2) Recreational, Industrial, Field Training. A solid waste landfill (Post School Landfill) intersects the MRS along the northeastern boundary. The remainder of the northwestern portion of the MRS is largely undeveloped. A housing area and part of the Child Development Center occupy the majority of the central and southeastern portions of the MRS. The undeveloped areas in the northwestern portion of the Fort Clinton West MRS and in the southeastern extent may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within the MRS or in the vicinity (Tetra Tech, Inc., 2011). No changes to the current land uses are anticipated.

2.1.2 Previous Investigations

2.1.2.1 Historical Information

Prior to Benedict Arnold's treason in September 1780, Fort Clinton was known as Fort Arnold. Construction of Fort Arnold and its water batteries began on March 12, 1778, on the eastern portion of West Point. The fort was constructed of timber, earth, and fascines (bundles of live cuttings used for soil stabilization) and was designed to provide fortification for the chain that was placed across the Hudson River. According to the Range Inventory Report, as of September 5, 1780, the fort contained one brass four-pounder on a traveling carriage, 11 brass mortars of various sizes, one iron 12-pounder on a garrison carriage, six iron 18-pounders on garrison carriages, and one iron 12-pounder on a stocked carriage. The batteries did not fire a shot during wartime; however, practice firings were routinely conducted. The position was abandoned at the end of the Revolutionary War, and the fort was renamed Fort Clinton (TLI, 2006).

The fort was later used for the practice firing of 75 millimeter (mm) guns from the mid-1800s until 1927. The firing of these guns was primarily directed toward Crows Nest mountain; however, the exact position of the targets is unknown. In a memorandum dated July 22, 1927, it was proposed that future summer coast artillery training for cadets be moved to Fort Monroe because of the hazards associated with firing from batteries over Storm King Highway into the Crows Nest area. The date on which this proposal was approved is not known. Since 1927, the fort site has been designated a monument and a national historic site. No additional information regarding the activities conducted at Fort Clinton was located during research conducted for the Historical Records Review (HRR).

2.1.2.2 Site Inspection Report and Results

During the site inspection (SI), the Fort Clinton MRS consisted of two non-contiguous parcels of land. Fort Clinton East consisted of the location of Fort Clinton (which included the firing point). Fort Clinton West consisted of a portion of the range fan that extends to the west, which is not overlain by other range fans or the operational range area (TLI, 2006). The SI results for the Fort

Clinton East MRS indicated that the area had not been impacted by military munitions activities (i.e., no MEC or MD was found), and the analytical results reflected no munitions constituents (MC). Therefore, the Fort Clinton East MRS was recommended for no further action (NFA). The remaining portion of the Fort Clinton MRS consisting of the range fan is now referred to as the Fort Clinton West MRS (WSTPT-008-R-01). Although both portions of the original Fort Clinton MRS were investigated during the SI, only the investigation results applicable to the current Fort Clinton West MRS are discussed below.

The SI field activities at the Fort Clinton West MRS included a visual survey and surface soil sampling. The visual survey was conducted along approximately 4.75 linear miles at the Fort Clinton West MRS.

During the visual survey, each team member walked individual transects, nominally spaced at 10- to 50-foot intervals (based on terrain, ground cover, and vegetation to identify and record all MEC, munitions debris (MD), and munitions-related materials. Hand-held Global Positioning System (GPS) units were used to track the visual survey transects, and a waypoint was logged if items were observed. Schonstedt magnetic locators and handheld electromagnetic metal detectors were used during the visual survey to aid in the identification of metallic items at the ground surface (TLI, 2007). The visual survey coverage and the sample location for the Fort Clinton West MRS are presented in **Figure 2-4**.

MD and munitions-related features were observed in the Fort Clinton West MRS during the SI visual survey. No MEC was found within the MRS. The MD items found included six fragments, two of which were identified as possible "Parrott" round fragments (TLI, 2007). One surface soil sample (USMA-FC-SO002) was collected from the northwestern edge of the Fort Clinton West MRS at a location where MD was identified. The surface soil sample was analyzed for Target Compound List (TCL) explosives by Method 8330 and a subset of the Target Analyte List (TAL) metals by Methods SW846 6010B and 7471A. Metals were selected for analysis based on the metals known to be associated with the munitions historically used at West Point. The surface soil sample was analyzed for antimony, copper, iron, lead, mercury, potassium, and zinc. The analytical results for seven TAL metals and TCL explosives were compared, for evaluation purposes only, against U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for residential soils (current screening levels at that time), where available.

A trace amount of an explosive was detected in the surface soil sample; however, the concentration was below the corresponding EPA Region 9 PRGs and laboratory reporting limit required by Method SW 8330. The remaining TCL explosive compounds were not detected. The results for the Fort Clinton West are as follows:

- 4-Amino-2,6-dinitrotoluene was detected in sample USMA-FC-SO002 at 0.40 mg/kg. USMA-FC-SO002 was collected near a fragment found in the Fort Clinton West MRS. There is no established PRG for 4-amino-2,6-dinitrotoluene; however, the detected level is well below the PRG for aminodinitrotoluene (12 mg/kg), which is used as the standard for comparison.

Copper, iron, lead, mercury, potassium, and zinc were detected in the sample, but the concentrations were below the applicable screening values.

Further investigation of MEC at the Fort Clinton West MRS was recommended in the SI. Further evaluation of MC was determined not to be warranted unless additional investigation of MEC identifies areas of concern.

2.1.2.3 Munitions Response Site Prioritization Protocol Scoring

The Munitions Response Site Prioritization Protocol (MRSPP) reflects the statement in 10 United States Code (U.S.C.) §2710(b)(2) that the priority assigned should be based on the overall conditions at each location, taking into consideration various factors relating to safety and environmental hazard potential. As required under 10 U.S.C. §2710(b)(1), the priority assigned to each MRS will be included with the inventory information made publicly available. The requirement for an inventory of MRSs known or suspected of containing UXO, discarded military munitions (DMM), or MC is found at 10 U.S.C. §2710(a). The assigned priority is reviewed annually and updated to reflect new information that becomes available.

The MRSPP was applied to the Fort Clinton West MRS after the SI. The Fort Clinton West MRS was assigned a Priority 4 (out of 8) based on the potential explosive hazard identified during construction activities. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with chemical warfare materiel (CWM) can be assigned to Priority 1, and no MRS with CWM can be assigned to Priority 8. The MRSPP was reapplied based on the RI results, and is presented in Section 2.9.2.

2.1.3 Remedial Investigation Report Organization

Section 2 is organized as follows:

- Section 2.1 provides the purpose and scope of the project, a description and history of the MRS, and a summary of the previous investigations.
- Section 2.2 includes a discussion of the preliminary CSM, preliminary remediation goals, data needs, and data quality objectives (DQOs) used to develop the RI.
- Section 2.3 provides details on the approach, methods, and procedures used to characterize MEC.
- Section 2.4 provides the details of the MC sampling.
- Section 2.5 provides the results of the RI characterization activities.
- Section 2.6 presents the results of the human health and ecological baseline risk assessment activities for MC and also presents the preliminary identification of potential applicable or relevant and appropriate requirements (ARARs).
- Section 2.7 addresses MEC and MC fate and transport processes.
- Section 2.8 presents the revised CSM developed for the MRS based on the RI findings.
- Section 2.9 addresses the MEC hazard assessment and the reapplication of the MRSPP to the Fort Clinton West MRS based on the data collected during the RI.
- Section 2.10 presents the RI summary and conclusions.

References cited in Section 2 are provided in Section 8.

2.2 PROJECT REMEDIAL RESPONSE OBJECTIVES

The goal of the RI was to characterize the nature and extent of potential MEC and MC by conducting an investigation at the Fort Clinton West MRS to assess the hazards and baseline risks to human health or the environment from MEC and MC. The overall RI approach included the following:

- Developing DQOs and data needs through the Technical Project Planning (TPP) process.
- Performing mag and dig and digital geophysical mapping (DGM) surveys.
- Intrusively investigating the anomalies detected during the mag and dig and DGM surveys.
- Removing and disposing of the recovered MEC and material documented as safe (MDAS).
- Conducting MC sampling at the Fort Clinton West MRS based on the recovery of MEC and MD.
- Reporting results through the TPP process throughout the RI to gain stakeholder concurrence.
- Revising the CSM and reapplying the MRSPP based on the RI data collected.
- Submitting the RI Report.

The specific processes and procedures used to conduct the investigation are detailed in the *Final Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (Final RI Work Plan) (WESTON, 2011a). The characterization approach followed the methods presented and approved in the TPP 1 and TPP 2 meetings (see Section 2.2.2). These investigation methods are summarized in Sections 2.3 and 2.4, and the RI results are presented in Section 2.5.

2.2.1 Preliminary Conceptual Site Model

The CSM is used as a planning tool to integrate MRS information from a variety of sources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process of further data collection or action. The CSM development should be viewed as a process that reflects the progress of activities at an MRS from initial assessment through closeout. The CSM is divided into three primary components: potential sources, interactions, and receptors for MEC and/or MC, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. Each component is described below:

- Sources — Sources are those areas where MEC or MC has entered (or may enter) the physical system. An objective of the RI is to detect and delineate sources using geophysical surveys and intrusive investigations.

- Interactions — The hazard from MEC and the risk from MC are a result of direct human contact through an activity. Interactions describe ways that receptors come into contact with a MEC and/or MC source. For MC, interactions can include physical transport of the contaminant and transfer from one media to another through various processes so that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. For MEC, movement is not typically significant, and interaction will occur only at the source area, limited by access and activity. There can be movement of MEC through natural processes such as frost heave and soil erosion.

- Receptors — A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use because receptors are determined on that basis. Receptors include human receptors, such as West Point residents (adults and children), school children, contractor personnel, West Point installation personnel, recreational users, and site visitors, and ecological receptors.

The preliminary CSM for the Fort Clinton West MRS was based on the information collected during the SI (TLI, 2007). Based on the SI results, MEC exposure pathways are complete because MD was observed at the Fort Clinton West MRS. The primary exposure mechanism for human and ecological receptors to surface MEC is through handle/tread underfoot. In addition, a subsurface pathway may occur because biota may nest or burrow at the Fort Clinton West MRS (TLI, 2007). **Figure 2-5** depicts the MEC exposure pathways for the Fort Clinton West MRS based on the results of the SI.

Based on the results of SI soil sampling, no MC was identified above the EPA Region 9 PRGs (screening levels current at the time) at the Fort Clinton West MRS, except iron, which was observed at concentrations indicative of natural background levels. Therefore, the pathways of MC to all human and ecological receptors were considered incomplete (TLI, 2007). **Figure 2-6** depicts the SI exposure pathways for receptors to MC at the Fort Clinton West MRS.

The CSM is updated as new data and information become available. The data collected during the RI were used to revise the preliminary CSM developed following the SI, and the revised CSM is presented in Section 2.8.

2.2.2 Technical Project Planning

Prior to finalizing the project DQOs, representatives and stakeholders from the United States Army Corps of Engineers (USACE), West Point, EPA, New York State Department of

Environmental Conservation (NYSDEC), WESTON, and TLI participated in two TPP meetings. TPP 1 was conducted on July 29, 2010. At this meeting, the MRS summary and the RI approach, objectives, planning documentation and field investigation and reporting requirements were discussed.

TPP 2 was conducted on February 3, 2011. The project stakeholders reviewed the Draft Final RI Work Plan and identified and discussed project goals and DQOs. Details regarding the implementation of the MMRP RI were presented and discussed among the group. Based on the results of the second meeting, specific details of the investigation approach for the MRS, including coverage area, survey type (grid versus transect), and quantities, were determined. The results from the TPP 2 meeting were integrated into Fort Clinton West MRS DQOs and presented in the Final RI Work Plan (WESTON, 2011a).

2.2.3 Data Quality Objectives

The data needs and DQOs were determined at the planning stage and are discussed in more detail in the Final RI Work Plan (WESTON, 2011a). The data needs include characterization of the nature and extent of MEC and MC at the Fort Clinton West MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of the data generated for its intended use; and the ability to infer valid assessments from the data. The DQO process includes the following seven steps:

1. **State the problem:** Provide a concise description of the problem.
2. **Identify the decisions:** Develop decision statements to solve the problem.
3. **Identify inputs to the decision**: Identify information and measurements needed to make the decisions.
4. **Define study boundaries:** Identify conditions such as spatial and temporal boundaries.
5. **Develop a decision rule:** Qualify the decisions to understand data needs.
6. **Specify tolerable limits on decision errors:** Develop performance criteria.
7. **Optimize the design:** Design an effective data collection strategy based on the previous steps.

2.2.3.1 Fort Clinton West MRS Data Quality Objectives

The following DQOs were developed specifically for the Fort Clinton West MRS and were agreed upon by the stakeholders during the TPP sessions:

1. **State the problem:** This MRS is associated with former Fort Clinton and the former Artillery Range. The firing point for the range was located to the south and east of the MRS. The target area for this range was located north of West Point and not in this MRS. MD has been observed in the MRS; however, the approximate density of MEC, if present, has not been verified. MC also may be present if a MEC release is detected within the MRS.

2. **Identify the decisions:** The primary decisions for this MRS include:

   - Determine the approximate MEC density in the MRS based on UXO Estimator coverage requirements.
   - If a MEC release is observed in the MRS, characterize the nature and extent of MEC and evaluate MC.

3. **Identify inputs to the decision:** Several inputs will be acquired during the course of the RI to support the decision. UXO Estimator requires that 4.26 acres be investigated to determine at a 95% confidence level that less than 0.5 MEC/acre is present within the MRS. DGM and mag and dig surveys will be performed along transects and in grids to accomplish the UXO Estimator requirements. All anomalies will be investigated. Intrusive results for MEC, MD, and non-MD will be evaluated in the project Geographic Information System (GIS). If a MEC release is detected, discrete or incremental soil and sediment sampling will be performed to determine whether MC is present.

4. **Define study boundaries:** This MRS is a 14.4-acre area bounded to the north by the Siege Battery MRS and to the south by the Artillery Firing Range and Lusk Reservoir MRSs. The northernmost extent of the MRS intersects with the operational range area. The extent of potential MEC and MC observed during the RI will be delineated using DGM, mag and dig, discrete MC sampling, and incremental MC sampling; however, the operational range areas will not be accessed.

5. **Develop a decision rule:** The results of the RI at the Fort Clinton West MRS will be used to:

   - Assess, based on intrusive anomaly investigations, whether MEC density is less than 0.5 MEC/acre in the MRS.
   - Reassess the characterization approach if MEC density is found to be greater than 0.5 MEC/acre or if the CSM is not valid.

6. **Specify tolerable limits on decision error:** It is anticipated that a low density of MEC exists at this MRS because of its location near the firing points of the overall range fan complex. The characterization approach will confirm that less than 0.5 MEC/acre is present at the MRS. If there is less than 0.5 MEC/acre within the MRS, no additional MEC investigations will be required to validate MEC density. If MEC is identified during intrusive work within the MRS, additional sampling may be warranted to achieve the desired confidence level. Additional sampling will be performed only if the MRS is still assumed to have a low density of MEC. Additional coverage requirements will be determined by UXO Estimator.

7. **Optimize the design:** DGM surveys using a Geonics EM61-MK2 and mag and dig surveys using White's XLT all-metals detectors will be performed across the required 4.26 acres consistent with UXO Estimator assumptions. This includes ten 100-foot by 100-foot grids and approximately 1.6 miles of transects. Mag and dig surveys will be used in areas inaccessible to the DGM instrumentation. All anomalies will be investigated to determine the approximate MEC density.

2.3 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN

This section provides the comprehensive approach, methods, and operational procedures used for the MEC characterization performed at the Fort Clinton West MRS. The RI field activities were conducted between April 8 and August 10, 2011 (see **Table 2-1**).

Table 2-1 Fort Clinton West RI Field Activities

RI Field Activity	Dates
Location Surveying and Mapping	04/08/11 and 04/11/11
DGM Survey	04/18/11
Mag and Dig Survey	06/21/11 to 07/27/11
Anomaly Reacquisition and Intrusive Investigation	07/27/11
MC Sampling	08/09/11 to 08/10/11

2.3.1 Investigation Coverage Requirements

UXO Estimator (Version 2.2) is a software package developed by USACE to assist in designing field sampling plans to determine the MEC density for MRSs and to analyze field data after the data have been collected. UXO Estimator calculates the amount of acreage within an MRS that needs to be investigated to determine that a specific MEC density is present across the MRS to a preselected confidence level. The software inputs include the size of the MRS, the anticipated MEC density, and the confidence level to which the anticipated MEC density is to be tested.

A 0.5 MEC/acre density and a 95% statistical confidence at which to test the MEC density hypothesis were selected for the Fort Clinton West MRS. The 0.5 MEC/acre density was chosen by the project team during the project planning phase based on the historical use of the former Fort Clinton range fan, the recovery of MD within and surrounding the MRS, and the guidelines provided in the help menu of the UXO Estimator software. Based on these factors, at least

4.26 acres would require investigation to be 95% confident that there are less than 0.5 MEC/acre at the Fort Clinton West MRS.

UXO Estimator provides a quantitative assessment of the upper bound MEC density. In the case of the Fort Clinton West MRS, the upper bound density is 0.5 MEC/acre, which means that the MEC density can range from 0 MEC/acre to 0.5 MEC/acre if no MEC is recovered in the MRS. As part of the post-results analysis, qualitative assessments using information from the revised CSM should be conducted to determine the actual MEC density within this range.

2.3.1.1 Data Collection and Site Coverage

To achieve the investigation coverage calculated by UXO Estimator, geophysical surveys were performed at pre-planned transect and grid locations, depicted on **Figure 2-7**, across the Fort Clinton West MRS based on the Final RI Work Plan (WESTON, 2011a). Both DGM and mag and dig surveys were performed to locate surface and subsurface anomalies for further investigation along the transects and grids within the MRS. Both methods of anomaly detection were employed to maximize the coverage based on MRS accessibility and terrain. A total coverage of 4.05 acres was performed at the Fort Clinton West MRS, which is slightly less than the amount of coverage required based on the initial UXO Estimator calculation. However, based on the MEC findings and the identified impact area, the project team determined that additional characterization was not warranted. The following sections detail the geophysical investigations performed as part of the RI.

2.3.1.1.1 Location Surveys and Mapping

Location surveys and mapping activities were conducted within the Fort Clinton West MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Surveying was performed by Beatty & Watson, a New York-licensed surveyor. The location surveys and the mapping task included the following:

- Establish site control relative to North American Datum 1983 (NAD 83), Universal Transverse Mercator (UTM) coordinate system, in units of U.S. Survey Feet.
- Install DGM survey control and mark out with survey nails.

The survey control points established for the DGM activities are documented in **Appendix 2-A**.

2.3.1.1.2 Mag and Dig Surveys

UXO Technicians traversed 1.3 miles of pre-planned transects using GPS as a navigational aid. Each transect was 10 feet wide, equating to a total of 1.6 acres. UXO Technicians used analog instrumentation (White's XLT all-metals detectors) to detect anomalies. Full coverage mag and dig surveys were also completed at seven 100-foot by 100-foot grids and one grid (FCW-10), which was 100 foot by 150 foot, for a total of 1.99 acres. A mag and dig investigation method was selected because the terrain and vegetation would have limited the ability to perform DGM surveys. **Figure 2-7** and **Appendix 2-B** present the survey locations within the MRS.

2.3.1.1.3 Digital Geophysical Mapping Surveys

Two DGM grids, each measuring 100 feet by 100 feet, were placed in accessible locations of the MRS. Grid locations were adjusted in the field to avoid obstructions that might affect data quality or coverage. Once the general locations of the DGM grids were established, the surveyor set survey control at regular intervals to be used for digital data positioning. DGM surveys were then performed using a Geonics EM61-MK2 with line and fiducial navigation and positioning. DGM surveys were conducted within the Fort Clinton West MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Any obstructions, such as trees or large boulders, were documented in field notes.

Approximately 0.46 acre of DGM surveys was completed at the Fort Clinton West MRS. **Appendix 2-B** presents the survey locations within the MRS. Tests for instrumentation detection capabilities and functionality were conducted for the Fort Clinton West MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a).

Geophysical System Verification

The Geophysical System Verification (GSV) approach was used to monitor and verify the geophysical equipment functionality during the DGM surveys. The GSV approach includes an Instrument Verification Strip (IVS) and a blind seeding program to monitor the sensor detection performance throughout the duration of the DGM survey effort. IVS specific data and results are provided in **Appendix 2-C**.

Instrument Verification Strip

The IVS was installed near current H-Block Field and linearly seeded with five items, including one small industry standard object (ISO), two medium ISOs, one inert 37mm projectile, and one inert 75mm projectile. Item types were confirmed with the USACE QA Geophysicist prior to construction. **Table 2-2** lists the IVS seed items and descriptions.

Table 2-2 Instrument Verification Strip Seed Items and Descriptions

IVS Seed Item Type	Northing	Easting	Orientation	Depth	Description
Small ISO[a] (1 inch by 4 inches)	15033479.01	1921684.05	Horizontal	4.2 inches	Part Number[b]: 44615K466 ASTM Specification: A53/A773.
Medium ISO[a] (2 inches by 8 inches)	15033473.57	1921675.82	Horizontal	7.7 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.
37mm projectile	15033467.92	1921667.50	Horizontal	4.3 inches	Inert projectile.
75mm projectile	15033462.55	1921659.03	Horizontal	10.7 inches	Inert shrapnel projectile.
Medium ISO[a] (2 inches by 8 inches)	15033457.11	1921650.70	Horizontal	6.8 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.

Notes:
[a] ISOs are schedule 40 pipe nipples, threaded on both ends, made from black welded steel and manufactured to an American Society for Testing and Materials (ASTM) specification.
[b] Part number from the McMaster-Carr catalog.

The items were seeded linearly over 70 feet and were spaced 10 feet apart horizontally (least favorable orientation) with the long axis aligned parallel to the ground surface. Item types were confirmed with the USACE QA Geophysicist prior to construction. After IVS construction, a DGM survey was performed to demonstrate the instrument functionality and to verify that the seed item responses were consistent with the instrument response curves calculated for the EM61-MK2. All responses matched the appropriate response curves based on the seed item type and depth. IVS-specific data and results are provided in **Appendix 2-C**.

The IVS and unseeded test strip were visited daily before and after the DGM surveys and intrusive investigations. Both the EM6-MK2 and White's XLT were tested at the IVS. The results were then compared to the seed item response baseline and sensor response curves to determine that the geophysical equipment was operating properly.

The pre- and post-survey IVS results for the days that DGM data were collected at the Fort Clinton West MRS are presented in **Table 2-3**. The results collected for each day of DGM at the IVS show agreement and repeatable results for the series of seeds. The seed items placed within the IVS were observed in the geophysical data with signals consistent with the sensor response curves developed for the EM61-MK2. All peak responses from the seed items were observed to be greater than the least favorable orientation response and to have consistent responses between the surveys. These results demonstrate that the digital geophysical equipment was functioning within a tolerable range to achieve detection performance metrics. Photographs of the equipment are provided in **Appendix 2-D**.

Table 2-3 Instrument Verification Strip Results

Item Description	Small ISO	Medium ISO	37mm Projectile	75mm Projectile	Medium ISO
Item Depth (inches)	4.2	7.7	4.3	10.7	6.8
Least favorable orientation response (millivolt [mV])	10.8	64.2	14.8	60.6	73.4
IVS Date	**Response (mV)**				
18 April 2011 Pre-Survey	26.66	109.54	45.6	83.68	86.27
18 April 2011 Post-Survey	25.77	109.81	45.52	84.62	82.86

Blind Seeding

A seeding program was instituted in the geophysical survey grids to provide ongoing monitoring of the geophysical instrumentation detection performance. Seeds were blind to the geophysical data collection teams. After the medium ISO seed items were initially placed within the DGM grids, the locations and depths of the items were surveyed. All blind seed items were observed in the geophysical data with a signal consistent with the sensor response curves developed for the EM61-MK2, and within the 3.25-feet offset metric established in the project-specific measurement quality objectives (MQOs).

The seeds were recovered by the UXO teams during intrusive investigations. **Table 2-4** lists the depth, type, geophysical response, and offset of the seed items placed within the DGM grids. The location and depth of the seeds items were surveyed by Beatty & Watson.

Table 2-4 Blind Seeding Results

Grid	Item	Depth (inches)	Orientation	Target ID	Status	Peak Response (mV)	Offset (inches)
FCW-01	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	FCW-01-118	Recovered	47.50	2
FCW-02	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	FCW-02-55	Recovered	75.76	3

2.3.2 Data Processing and Quality Control

The EM61-MK2 data were imported into the Geonics® DAT61MK2 software for pre-processing. DAT61MK2 is used to convert the raw binary sensor data into a Geosoft®-compatible XYZ data file. Each XYZ file contains data for each of the four time gates recorded, the position, and the time stamp associated with each reading. Digital data were processed by the Site Geophysicist using Geosoft's Oasis montaj software. The IVS and quality parameters that were monitored and assessed daily during data processing included:

- Coverage.
- Velocity.
- Sample separation.
- Noise.
- Function tests: static, static response, and cable connection tests.

Instrument functionality tests were conducted before and after DGM surveying adjacent to the IVS located at H-Block Field. The Static Test and Static Response Test involved collecting non-dynamic data for a period of 1 minute without and with a small ISO item, respectively. Tests for the EM61-MK2 show background noise levels ranging from 0.5 to 2.2 standard deviations, with minimum and maximum readings between -6 millivolt (mV) and 2 mV. The Static Spike Test measurements range from a minimum value of 38 mV to a maximum value of 46 mV with a standard deviation between 0.66 and 1.86. Static Response Test data for the EM61-MK2 show consistent response values within the ±20% metric over the test object in pre- and post-survey tests. The project metric for test data was established at a standard deviation of less than 2.5. No anomalous data spikes or outside interference was observed during the static instrument tests.

Background noise was evaluated for each dataset by windowing a section of the data and generating statistics using the UX-Process QC module. Statistics calculated for Fort Clinton

West DGM data are presented in **Table 2-5**. Channel 2 was then gridded using a grid cell size of 0.25 feet with a search radius of 2 feet and a blanking distance of 2.25 feet.

Table 2-5 DGM Data Parameters

Data Metric		Mean Sample Separation (ft)	Mean Velocity (mph)	Background Noise (mean)	Background Noise (standard deviation)
	DQO	**< 0.5 ft**	**< 3 mph**	**MRS Specific**	**< 2.5**
Grid ID	FCW-01	0.22	1.37	0.33	0.63
	FCW-02	0.23	1.57	0.29	1.32
	FCW-01	0.22	1.37	0.33	0.63
	FCW-02	0.23	1.57	0.29	1.32

Anomalies were selected from the Channel 2 gridded data using the Blakely Test target selection algorithm. A target threshold value of 7.2 mV on Channel 2, as approved by the USACE QA Geophysicist, was used to select the initial target list. This threshold was based on the sensor response curve for a 75mm projectile at a depth of 3 feet in the least favorable (horizontal) orientation. Target review consisted of manually evaluating all selected targets and removing or merging multiple targets associated with large anomalies. Processing parameters are listed in **Table 2-6**.

Table 2-6 EM61-MK2 Data Processing Parameters

Process	Parameter
Drift – Non-Linear Drift Correction Filter (UCEDRIFT.GX)	Window Length: 100 % lowest values ignored: 10% % highest values ignored: 70% All data channels were processed using the same parameters.
Statistical Evaluation of Background Noise	Windowed section of background/using UX-Process QA/QC module to evaluate standard deviation and mean noise values.
Grid	Cell Size: 0.25 ft Blanking Distance: 2.25 ft Search Radius: 2 ft
Blakely Peak Picking Algorithm	Smooth Filter: 3 Normal Peak Detection Grid Value Threshold: EM 7.2 mV
Target Decay Analysis	Performed based on each data channel.
Target Review	Performed.

A target decay analysis was run to remove targets that had an atypical decay between the four time gate channels. An atypical decay is observed when an anomaly signal does not decrease through time, but instead shows an increase in any of the subsequent time gate channels. The most common causes of atypical decay are due to external radio frequency interferences or rough terrain encountered during data collection. **Appendix 2-B** presents the DGM data results with target locations.

All data related to DGM surveys were managed using Geosoft® Oasis montaj software. All spatial data were managed using a GIS and stored in Environmental Systems Research Institute® (ESRI)-compatible GIS formats, primarily ArcInfo coverage and ArcView shape files. All DGM data were provided electronically to the USACE QA Geophysicist for QA.

2.3.2.1 Anomaly Investigation Activities

A total of 189 anomalies were selected as part of the DGM data analysis. The anomalies were compiled into a dig list. The dig list data were logged into a hand-held computer and managed using WESTON's RespondFast® UXO Investigation software. Each of the anomalies was reacquired and intrusively investigated. Anomaly reacquisition was performed using a Trimble S8® Robotic Total Station (RTS) for navigation to the precise location of each target. A reacquisition team navigated to the location and marked it with a non-metallic pin flag designated by the unique anomaly ID. Twenty-three anomalies were detected during the mag and dig surveys. Dig lists developed following digital data analysis are presented in **Appendix 2-E**.

2.3.2.2 Anomaly Investigation Procedures

Intrusive investigations were conducted at the locations of the 212 anomalies detected as part of the geophysical surveys in accordance with the Final RI Work Plan (WESTON, 2011a), including the approved Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) and the Explosives Site Plan (ESP). Intrusive investigations at selected anomaly locations were performed to positively identify and recover MEC, material potentially presenting an explosive hazard (MPPEH), and MD. All recovered items were treated as MPPEH and were subject to field inspection to determine the nature of recovered anomalies. All items were verified free of explosives hazards prior to being relocated for future disposal.

The Senior UXO Supervisor (SUXOS) conducted oversight of all intrusive investigations, and the UXO Quality Control Specialist (UXOQCS) conducted daily QC following target reacquisition and intrusive investigation as documented in the Daily Reports for the RI (see **Appendix 2-F)**.

UXO Technicians began the anomaly investigations by sweeping a 3-foot radius around the pin flag with a White's XLT all-metals detector to focus the excavation at the peak response. The offset and northing and easting position of the peak response were recorded for each anomaly. Intrusive operations at each anomaly location were performed using hand tools. The UXO Technicians excavated at the location of the highest detector response until the source of the anomaly was found. The target location was considered clear when a signal source was no longer detected after the removal of the conductive item, or the source of the signal was identified to be associated with a cultural feature such as a fence or building.

Exclusion zones during intrusive operations were based on the project munition with the greatest fragmentation distance, which is a 75mm HE projectile. The minimum separation distance for nonessential personnel was 238 feet.

Dig teams used the personal handheld computers with RespondFast - UXO Investigation software to electronically log the target characteristics real time in the field. Characteristics logged in RespondFast include item category, item type, depth, dig data, and final disposition.

The results of the intrusive investigation are provided in the expanded dig lists in **Appendix 2-E.** Photographs of the anomaly reacquisition process are provided in **Appendix 2-D.**

2.3.2.3 Munitions and Explosives of Concern Management

2.3.2.3.1 Identification and Removal

Intrusive investigation activities were conducted by a three-man team consisting of one UXO Technician III (Team Leader), one UXO Technician II, and one UXO Technician I. Three UXO items were recovered during the RI from the Fort Clinton West MRS. Two MKII hand grenades (unfuzed) were recovered from DGM grid FCW-02, and one 8-inch Butler projectile was recovered from mag and dig grid FCW-05. The three UXO items were blown in place.

2.3.2.3.2 Inspection of Munitions-Related Items

Munitions-related items underwent a three-step inspection process during the intrusive investigations. Munitions-related items were inspected in the grid by a UXO Technician II and then a Technician III and were classified as MPPEH or MD. After the Technician III inspected the item, the item underwent a third inspection by the SUXOS, with verification by the UXOQCS, to determine the final disposition. The item was then determined to be MDAS or material documented as an explosive hazard (MDEH). The items classified as MDEH were then disposed of by detonation.

MD was recovered from the grids, certified and verified as free from explosives, and stored in a locked container as MDAS. The items classified as MDAS pose no explosive hazard and were transported to a collection point for final disposal. A final inspection was conducted immediately prior to the transfer of MDAS to the West Point Recycle Center. Certified MDAS was transferred to the West Point Recycle Center with the completed DoD Form 1348-1A, signed by the SUXOS to certify that the material listed had been thoroughly inspected and, to the best of the SUXOS's knowledge and belief, was inert and/or free of explosives or related materials.

After the DoD Form 1348-1A was verified and signed by the UXOQCS, a copy was maintained and the original accompanied the MDAS to its final disposition at the West Point Recycle Center. Copies of the forms are provided in **Appendix 2-G**.

2.3.2.3.3 Intrusive Investigation Quality Control

In accordance with the Final RI Work Plan, the UXOQCS inspected at least 10% of the dig locations using a White's XLT all-metals detector to determine whether the removal was effective. The UXOQCS joined the intrusive team and inspected all digs made during one day. The results of the QC inspections for the intrusive investigation are provided in the UXOQCS reports (**Appendix 2-F**).

2.4 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS CONSTITUENTS

2.4.1 Purpose of Munitions Constituent Sampling

Characterization activities for MC were conducted in accordance with the Final RI Work Plan, specifically the UFP-QAPP and the MC Sampling Methodology Memorandum. Based on the MC Sampling Methodology Memorandum, sampling activities would be performed at locations based on information obtained during the MEC investigation activities. MC investigations would be initiated in the following instances:

- Further investigation of MC at currently unknown but potential MEC releases (i.e., concentrated munitions use areas) identified during the geophysical surveys conducted as part of the West Point RI.
- MC sampling at individual MEC item locations where soil staining or visible evidence of a potential MC release is observed.

Based on the presence of MEC and MD identified during the RI, incremental sampling for MC in surface soil was performed at the Fort Clinton West MRS in the northwestern portion of the MRS observed to be impacted. The results of the MC characterization are reported in Section 2.5.2.

2.4.2 Remedial Investigation Munitions Constituent Sampling

An RI MC sampling scheme based on historical data was developed prior to field work, and was presented in the Final RI Work Plan. However, following the intrusive investigation at the Fort Clinton West MRS, the MRS-specific sampling scheme was revised to account for the results of the investigation and to ensure that the MC sampling was conducted in the most appropriate locations of the MRS. On 8 August 2011, representatives from U.S. Army Corps of Engineers, Baltimore District (CENAB), West Point, NYSDEC, WESTON, and TLI participated in an MC Sampling Methodology Memorandum teleconference meeting. The purpose of this meeting was to bring all of the stakeholders together to discuss the proposed revisions to the MMRP RI MC sampling approach outlined in the MC Sampling Methodology Memorandum (**Appendix 2-H**), which specifically addresses the Fort Clinton West MRS, and to gain approval from the group to implement sampling.

The locations of the sampling units within the MRS, as presented in the MC Sampling Methodology Memorandum, were established based on the locations of the MEC and MD identified within the Fort Clinton West MRS and the adjacent Siege Battery MRS during the SI and RI. The acreage associated with each sampling unit was determined based on the density and distribution of MEC and MD identified. The number of increments collected from within each sampling unit was based on the USACE Interim Guidance Document 09-02, *Implementation of Incremental Sampling of Soil for Military Munitions Response Program* (USACE, 2009). Therefore, the following sampling was proposed in the MC Sampling Methodology Memorandum:

- Two 0.8-acre sampling units (plus one field duplicate and a duplicate/triplicate) would sufficiently cover the areas where MEC and MD were identified, with one of the sampling units placed strategically along the border shared with the Siege Battery MRS. The 0.8-acre sampling unit size was based on the average size of a residential lot, but enlarged slightly to encompass the distribution of MEC and MD within the impact area. Fifty increments were proposed for collection within each of the sampling units established in the MRS.

At the conclusion of the meeting, representatives from CENAB, West Point, NYSDEC, WESTON, and TLI agreed upon the proposed sampling scheme.

Once the locations of the sampling units had been identified, as depicted on **Figure 2-7**, the increment locations were selected using a random number generator. The increment coordinates for each incremental sample were loaded into GPS units as waypoints for the field team and were also printed on the aerial maps that were used in the field. The field maps showing the locations of the proposed incremental samples within the sampling units are included in **Appendix 2-I**.

One field team consisting of two environmental scientists and one UXO Technician II performed incremental sampling at the Fort Clinton West MRS. The field team located each increment in accordance with the waypoint data that was loaded into the GPS unit prior to field activity. The sample team used a hand-held GPS unit to navigate to each increment location, or used a measuring tape to locate a specific offset, and placed numbered pin flags at each increment location. Sample increments were then collected by field personnel travelling a meandering path. Field personnel confirmed the collection of each increment in the field logbook according to the numbered flags in the sampling unit. The sample team did not record the specific path travelled to collect increments.

Once a surface soil increment area was located, the UXO Technician II performed anomaly avoidance using a metal detector. After the area was deemed safe, the environmental scientists collected a soil sample using a Multi-Incremental Sampling Tool (MIST) and placed the sample in a plastic resealable bag. If an area could not be cleared by the UXO Technician II, or if rocks or other debris were in the way, the field team sampled an area 1 meter away. There were no cases in which the location had to be eliminated because of explosive safety issues.

For some locations, surface features, such as tree roots, rocky areas, standing water, or steep drop-offs, were found at an increment location that was selected by the random number generator prior to mobilization. In these cases, the incremental sample was collected as close as possible to the original location. The direction and distance the incremental sample was moved were noted in the field logbooks included in **Appendix 2-I**. All incremental samples were surface samples and were collected from a depth of 0 to 3 inches. Sufficient sample mass, approximately 1 kilogram, was obtained for each sampling unit. Once all the increments were placed in the plastic resealable bag, the soil contents were labeled, homogenized, sealed, placed on ice, and shipped to the laboratory for analysis. Each incremental sample was collected using new, clean, dedicated, and disposable equipment; therefore, no investigation-derived waste (IDW) (solid or liquid) was generated.

All increments were collected from surface soil. There was no subsurface soil sampling at the Fort Clinton West MRS. The incremental samples, the field duplicate, and the duplicate/triplicate samples were analyzed for explosives and metals (see **Table 2-7)**.

Table 2-7 Incremental Sample Summary at the Fort Clinton West MRS

MRS	No. of Incremental Samples (Sample Numbers)	Size of Incremental Sampling Unit (acres)	No. of Increments	Analysis
Fort Clinton West	1 sample (plus 1 duplicate/triplicate pair): WPR03-SS28, WPR03-SS29 (duplicate) and WPR03-SS30 (triplicate)	0.8	50	Explosives and Metals
Fort Clinton West/Siege Battery	1 sample (plus 1 field duplicate): WPR03-SS26 and WPR03-SS27 (field duplicate)	0.8	50	Explosives and Metals

*Samples WPR03-SS26 and WPR03-SS27 (field duplicate) are discussed in both Section 2 and Section 3 related to characterization of the Fort Clinton West MRS and the Siege Battery MRS because the sampling unit was located within both MRSs.

2.4.3 Analytical Laboratory and Analyses

Explosives and metals were analyzed in surface soil for the Fort Clinton West MRS. Compounds potentially associated with each MRS were evaluated for MC sampling. Because of the time period during which munitions were used at the Fort Clinton West MRS, specific nomenclature for the munitions was not available in the historical records; therefore, generic MC information was compiled. The explosives used in the greatest quantity at the MRS were trinitrotoluene (TNT) and nitroglycerin. These explosives are insoluble in water and do not hydrolyze, volatilize, or bioconcentrate under normal environmental conditions. They also have average adsorption coefficients, suggesting that they will reasonably adsorb to soil and sediments and maintain low soil mobility. In addition, the volatilization rate from soil is extremely low. Therefore, TNT, its breakdown products, and nitroglycerin are anticipated to remain in the environment and are good indicators for explosives at the Fort Clinton West MRS. **Table 2-8** lists the explosive compounds and metals analyzed in the surface soil samples.

Table 2-8 Explosives and Metals Analyzed in Surface Soil Samples from Fort Clinton West MRS

Analyte*	Notes
Explosives	
Nitroglycerin	Known MC associated with munitions
2,4,6-Trinitrotoluene (TNT)	Known MC associated with munitions
2,4-Dinitrotoluene (2,4-DNT)	Breakdown product of TNT
2,6-Dintrotoluene (2,6-DNT)	Breakdown product of TNT
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	Breakdown product of TNT
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	Breakdown product of TNT
Pentaerythritol tetranitrate (PETN)	Not associated with munitions used at the Fort Clinton West MRS; however, trace amounts of PETN were detected in soil samples collected from the Siege Battery MRS during the SI. Therefore, because of the proximity of the Siege Battery and Fort Clinton West MRSs, analysis for PETN was included in the RI.
Metals	
Lead	Known MC associated with munitions
Mercury	Known MC associated with munitions

*Explosives were analyzed using EPA Method SW-846 535A/8330B; lead was analyzed using EPA Method SW-846 3010A/3050B/6010B; and mercury was analyzed using EPA Method SW-846 3050B/7471B.

Soil samples were submitted for analysis to a DoD Environmental Laboratory Accreditation Program (ELAP)-certified and National Environmental Laboratory Accreditation Conference (NELAC)-accredited laboratory, TestAmerica, Inc., located in South Burlington, VT. The laboratory provided a Level IV data package for validation that met the reporting requirements of *DoD Quality System Manual for Environmental Laboratories Version 4.2* (QSM 4.2) (DoD, 2010). The Level IV data package included all elements required to perform a full data validation, such as sample and QC data, chromatograms, raw data, instrument printouts, chain of custody records, log pages, and instrument calibration data. Samples were analyzed in accordance with the requirements of the analytical method, method-specific requirements of DoD QSM 4.2, and the project's Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) to ensure that sample results met project requirements for quality and technical competency. The analytical laboratory results are provided in **Appendix 2-J**.

Data validation was manually performed by an independent third party, MEC^x, LP for 100% of the sample results.

Explosives data were validated in accordance with the requirements of the following:

- Method 8330B, Nitroaromatics, Nitroamines, and Nitrate Esters by High Performance Liquid Chromatography (HPLC) (EPA, 2006a).
- Validation of Data, Nitroaromatics and Nitroamines by HPLC, SW-846 Method 8330A (SOP HW-16, Rev. 2) (EPA Region 2, 2006).
- Data Validation Procedure for Explosives, Nitroaromatics, and Nitroamines (DVP-16, Rev. 0) (MEC^x, LP, 2009).
- Standard Operating Procedure for Routine Validation of High Explosive (HE) Analytical Data (SOP-5164, Rev. 0) (Los Alamos National Laboratory [LANL], 2008).
- *Final Uniform Federal Policy Quality Assurance Project Plan, Remedial Investigation for Military Munitions Response Program Sites, U.S. Army Garrison West Point, West Point, NY (UFP-QAPP)* (WESTON, 2011b), as presented in Appendix J of the *Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (WESTON, 2011a).
- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

Metals data were validated in accordance with the requirements of the following:

- Method 6010B, Inductively Coupled Plasma-Atomic Emission Spectrometry (EPA, 1996).
- Validation of Metals for the Contract Laboratory Program (CLP) based on SOW ILMO5.3 (SOP Revision 13) (EPA, 2006b).
- Data Validation Procedure for Metals (DVP-5, Rev. 0 and DPV-21, Rev. 0) (MEC^x, LP, 2009).
- *Final Uniform Federal Policy Quality Assurance Project Plan, Remedial Investigation for Military Munitions Response Program Sites, U.S. Army Garrison West Point, West Point, NY (UFP-QAPP)* (WESTON, 2011b), as presented in Appendix J of the *Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (WESTON, 2011a).
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004).

2.4.4 Screening Levels

The MC sample analysis results were compared against two sets of screening levels, human health soil screening values and soil ecological screening values (ESVs), which were defined in the Final RI Work Plan prior to the RI field work for the Fort Clinton West MRS. To facilitate RI data evaluation and comparisons, the Final RI Work Plan list of selected ESVs was expanded to include all potential ESVs available from various sources.

For human health soil screening values, Oak Ridge National Laboratory (ORNL) regional screening levels (RSLs) for residential soils and NYSDEC soil cleanup objectives (SCOs) for residential and unrestricted use were compared for each analyte. The ORNL RSLs, which are updated by ORNL (EPA, 2012) semi-annually, are now used by EPA as risk-based screening benchmarks (in place of the EPA Region 9 PRGs that were used in the SI).

For ESVs, NYSDEC, EPA ecological soil screening level (Eco-SSL), EPA Region 5 ecological screening level (ESL), ORNL Benchmark 1, and ORNL Benchmark 2 were compared for each analyte. For analytes for which there was no benchmark available (NBA) in the screening values listed in the Final RI Work Plan, additional research was conducted to identify ESVs. Publications, including U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) and scientific reports written by Efroymson et al. (1997a and 1997b) and Kuperman et al. (2006) were evaluated.

The screening values referenced in this section are deemed to-be-considered information (TBCs), except for NYSDEC SCOs, which are considered ARARs, as discussed in more detail in Section 2.6.3. **Table 2-9** lists the analytes and the lowest of the human health and ecological screening values used for sample comparison. MC sampling and analytical results are reported in Section 2.5.2.

Table 2-9 Screening Levels for Explosives and Metals

Analyte	Human Health Soil Screening Value	Human Health Soil Screening Value Method Used	Ecological Soil Screening Value	Ecological Soil Screening Value Method Used[4]
Explosives (µg/kg)				
Nitroglycerin	610	ORNL Residential RSL[1]	3,000	USACHPPM[5]
2,4,6-Trinitrotoluene (TNT)	3,600	ORNL Residential RSL	70	USACHPPM[6]
2,4-Dinitrotoluene (2,4-DNT)	1,600	ORNL Residential RSL	1,280	EPA Region 5 ESL[3]
2,6-Dintrotoluene (2,6-DNT)	1,030	NYSDEC Unrestricted Use SCO[2]	32.8	EPA Region 5 ESL
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[7]
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[7]
Pentaerythritol tetranitrate (PETN)	NBA	NBA	170,000	USACHPPM[8]
Metals (mg/kg)				
Lead	63	NYSDEC Unrestricted Use SCO	63	NYSDEC
Mercury	0.18	NYSDEC Unrestricted Use SCO	0.18	NYSDEC

Notes:
[1] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (April 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.
[2] NYSDEC, 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html.
[3] EPA, 2003. Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels - http://www.epa.gov/reg5rcra/ca/ESL.pdf.
[4] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the following hierarchy was used to select the screening value: EPA EcoSSL, EPA Region 5 ESL, ORNL Benchmark 1, ORNL Benchmark 2.
[5] USACHPPM, 2000.
[6] USACHPPM, 2001b.
[7] USACHPPM, 2005.
[8] USACHPPM, 2001a.
NBA=no benchmark available
mg/kg=milligram/kilogram
µg/kg =microgram/kilogram

2.5 REMEDIAL INVESTIGATION RESULTS

This section presents the results of the RI MEC characterization (Section 2.5.1) and of the MC characterization (Section 2.5.2).

2.5.1 Results for Munitions and Explosives of Concern Characterization

As described in Section 2.3, the characterization performed at the Fort Clinton West MRS during the RI involved the following tasks:

- Mag and dig and DGM surveys.
- Digital data processing, analysis, and anomaly selection.
- Anomaly reacquisition.
- Intrusive investigation of detected anomalies.

The following paragraphs detail the results of these activities.

2.5.1.1 Geophysical Survey Results

A total of 4.05 acres within the Fort Clinton West MRS were investigated using DGM and mag and dig surveys. The mag and dig surveys were conducted over 3.59 acres using a White's XLT all-metals detector. All anomalies (a total of 23) detected were investigated by UXO Technicians to determine the anomaly source. A total of 0.46 acre of DGM surveys was performed using a man-portable EM61-MK2 sensor in cart mode. A total of 189 anomalies were selected from the DGM data for intrusive investigation. The intrusive investigation results of the 212 anomalies are discussed in the following subsection.

2.5.1.2 Intrusive Investigation Results

Three UXO items were recovered from the Fort Clinton West MRS—two hand grenades, MKII unfuzed, and one 8-inch Butler projectile. Both hand grenades were recovered at 3 inches below ground surface (bgs), and the 8-inch Butler projectile was recovered at 8 inches bgs.

In addition, 32 MD items were recovered during the RI. The MD includes two hand grenades (MKII), one 8-inch Butler projectile, and 29 fragments from unknown munitions. All MD was found between ground surface and 12 inches bgs (see **Figure 2-8**).

The remaining 177 anomalies included 175 non-MD-related material classified as cultural debris and 2 seed items. All cultural debris was recovered between the ground surface and 6 inches bgs. Non-munitions-related materials recovered during the RI and transferred to the West Point Recycling Center as cultural debris included scrap metal, wire, horse shoes, metal piping, barbed wire, aluminum scrap, a segment of chain, nails, spikes, rebar, and bolts. **Figure 2-8** and **Appendix 2-B** show the locations of the items recovered from the MRS. **Table 2-10** summarizes the MEC and MD recovered during the RI. The complete dig lists are provided in **Appendix 2-E**.

Table 2-10 MEC and MD Summary at the Fort Clinton West MRS

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (lb)	Quantity
FCW-02-133	UXO	MKII hand grenade (unfuzed)	07/27/2011	3.0	2.0	1
FCW-02-139	UXO	MKII hand grenade (unfuzed)	07/27/2011	3.0	1.5	1
FCW-05	UXO	8-inch Butler projectile	06/23/2011	8.0	187	1
FCW-02-41	MD	MKII hand grenade (empty)	07/27/2011	6.0	2.0	1
FCW-02-128	MD	MKII hand grenade (empty)	07/27/2011	3.0	2.0	1
FCW-02-05	MD	Fragment	07/27/2011	3.0	6.0	1
FCW-02-49	MD	Fragment	07/27/2011	6.0	3.0	1
FCW-02-65	MD	Fragment	07/27/2011	3.0	2.0	1
FCW-02-73	MD	Fragment	07/27/2011	15	15	1
FCW-02-96	MD	Fragment	07/27/2011	3.0	0.5	1
FCW-02-108	MD	Fragment	07/27/2011	3.0	2.0	1
FCW-02-132	MD	Fragment	07/27/2011	3.0	0.5	1
FCW-02-142	MD	Fragment	07/27/2011	3.0	10	1
FCW-08	MD	Fragment	06/21/2011	0-12	100	26
FCW-09	MD	Fragment	06/21/2011	0-12	48	13
FCW-05	MD	Fragment	06/23/2011	0-12	100	22
FCW-07	MD	Fragment	06/23/2011	0-12	124	34
FCW-T01	MD	Fragment	07/12/2011	6	2.0	1
FCW-T01	MD	Fragment	07/12/2011	3	4.0	1
FCW-T02	MD	Fragment	07/12/2011	1	4.0	1
FCW-T02	MD	Fragment	07/12/2011	2	5.0	1
FCW-T02	MD	Fragment	07/12/2011	3	2.0	1
FCW-T02	MD	Fragment	07/12/2011	2	3.0	1
FCW-T02	MD	Fragment	07/12/2011	6	2.0	1
FCW-T02	MD	Fragment	07/12/2011	4	2.0	1
FCW-T06	MD	Fragment	07/12/2011	2	3.0	1

Table 2-10 MEC and MD Summary at the Fort Clinton West MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (lb)	Quantity
FCW-T06	MD	Fragment	07/12/2011	4	4.0	1
FCW-03	MD	Fragment	07/25/2011	0-12	12	14
FCW-04	MD	Fragment	07/25/2011	0-12	5.0	7
FCW-T05	MD	Fragment	07/25/2011	2	1.0	1
FCW-T06	MD	Fragment	07/25/2011	4	2.0	1
FCW-T06	MD	Fragment	07/25/2011	7	3.0	1
FCW-10	MD	8-inch Butler Projectile (empty)	07/26/2011	7	180	1
FCW-10	MD	Fragment	07/26/2011	0-12	19	10
FCW-06	MD	Fragment	07/27/2011	0-12	14	33

2.5.1.3 Geophysical Survey and Intrusive Investigation Analysis

The Fort Clinton West MRS is part of a surface danger zone for a former range. Geophysical transect and grid surveys performed within the MRS were used to assess the nature and extent of MEC and MD. A majority of the MD recovered within the Fort Clinton West MRS are fragments from former munitions use. Several inert projectiles were also recovered in this MRS. The MEC and MD recovered during the RI field activities were concentrated in the northwestern portion of the MRS. The northwestern portion of the MRS is closer to the range impact area where MEC and MD are most likely to be encountered. No MEC or MD was observed in the southeastern portion of the MRS. The southeastern portion of the MRS is located closer to the range firing point where MEC and MD are less likely to be encountered.

The southeastern portion of the MRS has been developed with buildings, parking areas, and roadways more than the northwestern portion of the MRS. MEC and MD could have been covered or moved during construction activities. The nature and extent of MEC and MD observed and delineated at the Fort Clinton West MRS is consistent with the survey results in adjacent MRSs. An elevated MEC and MD density similar to that observed in the northwestern portion of the Fort Clinton West MRS was also observed in the adjacent Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. A reduced amount of MEC and MD was found in the portions of the Fort Clinton West MRS and of the adjacent MRSs closer to the range firing point.

Based on the observed density, distribution, and the type of MEC and MD, the source of these items is attributed to the historical firing at targets on Crows Nest mountain. The collective RI characterization strategy using geophysical transects and grids allowed the successful delineation of the southern boundary of the Crows Nest impact area.

In accordance with the DQOs, the RI field results were also evaluated using the UXO Estimator *Analyze Field Data Module*. The following inputs were assessed in UXO Estimator:

- **Total number of acres in MRS**: 14.4 acres
- **Number of acres investigated:** 4.05 acres
- **Number of MEC recovered in the investigated area:** 3 MEC were recovered.
- **Specify the MEC target density per acre (same value used to develop DQOs)**: 0.5 MEC/acre
- **Specify the desired upper confidence level (same value used to develop DQOs):** 95% confidence

The UXO Estimator calculations were initially designed to evaluate the entire 14.4-acre MRS. UXO Estimator calculated a statistical upper bound MEC density of 1.74 MEC/acre at a 95% confidence level based on the RI field results. The calculated average MEC density across the MRS based on the UXO Estimator results is 0.92 MEC/acre.

It is statistically possible that MEC may be present across the entire MRS. However, based on the results of the geophysical transect and grid characterization and because no MEC or MD was recovered in the southeastern 1.7-acre portion of the MRS, there are no MEC anticipated in this portion of the MRS. The southeastern portion of the MRS is closer to the range firing point where MEC and MD are less likely to be encountered. The MEC and MD recovered in the MRS were concentrated in the northwestern portion of the MRS where it is more likely additional MEC and MD are present because of the proximity to the range impact area. These results are consistent with the RI findings in adjacent MRSs. The CSM for the Fort Clinton West MRS is discussed further in Section 2.8.

2.5.2 Results for Munitions Constituents Characterization

Sampling was conducted at the Fort Clinton West MRS to further investigate MC based on the presence of MEC and MD that were identified during the geophysical investigations and that pose a potential source for MC. As depicted on **Figure 2-7**, two incremental samples (plus one field duplicate and one duplicate/triplicate pair) were collected from the impacted portion of the Fort Clinton West MRS (WPR03-SS26, WPR03-SS27 [field duplicate], WPR03-SS28, WPR03-SS29 [duplicate] and WPR03-SS30 [triplicate]). Each incremental sample, field duplicate, and duplicate/triplicate was comprised of 50 increments distributed over a 0.8-acre sampling unit area. The incremental samples were collected and analyzed to identify the presence of MC (if any) and to fully characterize the nature and extent of MC. The incremental samples were collected using new, clean, dedicated, and disposable equipment; therefore, no IDW (solid or liquid) was generated. Analytical results for the Fort Clinton West MRS are provided in **Table 2-11**.

Table 2-11 Analytical Results for Soil Sampling for MC

Sample ID:	**WPR03-SS26**		**WPR03-SS27**		**WPR03-SS28**		**WPR03-SS29**		**WPR03-SS30**	
Lab Sample ID:	**200-6475-1**		**200-6475-2**		**200-6491-3**		**200-6491-1**		**200-6491-2**	
Sample Type:	**Soil**		**Soil**		**Soil**		**Soil**		**Soil**	
Date Sampled:	**8/8/2011**		**8/8/2011**		**8/9/2011**		**8/9/2011**		**8/9/2011**	
MRS:	**Fort Clinton West/Siege Battery**		**Fort Clinton West/ Siege Battery**		**Fort Clinton West**		**Fort Clinton West**		**Fort Clinton West**	
Comments:			**Field Duplicate QC Sample of SS26**				**Duplicate QC Sample of SS28**		**Triplicate QC Sample of SS28**	
Explosives (µg/kg)	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.
2,4,6-Trinitrotoluene	14	U	14	U	14	U	14	U	14	U
4-Amino-2,6-dinitrotoluene	23	U	23	U	23	U	23	U	23	U
2-Amino-4,6-dinitrotoluene	23	U	23	U	23	U	60	U	23	U
2,6-Dinitrotoluene	14	U	14	U	95	UJ	63	U	96	UJ
2,4-Dinitrotoluene	28	U	28	U	28	U	28	U	28	U
PETN	1700	U	1700	U	1700	U	1700	U	1700	U
Nitroglycerin	1300	UJ	550	U	540	U	1600	UJ	550	U
Metals (mg/kg)										
Lead, Total	150	J	130		68	J	120	J	93	J
Mercury, Total	0.24	J	0.20	J	0.16	J	0.19	J	0.17	J

Notes:
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).
U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

2.5.2.1 Explosives

There were no reported detections of explosives for the samples collected from the MEC- and MD-impacted portions of the Fort Clinton West MRS. Analytical results for nitroglycerin and 2,6-DNT were reported with UJ qualifiers, which indicates that the analytes were not detected above the reported sample quantitation limits (SQLs). However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analytes in the sample. The analytical results for the remainder of the explosives included U qualifiers for each reported value, indicating that the explosive was analyzed for, but was not detected, above the reported SQL (**Table 2-11**). Data qualifiers are discussed in more detail in Section 2.5.2.3.2.

Section 2.6 presents the analytical results in comparison to the human health and ecological screening values (**Table 2-9**), used to establish baseline risks to potential human and ecological receptors from MC.

2.5.2.2 Metals

Lead and mercury were the only metals suspected to be MC associated with the recovered MEC and MD. Both analytes were positively detected by the laboratory in all samples (see **Table 2-11**):

- Lead ranged from 68 mg/kg to 150 mg/kg. All results, except one, were J qualified, indicating the result was an estimated quantity.
- Mercury ranged from 0.16 mg/kg to 0.24 mg/kg. All results were J qualified, indicating the results were an estimated quantities.

Data qualifiers are discussed in more detail in Section 2.5.2.3.2. Section 2.6 presents the analytical results in comparison to the human health and ecological screening values (**Table 2-9**), used to establish baseline risks to potential human and ecological receptors from MC.

2.5.2.3 MC Data Quality

An assessment of data quality for MC sampling was conducted in accordance with the Final RI Work Plan (WESTON, 2011a) and UFP-QAPP (WESTON, 2011b). Field QC samples were collected and analyzed to assess the quality of the data resulting from the field sampling program at a program-wide level for the MMRP RI at West Point. Additionally, as discussed in Section 2.4.3, 100% of the MC data results were validated by an independent third party, MEC^x, LP.

Field QC samples specified in the UFP-QAPP include rinsate, field blanks, field duplicates, and triplicates. Field duplicates, which consist of one soil sample split into two parts with each aliquot analyzed by the laboratory for the identical parameters, are collected to estimate sampling and laboratory analysis precision, including sample homogeneity. Precision is measured using routine and duplicate sampling results and is expressed as the relative percent difference (RPD). Calculation of the RPD is described in the UFP-QAPP.

The incremental duplicate/triplicate (also referred to as replicates) involves the collection of three individual samples from within the same sampling unit (routine sample, duplicate, and triplicate). Each sample of equal volume is comprised of the same number of unique increments. The collection of random increments from within the sampling unit is performed three separate times to create the routine, duplicate, and triplicate samples. The collection approach allows the comparison of relative standard deviation (RSD) between the three incremental sample results for the same sampling unit to evaluate whether the sampling procedure was accurate. The RPD can also be calculated for the incremental duplicate sample.

Matrix spike/matrix spike duplicate (MS/MSD) samples are the introduction of a known concentration of a compound into a sample to provide information about the effect of the sample matrix on the extraction and/or measurement methodology. MS/MSDs are reviewed as part of the data validation process and are discussed in the data validation narrative.

2.5.2.3.1 Field QC Samples and Sampling QC

Field QC samples were collected and assessed during the MMRP RI at West Point at a program-level based on the sample delivery groups submitted to the laboratory for analysis. Some MRSs had one or very few soil samples, and samples were batched together where possible. Field duplicates and incremental replicates (duplicate and triplicates) were collected at the Fort Clinton West MRS and represent field QC for other MRSs at West Point because of similarities in past munitions use, soil types, and land use. The unique increments collected for the incremental replicate samples were obtained by following the same path of travel that had been used to collect the primary sample.

High-quality MC data were collected at the Fort Clinton West MRS as evidenced by the following parameters employed to assess data usability:

- Precision is represented as the RPD between measurements of an analyte in duplicate samples, or as the RSD when the number of samples exceeds two. The RPD and RSD were evaluated as part of the data validation task during the RI. Sample WPR03-SS27 was collected as a field duplicate of sample WPR03-SS26, from the sampling unit along the border of the Fort Clinton West and Siege Battery MRSs. Sample WPR03-SS27 did not have reportable detects of explosive chemicals. Sample WPR03-SS26 had one explosive compound reported with an elevated SQL. Therefore, the RPDs were not calculated for explosives. Metals were detected in both samples. The lead RPD was within the UFP-QAPP control limit of ±20% for analytes with concentrations $\geq$ 5X the limit of quantitation. The mercury RPD was within the control limit of <50% specified in the UFP-QAPP. Overall precision was assessed by evaluating the RSD between the primary and replicate incremental samples, which accounts for both field and laboratory processing/analytical error. Incremental replicates for the MRS consisted of samples WPR03-SS28, WPR03-SS29, and WPR03-SS30. None of the samples had reportable detections of explosive chemicals; however, one compound with an elevated SQL was reported in the three samples. Therefore, RSDs were not calculated for explosives. Both lead and mercury were detected in the three samples, thus RSDs were calculated for the sampling unit. The RSD for lead between the three samples was 28%, and the RSD for mercury was 9%, both of which are within the 30% acceptance limit specified by USACE (USACE, 2009) for incremental sampling. The data do not indicate a concern about the sampling or laboratory precision. See **Appendix 2-J** for the data validation reports.

- Accuracy was ensured by selecting appropriate data collection instruments, having clearly delineated instructions for their correct use, and following the sampling plan discussed in Section 3.13 of the Final RI Work Plan (WESTON, 2011a), the MC Sampling Methodology Memorandum (**Appendix 2-H**), and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No deviations from the sampling plan were documented during the RI field activities **(Appendix 2-F)**. Additional information is presented in the data validation reports provided in **Appendix 2-J**. Rinsate and field blanks were not obtained during the soil investigation because of the use of new, clean, dedicated disposable equipment (i.e., scoops, aluminum pans, and sterile gloves).

- Data representativeness at the Fort Clinton West MRS was accomplished by implementing the approved sampling procedures discussed in Section 3.13 of the Final RI Work Plan, the MC Sampling Methodology Memorandum (**Appendix 2-H**), and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No significant deviations from the sampling procedures were documented during the RI field activities (**Appendix 2-F and Appendix 2-I**). Incremental sampling reduces data variability and increases sample representativeness. Increment placement within the sampling unit and collection along a random meandering path was inconsistent with the approach detailed in the Final RI Work Plan that stated, "Increments will be collected using a systematic random approach." However, the simple random approach for sampling unit design that was employed is an equivalent approach supported by industry and USACE guidance, and all increment locations were sampled. Therefore, the impact to data usability relative to representativeness is considered minimal.

- Completeness was achieved because the number of locations (**Figure 2-7**) sampled equaled the number of planned sample locations, as discussed in the MC Sampling Methodology Memorandum provided in **Appendix 2-H**.

- Comparability of data sets generated for the project was obtained through the implementation of, and adherence to, the standard sampling procedures discussed in Section 3.13 of the Final RI Work Plan, the MC Sampling Methodology Memorandum (**Appendix 2-H**), and the UFP-QAPP (Appendix J) of the Final RI Work Plan. A review of the field daily reports (**Appendix 2-F**) indicated no deviations from standard sample management procedures.

The high-quality data meet the data quality objectives of the RI established in the Final RI Work Plan and provided in Section 2.2.4 of the RI Report. These data are sufficient to support the risk assessment and the evaluation of alternatives.

2.5.2.3.2 Data Validation Results

The data validation guidelines are listed in Section 2.4.3. The data validation package for the Fort Clinton West MRS, including the validation report narratives for the MRS analytical results and a glossary of QA/QC terms and data qualifier codes, is provided in **Appendix 2-J**. The data validation guidelines ensure that all data meet uniform requirements for accuracy and determine the validity of the data. If the data quality parameters for the MRS-specific analyses did not meet the criteria of the EPA and DoD Quality Systems Manual (QSM) Version 4.2 or the laboratory standard operating procedure (SOP), a discussion of the implications regarding the guidelines was included in the data validation narrative.

No major issues were identified during data validation. The results for the incremental sample for the Fort Clinton West MRS included some nondetects with elevated SQLs. These values were qualified as UJ due to poor photodiode array spectral match, which is a method routinely used for further identification of any detection above the limit of quantitation. A validation note consisting of an "H8" code was added to the UJ qualifier verifying that the analyte was not confirmed on a second dissimilar column or that the diode array spectrums did not match library. These UJ values are considered estimated, but still usable data, which meet all remaining acceptance criteria. Some sample results were below the detection limit and had an elevated intercolumn RPD; as a result, they were qualified with a nondetect, U. Some data were qualified with a J because of detections reported between the detection limit and the SQL, or confirmed results with a relatively high intercolumn RPD. These J values are considered estimated values but are still usable data. Using J values for risk assessment is consistent with the allowable use of J qualified data as discussed in the *Guidance for Data Useability for Risk Assessment (Part A)* (EPA, 1992).

Overall, the data validation showed that the data received from the laboratory were valid. The preceding data usability assessment (see Section 2.5.2.3.1) determined the data are usable for assessing the environmental conditions related to MC. Sufficient usable data were available for the Fort Clinton West MRS to meet the objectives of the RI and to complete the risk assessment.

2.6 RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS

2.6.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was performed for the Fort Clinton West MRS. Based on the revised CSM in Section 2.8, the potential human receptors include West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

2.6.1.1 Data Evaluation

Sampling within the Fort Clinton West MRS consisted of one incremental sample (plus one field duplicate) collected at the border between the Siege Battery MRS and the Fort Clinton West MRS, and one incremental sample (plus one field duplicate and one duplicate/triplicate pair) collected within the boundary of the Fort Clinton West MRS, where UXO and/or significant concentrations of MD were identified. Each of the samples consisted of a 0.8-acre sampling unit from which 50 increments were collected and analyzed for explosives, lead, and mercury (see **Figure 2-7**). **Table 2-11** presents the validated analytical results for the Fort Clinton West MRS surface soil incremental samples. No explosives were detected above the SQLs. However, because elevated SQLs were reported for several explosive chemicals and positive detections of both lead and mercury were observed, a human health risk evaluation was initiated as a conservative measure.

A discussion of the results in relation to human health screening levels and rural background levels (for metals) is provided in the following subsections.

2.6.1.2 Selection of Chemicals of Potential Concern

Typically, soil chemicals of potential concern (COPCs) are identified by comparing the maximum detected concentration of each chemical with the recommended human health screening value. The analytical results for the surface soil incremental sample at the Fort Clinton West MRS showed all U and UJ values for explosives, indicating the analytes were not detected above their reported SQLs. The laboratory would have reported detects below the screening level, even if they were estimated values (J), and no detects were reported. Both mercury and lead were positively detected; however, all results except for one were flagged with a J, indicating that they were estimated.

To be conservative, a screening was performed to ensure the protectiveness of the SQLs. As presented in **Table 2-12**, the recommended human health screening value is the lowest human health NYSDEC value (NYSDEC, 2006). If a NYSDEC value was not available, the ORNL residential RSL (EPA, 2012) was used. For COPC screening purposes, noncarcinogenic RSLs were adjusted to correspond to a target hazard quotient (THQ) of 0.1 rather than 1. Thus, chemicals with additive effects were not prematurely eliminated during screening. If RSLs were available for carcinogenic and noncarcinogenic endpoints and both ingestion and inhalation exposure routes, the lower (i.e., more stringent) value was used for the screening comparison.

The results presented in **Table 2-12** indicate that no chemicals had SQLs above the recommended screening level used to assess baseline risk to human health. The nitroglycerin SQL exceeded its benchmark when using the risk-based screening level at a THQ of 0.1 (610 micrograms per kilogram [µg/kg]). However, no other chemicals were detected (i.e., no additive effects from multiple chemicals). Therefore, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg, which is above the nitroglycerin SQL of 1,600 µg/kg.

Table 2-12 Human Health Soil Screening for MC Fort Clinton West MRS, U.S. Army Garrison West Point, MMRP Remedial Investigation

Analyte	ORNL Residential RSL[a]		NYSDEC Residential SCO[b]	NYSDEC Unrestricted Use SCO[b]	Recommended Human Health Screening Value[c]		WPR03-SS26 200-6475-1 8/8/2011 Fort Clinton West/Siege Battery		WPR03-SS27 (Duplicate of SS26) 200-6475-2 8/8/2011 Fort Clinton West/Siege Battery		WPR03-SS28 200-6491-3 8/9/2011 Fort Clinton West		WPR03-SS29 (Duplicate of SS28) 200-6491-1 8/9/2011 Fort Clinton West		WPR03-SS30 (Triplicate of SS28) 200-6491-2 8/9/2011 Fort Clinton West		HH COPC?
Explosives (µg/kg)																	
2,4,6-Trinitrotoluene	3,600	n	NBA	NBA	3,600	n	14	U	14	U	14	U	14	U	14	U	No
4-Amino-2,6-Dinitrotoluene	15,000	n	NBA	NBA	15,000	n	23	U	23	U	23	U	23	U	23	U	No
2-Amino-4,6-Dinitrotoluene	15,000	n	NBA	NBA	15,000	n	23	U	23	U	23	U	60	U	23	U	No
2,6-Dinitrotoluene	6,100	n	NBA	1,030	1,030		14	U	14	U	95	UJ	63	U	96	UJ	No
2,4-Dinitrotoluene	1,600	c	NBA	NBA	1,600	c	28	U	28	U	28	U	28	U	28	U	No
PETN	12,000	n	NBA	NBA	12,000	n	1700	U	1700	U	1,700	U	1,700	U	1,700	U	No
Nitroglycerin	610	n	NBA	NBA	610	n	1300	UJ	550	U	540	U	1,600	UJ	550	U	No [d]
METALS (mg/kg)																	
Lead, Total	400		400	63.00	63		150 [f]	J	130 [f]		68 [e]	J	120 [f]	J	93 [e]	J	No
Mercury, Total	1.00	n	0.81	0.18	0.18		0.24 [e]	J	0.20 [e]	J	0.16	J	0.19 [e]	J	0.17	J	No

[a] Residential Screening Levels (RSLs) were obtained from the Oak Ridge National Laboratory (ORNL) Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (May 2012).
RSLs are shown as (c) = target risk (TR) of 1.0E-6 or, (n) = target hazard quotient (THQ) of 0.1.

[b] New York State Department of Environmental Conservation (NYSDEC). 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html

[c] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the ORNL Benchmark was used.

[d] When using the ORNL RSL values, noncarcinogens were reduced by an order of magnitude to yield a risk-based screening level with a THQ of 0.1 to address the additivity of noncancer effects when there is exposure to multiple chemicals. However, because no other chemicals were detected, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg.

[e] Exceeded recommended human health screening value but were within the rural background range of concentrations obtained from New York Department of Environmental Conservation. 2005. Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D. August 2005.

[f] The lead arithmetic mean for the Siege Battery and Fort Clinton West MRSs is 112 mg/kg, which is consistent with the rural maximum concentration of 112 mg/kg (NYSDEC, 2005).

µg/kg = micrograms per kilogram.
mg/kg = milligrams per kilogram.
NBA = No benchmark available.
ORNL = Oak Ridge National Laboratory
RSL = Regional screening level.
SCO = Soil cleanup objectives.

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).

U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis using photo diode array confirmed that the analyte was not present.

Highlighting indicates that the detected result is equal to or exceeds the Recommended Human Health Screening Value.

For metals detected at the Fort Clinton West MRS, lead was detected at concentrations greater than the recommended human health screening level (i.e., NYSDEC Unrestricted Use SCO, 63 mg/kg). However, as presented on **Table 2-12**, the values were less than the ORNL residential soil RSL and the NYSDEC residential SCO value of 400 mg/kg. The difference between the two NYSDEC values is that the Unrestricted Use screening is for the protection of public health and ecological resources due to the presence of contaminants in the soil. Therefore, the NYSDEC residential SCO value is appropriate to use as an alternative screening number for the human health risk evaluation and supports the future use of the MRS. Furthermore, the lead arithmetic mean (112 mg/kg) was consistent with the rural maximum concentration background level of 112 mg/kg reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey,* Appendix D, Table D1, August 2005 (NYSDEC, 2005).

Mercury was detected at concentrations greater than the recommended human health screening level (i.e., NYSDEC Unrestricted Use SCO, 0.18 mg/kg) in three out of five samples as presented in **Table 2-12**. However, the values were less than the maximum background level of 0.30 mg/kg established for soils by NYSDEC (NYSDEC, 2005). In addition, mercury concentrations were less than the ORNL residential soil RSL and the NYSDEC residential SCO value of 1.0 mg/kg and 0.81 mg/kg, respectively. Although lead and mercury were detected in samples collected in the Fort Clinton West MRS, the analytes were not detected at levels that would pose a potential risk to human health.

2.6.1.3 Human Health Risk Assessment Summary and Conclusions

Both UXO and MD were found in the Fort Clinton West MRS. The sample results for explosives were qualified as U or UJ, indicating the chemicals were not detected above their reported SQLs. Lead and mercury were detected in all samples collected from the Fort Clinton West MRS. Based on results of the HHRA, the surface soil incremental sample did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

2.6.2 Ecological Risk Assessment

A focused Screening Level Ecological Risk Assessment (SLERA) was completed to assess the potential adverse impacts on current and future ecological receptors exposed to MC in surface soil at the Fort Clinton West MRS. The assessment endpoint for the SLERA is the protection of local populations and communities of biota from exposure to chemicals of potential ecological concern (COPECs) in soil. The revised CSM for the Fort Clinton West MRS is presented in Section 2.8.

2.6.2.1 Ecological Screening Values

Average concentrations of chemicals detected in soil at the Fort Clinton West MRS (based on incremental sampling) were compared to conservative ESVs selected to assess baseline risks during the RI. All chemicals detected in soil at concentrations greater than the ESVs were considered to potentially adversely impact ecological receptors and were identified as COPECs. The ecological screening values are presented in **Table 2-9** and **Table 2-13**.

The ESVs used for comparison to chemicals detected in soil samples were obtained from the NYSDEC Remedial Program SCOs, EPA EcoSSLs, EPA Region 5 Resource Conservation and Recovery Act (RCRA) ESLs, information obtained from select ORNL guidance, and additional appropriate guidance, as necessary. The primary source for the recommended screening value was the NYSDEC value. If a NYSDEC value was not available, ecological screening values were selected in accordance with the hierarchy listed above.

If no value was established within the hierarchy presented in the Final RI Work Plan, additional research was conducted to identify ESVs during the development of the SLERA. ESVs were obtained for the following analytes: 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, nitroglycerin, PETN, RDX, and 2,4,6-trinitrotoluene (**Table 2-13**).

Table 2-13 Screening Level Ecological Risk Assessment Results for Soil

Analyte	Recommended Ecological Screening Value	MEC Release Area Sample Number	Maximum Detected Incremental Sample Value at the MEC Release Area[h]	Maximum Background Screening Value[i]	COPEC?
Explosives (µg/mg)					
2-Amino-4,6-dinitrotoluene	9,000[a,b]	WPR03-SS29	60 U	N/A	N
4-Amino-2,6-dinitrotoluene	9,000[a,b]	all samples	23 U	N/A	N
2,4-Dinitrotoluene	1,280[c]	multiple samples	29 U	N/A	N
2,6-Dinitrotoluene	32.8[c]	WPR03-SS30	96 UJ (48)	N/A	Y
Nitroglycerin	3,000[a,d]	WPR03-SS29	1,600 U	N/A	N
PETN	170,000[a,e]	all samples	1,700	N/A	N
RDX	21,000[f]	---	---	N/A	N
2,4,6-Tinitrotoluene	70[a,g]	all samples	14 U	N/A	N
Metals (mg/kg)					
Lead, Total	63[g]	WPR03-SS26	150 J	112	Y
Mercury, Total	0.18[g]	WPR03-SS26	0.24 J	0.3	Y

Notes:
µg/kg = micrograms per kilogram
[a]µg/kg/d = micrograms per kilogram per day, no observed adverse effect level (NOAEL).
[b]USACHPPM, 2005.
[c]EPA, 2003.
[d]USACHPPM, 2000.
[e]USACHPPM, 2001a.
[f]Kuperman et al., 2006.
[g]USACHPPM, 2001b.
[h]Second value is half of the estimated sample quantitation.
[i]NYSDEC, 2005.

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).

U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis using photo diode array confirmed that the analyte was not present.

2.6.2.2 Habitat and Receptors

The Fort Clinton West MRS is comprised of 14.4 acres of range fan area, located in the northern portion of West Point. The MRS begins beyond the former firing point, extends northwesterly and terminates south of Crows Nest mountain, which is situated in the northernmost extent of West Point. Portions of the southern MRS boundary are shared with the Lusk Reservoir and Artillery Firing Range MRSs. The northern boundary abuts the Siege Battery MRS. Approximately 50% of the Fort Clinton West MRS has been disturbed through development of the area.

Ecological receptors that could potentially be exposed to MC at the Fort Clinton West MRS include terrestrial plants; terrestrial invertebrates; and terrestrial avian and mammalian species, including herbivores, omnivores, and carnivores. Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Fort Clinton West MRS. A list of the potential ecological receptors for West Point is presented in Section 2.1.1.6.5.

2.6.2.3 Screening of Chemicals of Potential Ecological Concern

The maximum detected values for incremental soil samples at the Fort Clinton West MRS were compared to appropriate ESVs. Sampling within the Fort Clinton West consisted of one incremental sample (plus one field duplicate) collected at the border between the Siege Battery MRS and the Fort Clinton West MRS, and one incremental sample (plus one field duplicate and one duplicate/triplicate pair) collected from within the boundary of the Fort Clinton West MRS where UXO and/or MD had been identified.

Explosives were not detected in samples from the Fort Clinton West MRS. The compound 2,6-dinitrotolutene (2,6-DNT) was reported as nondetected in all samples, with SQLs ranging from 14 µg/kg to 96 µg/kg. Of the five samples, three samples had SQLs greater than the ESV (32.8 µg/kg). Because all samples collected from West Point MRSs during the MMRP RI had results for 2,6-DNT that were qualified as nondetects, half of the reported sample result was used for comparison to the ESV of 32.8 µg/kg (Region 5 RCRA Ecological Screening Levels [EPA, 2003]). The SQLs for two samples still exceeded the ESV. However, all results were less than the alternative no observed adverse effect level (NOAEL) value for 2,6-DNT of 700 µg/kg for ingestion exposure for mammals (USACHPPM, 2006). 2,6-DNT was not positively detected in any of the MC samples collected from the MRSs included in the MMRP RI at West Point. It is highly unlikely that 2,6-DNT is present related to historical activities at the Fort Clinton West MRS. Furthermore, even if a release to surface soil at the MRS had occurred, 2,6-DNT is unlikely to persist in the environment because this compound readily breaks down in the presence of oxygen and sunlight, and is highly water soluble (Agency for Toxic Substances and Disease Registry [ATSDR], 1998).

Lead was detected in all Fort Clinton West MRS samples at concentrations ranging from 68 mg/kg and 150 J mg/kg, which exceed the screening level of 63 mg/kg (NYSDEC Unrestricted Use SCO) (**Table 2-13**). The results for all but one of the five samples were J qualified, indicating that the associated value is an estimated quantity. However, the presence of lead does not present an unacceptable risk to the environment because the detected lead concentrations at the Fort Clinton West MRS were less than the alternative ORNL benchmark of 500 mg/kg. Additionally, the arithmetic mean concentration of lead in all samples was consistent with the rural maximum concentration of 112 mg/kg, as reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table D1, August 2005 (NYSDEC, 2005).

Mercury was detected in all Fort Clinton West MRS samples at concentrations ranging from 0.16 J mg/kg to 0.24 J mg/kg, which exceeds the screening level of 0.18 mg/kg (NYSDEC Unrestricted Use SCO) (**Table 2-13**). All of the mercury results were J qualified, which indicates that mercury was positively identified, and the associated value is an estimated quantity. However, the presence of mercury does not present an unacceptable risk to the environment because the results are within the rural background range of concentrations. The range for the rural background mercury concentrations is 0.01 to 0.30 mg/kg, as reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table D1, August 2005 (NYSDEC, 2005).

2.6.2.4 Uncertainty Assessment

The 2,6-DNT concentration is listed as a nondetect/estimated value (UJ), but the SQL exceeds the established conservative ESV. Therefore, it is unclear whether 2,6-DNT is present and poses a quantifiable risk of exposure to ecological receptors within the Fort Clinton West MRS. Based on the secondary spectral analysis performed by the laboratory, which confirmed that no explosives were present, and on the screening-level evaluation results presented above, the uncertainty associated with the elevated SQLs is considered minimal.

2.6.2.5 Summary of Ecological Risk

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. No threatened or endangered species are known to be present within the area sampled at the Fort Clinton West MRS. The ecological habitat within the MRS is not considered to be of high quality because of the development in the area, and it is expected that potential ecological receptors would use other habitats within surrounding areas.

There is little to no potential for adverse ecological impacts from MC in surface soil at the Fort Clinton West MRS based on the following reasons. Although UXO and MD were detected in the MRS, explosives were not detected in any soil samples from impacted areas. The SQL for 2,6-DNT was greater than the conservative ESVs, which may be of concern; however, the SQL value is less than the alternative NOAEL. Additionally, 2,6-DNT was not positively detected in any of the program-level MC samples collected at West Point to support the RIs, and the toxicological information indicates that this compound would not be likely to persist in surface soil. The uncertainty associated with the estimated SQLs observed using Method 8330B analysis was minimized by obtaining secondary confirmation by spectral analysis that 2,6-DNT was not present.

Even though lead and mercury were detected in all samples, concentrations were less than alternative ESVs or within the range of background concentrations published for the area. Therefore, the risk of exposure to COPECs for ecological receptors at the Fort Clinton West MRS is considered to be minimal.

2.6.3 Preliminary Identification of Applicable or Relevant and Appropriate Requirements

A preliminary identification of potential ARARs is conducted during RI characterization. The ARARs are used as a “starting point” in determining remedial action objectives and the protectiveness of a remedy to be assessed in a feasibility study (FS).

As the RI/FS process continues, the list of ARARs is further refined. The ARARs are used to establish the appropriate extent of cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative.

Pursuant to Section 300.400(g) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a list of ARARs and other to-be-considered advisories, criteria, and guidance (TBCs) is developed for a site or sites to identify the requirements that may apply to response actions. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the NCP provide that the development and evaluation of remedial actions must include remedial alternatives that attain ARARs and ensure protection of public health and the environment.

ARARs are defined as follows:

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

First, it is determined whether a requirement is applicable to the MRS. If a requirement is not applicable, then it is determined whether the requirement is relevant and appropriate. The procedure for determining whether a requirement is relevant <u>and</u> appropriate is a two-step process. First, to determine relevance, it is evaluated whether the requirement addresses problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made about whether the requirement would also be well-suited to the conditions of the MRS. In some cases, only a portion of a requirement would be both relevant and appropriate. Once a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR. The results of the selection process for the Fort Clinton West MRS are provided in **Table 2-14**.

“Applicable requirements” and “relevant and appropriate requirements” are considered to have the same weight under CERCLA. Section 121(d) of CERCLA requires the attainment of federal ARARs and of state ARARs if the state environmental or facility siting laws are promulgated, are more stringent than federal laws, and are identified by the state in a timely manner.

CERCLA and the NCP also identify a TBC category, which includes nonpromulgated (not enforceable) federal and state criteria, advisories, and guidance documents, which are also considered. TBCs do not have the same status as ARARs; however, if no ARAR exists for a substance or particular situation, TBCs may be used to ensure that a remedy is protective.

Generally, ARARs pertain either to contaminant levels or to performance or design standards to ensure protection at all points of potential exposure. ARARs are divided into three general categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs.

ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the MRS.
- Chemical analysis performed or scheduled to be performed.
- Types of media (air, soil, groundwater, surface water, and sediment).
- Geology and other MRS characteristics.
- Use of MRS resources and media.
- Potential contaminant transport mechanisms.
- Purpose and application of potential ARARs and TBCs.
- Remedial alternatives considered for MRS cleanup.

Table 2-14 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments (Applicable or Relevant and Appropriate)
Action Specific			
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	*Applicable* Identify when military munitions become a solid waste; and, if these wastes are also hazardous under this subpart or 40 CFR Part 261, identify the management standards that apply to these wastes.
NY Division of Water - Classes and Standards of Quality and Purity and EPA National Pollutant Discharge Elimination System	6 NYCRR §750-1.5 and 40 CFR Part 122.26	Establishes water quality standards, including classifications of New York waters and water quality criteria to protect the ground and surface water resources; and controls stormwater and effluent discharges, including toxic substances, into state waters.	*Relevant and Appropriate* For remedial alternatives where soil excavation activities are performed and require stormwater management. Construction activities disturbing one or more acres of soil must be authorized under the NY General Permit for Stormwater Discharges from Construction Activities.
Hazardous Waste Manifest System and Related Standards For Generators, Transporters and Facilities	6 NYCRR Part 372	Establishes standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its record keeping requirements.	*Applicable* in the event that hazardous waste is generated as part of a remedial alternative; for example, if MEC were removed and would need to be shipped (by a party other than the Army) as hazardous waste.
Waste Transporter Permits	6 NYCRR Part 364	Protects the environment from mishandling and mismanagement of regulated waste transported from the site of generation to the site of ultimate treatment, storage or disposal.	*Applicable* to any off-site transport and disposal of classified hazardous wastes, if generated as part of remedial alternative.
Air Quality Classifications and Standards	6 NYCRR Part 257-1.3 and 257-1.4	Designed to provide protection from the adverse health effects of air contamination; intended to protect and conserve the natural resources and environment.	*Relevant and Appropriate* in the event that a remedial alternative, such as soil excavation/grading, could impact ambient air quality for an extended period of time. The state regulation has 12-month average standards for dust levels from a specific source.

Notes:
CFR Code of Federal Regulations
NYCRR New York Codes, Rules and Regulations

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 an MRS. The preliminary ARARs are summarized in **Table 2-14.** Based on the findings of the RI, it is anticipated that the remedial alternatives will not include on-site treatment, on-site storage (greater than 90 days), or on-site disposal of hazardous waste. Therefore, potential action-specific ARARs related to these activities were not considered applicable at this time. The ARARs will be further refined during future phases of work at the Fort Clinton West MRS. In addition, there are no wetlands or surface water bodies at or near the MRS that might be affected by potential remedial alternatives.

Location-specific ARARs were not identified for the Fort Clinton West MRS. Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. The Fort Clinton West MRS does not contain sensitive or unique areas.

Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Chemical-specific ARARs are used to provide benchmarks with which to compare environmental sampling results for metals and explosives. Residential SCO values published in NYSDEC regulations (NYSDEC, 2006) would be considered chemical-specific ARARs for MC concentrations at the MRS. However, MC was not found at levels of concern (i.e., not detected or detected below risk-based screening values and/or background levels) at the Fort Clinton West MRS. Therefore, chemical-specific ARARs did not need to be carried forward based on the information available at the time of the RI. TBCs were identified for the Fort Clinton West MRS and are discussed in Section 2.4.4.

NYSDEC participated in TPP 1 (General Project Introduction and Approach) and TPP 2 (Presentation of RI Field Work Approach). Discussions at TPP 1 and TPP 2 generally consisted of establishing which NYSDEC and EPA standards for MC would apply to the entire project (WESTON, 2011a). The RI reports will be presented at the TPP 3 meeting.

The ARARs will be further refined during future phases of work at the Fort Clinton West MRS as needed.

2.7 CONTAMINANT FATE AND TRANSPORT

The intent of this section is to describe the fate of contaminants in the environment and the potential transport mechanisms for MEC and MC identified at the Fort Clinton West MRS. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to migration mechanisms away from the source area. MEC and MD items were found within the Fort Clinton West MRS. Fate and transport dynamics related to MEC at the MRS are discussed in Section 2.7.1.

The surface soil incremental samples did not contain MC concentrations greater than the screening levels or published background levels that would pose a potential human health risk. There is little to no potential for adverse ecological impacts from MC in surface soil at the MRS. Explosives were not detected, and SQLs were less than ESVs or alternative ESVs. Metals detected were less than alternative ESVs or within the range of background concentrations published for the area. Therefore, the risk of exposure to COPECs for ecological receptors at the Fort Clinton West MRS is considered to be minimal. Based on the analytical data evaluation and subsequent risk assessment performed for the SI and RI, an MC risk is not present within the Fort Clinton West MRS. Therefore, further analysis of MC fate and transport dynamics was not warranted.

2.7.1 MEC Fate and Transport

Potential routes of migration include those physical processes that might result in the movement or relocation of MEC from its original placement. If not removed, the MEC will have the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement and are active at the Fort Clinton West MRS:

- Potential MEC being picked up or moved by a person(s).
- Disturbance of potential MEC during construction, excavation, or other soil moving activities.
- Natural processes such as erosion/deposition or frost heave.

Consistent with the preliminary CSM, the RI identified the following potential human receptors for the Fort Clinton West MRS: West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors. All of these potential receptors engage in activities at ground surface and may contact and subsequently transport MEC. Soil moving activities that may contact and transport MEC at the ground surface and in subsurface soil, or allow for transport of MEC to the Fort Clinton West MRS in construction fill material, may be performed by MRS residents (e.g., gardening, fencing, construction) or construction and installation personnel.

Over time, the natural erosion of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, this process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of the wash).

In addition to erosion, buried objects have been known to move or migrate toward the surface during freezing and thawing cycles. Movement occurs when cold penetrates the ground, and the water below the buried objects freezes and expands, gradually pushing the objects upward. The phenomenon is often referred to as "frost heave" and is most likely to affect items buried above the frost line. The soil type influences the occurrence of frost heave. Gravel, sand, and clay are not typically susceptible to frost heave, whereas silty soil is susceptible. The maximum frost penetration depth for the region is 1.00 to 1.25 meters (approximately 3.28 feet to 4 feet) below ground surface (National Oceanic and Atmospheric Administration [NOAA], 1978).

The recovered MEC was found between 3 and 8 inches bgs. The recovered MD was found between 0 and 12 inches bgs. The central and southeastern portions of the MRS are mostly developed and relatively flat with a low potential for erosion. The northwestern portion of the MRS where MEC and MD were identified is undeveloped and has a steeper topography with a greater potential for erosion. The MEC items identified within the MRS are classified as small (less than 100 pounds) and capable of being moved by surface erosion.

The soil types in the Fort Clinton West MRS range from well drained to somewhat excessively well drained with a limited capacity to retain moisture and thus a low potential for frost heave.

The MEC was identified above the frost line. The soils in the area are not readily susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion are likely to impact the source material in the northwestern portion; however, frost heave is unlikely. Burrowing biota might come in contact with residual MEC and MD because of the shallow depth of MEC observed during the RI, which was identified within the zone of biological activity.

No MEC or MD was identified in the southeastern developed portion of the MRS. Surface interactions such as wet/dry erosion and frost heave are unlikely.

2.8 REVISED CONCEPTUAL SITE MODEL

This section presents the revised MEC and MC CSMs for the Fort Clinton West MRS based on the results of the data collected for the RI and the information provided in the SI report. The preliminary CSMs are discussed in Section 2.2.1.

2.8.1 Revised Munitions and Explosives of Concern Conceptual Site Model

The Fort Clinton West MRS was documented in the preliminary CSM as being a portion of a former artillery firing range fan that encompassed 14.4 acres of the Main Post area of West Point. After completion of RI field work, an increase in MEC and/or MD densities was observed laterally extending across several MRSs, including the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, and the Artillery Firing Range MRS. Based on the observed density distribution and the type of MEC and MD recovered, the source of the increased clustering and densities is related to the former target area at the Crows Nest mountain in the northern extent of West Point. The Crows Nest impact area includes 12.7 acres of the Fort Clinton West MRS in its northwestern extent where the MRS intersects the Artillery Firing Range and the Siege Battery MRS and abuts the Crows Nest area.

Separating the 12.7 acres in the northwestern portion of the MRS from the original boundary of the Fort Clinton West MRS would reduce the total acreage from 14.4 acres to 1.7 acres (see **Figure 2-9**) based on the data collected during the RI. Because UXO and MD were confirmed to be present in the northwestern 12.7 acres as part of an impact area, but not identified in the southeastern 1.7 acres within the range fan, the revised CSM for the Fort Clinton West MRS addresses each area separately (see **Figure 2-10** and **Figure 2-11**).

2.8.1.1 Revised Munitions and Explosives of Concern Exposure Pathway Analysis

As described in Section 2.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered potentially complete when a source (MEC) has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered incomplete if any one of the three components (source, interaction, or receptors) is not present at an MRS.

2.8.1.1.1 Source

A MEC source is the location where MEC is situated or is expected to be found. Potential MEC source areas in the Fort Clinton West MRS were considered to be areas of UXO and MD along the range floor. High concentrations of MEC and MD were not anticipated within the MRS because the impact area for the former range was located on Crows Nest mountain and not included within the MRS boundary. Low concentrations of MEC may be found within the MRS as a result of misfires or undershots toward the former targets.

It is possible that MEC and MD may have been transported in fill material and placed within the Fort Clinton West MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

During the SI survey activities, MEC was not identified. However, the exposure pathways for MEC were determined to be complete for surface and subsurface soil based on finding MD within the MRS.

During the RI characterization coverage of 4.05 acres and the intrusive investigation of 212 anomalies within the Fort Clinton West MRS, a total of three UXO (two MKII hand grenades [unfuzed], and one 8-inch Butler projectile) and 32 MD items (2 MKII [empty] hand grenades, 29 unknown fragments, and one 8-inch Butler projectile [empty]) were recovered. The remaining 177 anomalies included 175 non-MD related materials classified as cultural debris and two seed items.

A statistical approach was developed to assess the potential MEC density within the Fort Clinton West MRS to satisfy the UXO Estimator parameters of 0.5 MEC/acre at a 95% confidence level. Following field work, the results were assessed using UXO Estimator. Based on the 4.05 acres that were surveyed and the three UXO items found, the actual range of MEC densities within the MRS was calculated to be between 0 and 1.74 MEC/acre with an average of 0.92 MEC/acre. Qualitatively, the delineated impact area within the northwestern 12.7-acre portion of the MRS includes all the MEC and MD found during the RI, and the MD identified previously during the SI.

The MEC and MD were recovered within the northwestern 12.7-acre portion of the Fort Clinton West MRS. No MEC or MD was observed in the southeastern 1.7 acres of the MRS. The increase in MEC and MD density observed within the northwestern 12.7-acre portion of the Fort Clinton West MRS was also observed laterally extending across several MRSs, including the Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. Based on the observed density distribution and the type of MEC and MD recovered, the source of the increased clustering and densities is related to the former target area on Crows Nest mountain in the northern extent of West Point. The MEC sources for the southeastern 1.7-acre portion and the northwestern 12.7-acre portion of the Fort Clinton West MRS are discussed separately in the following subsections.

Southeastern 1.7-Acre Portion

Based on the investigation coverage and the lack of MEC or MD detected in the southeastern 1.7-acre portion of the Fort Clinton West MRS during the SI and RI, no MEC source and thus no explosive hazard is anticipated to be present in the southeastern portion.

Northwestern 12.7-Acre Portion

All UXO and MD recovered during the RI were found within the northwestern 12.7-acre portion of the Fort Clinton West MRS between the surface and 12 inches bgs. The RI findings confirm the presence of a MEC source, and thus an explosive hazard in the northwestern portion of the Fort Clinton West MRS. Concentrations of MEC and MD were observed in the MRS and across its shared boundaries with both the Siege Battery and Artillery Firing Range MRSs. The MEC and MD are believed to be attributed to the MEC impact area associated with Crows Nest mountain. The delineated impact area associated with the Crow Nest includes the northwestern 12.7-acre portion of the Fort Clinton MRS, where all UXO and MD were recovered during the RI. Based on the RI results from the adjacent MRSs, the boundary for the Crows Nest impact area was determined to traverse the Fort Clinton West MRS northwest of Buckner Loop.

2.8.1.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes both access and activity considerations. Access describes the degree to which a MEC source or an environment containing MEC is available to potential receptors. Activity describes the action by which receptors come in contact with a source. Typically, a receptor may contact MEC, if present, on the ground surface simply by walking. A receptor may contact MEC in the subsurface, if present, by performing intrusive activities.

Southeastern 1.7-Acre Portion

The southeastern 1.7-acre portion of the Fort Clinton West MRS is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. There is one residence and a portion of the Child Development Center. The extreme southeastern extent of the MRS is forested and undeveloped and may be used for recreational purposes. The MRS is bounded to the south by the developed areas of the Main Post, including the former Post Exchange and service station, and by the West Point Cemetery (**Figure 2-9**).

There are no current plans to change the land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the southeastern portion of the MRS. Residential and maintenance activities in the Fort Clinton West MRS may disturb subsurface soil. Recreational activities are typically limited to surface soil interaction. The undeveloped area at the extreme southeastern extent of the MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

Northwestern 12.7-Acre Portion

The northwestern 12.7-acre portion of the Fort Clinton West MRS, where UXO and MD were recovered, is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. A portion of the Lee Housing Area and undeveloped, heavily wooded terrain are located in the northwestern portion of the MRS. A solid waste landfill (Post School Landfill) is located along the northeastern border, and the West Point Middle School is located adjacent to the southwestern border of the northwestern portion of the MRS (**Figure 2-9**).

There are no current plans to change the land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the northwestern portion of the MRS. A receptor may contact UXO that is on the ground surface simply by walking. A receptor may contact UXO in the subsurface by performing intrusive activities. Residential, maintenance, and recreational activities in the Fort Clinton West MRS may disturb surface and subsurface soils. The undeveloped areas in the northwestern portion of the MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

2.8.1.1.3 Receptors

A receptor is an organism (human or ecological) that comes in physical contact with MEC. Human receptors identified for the Fort Clinton West MRS include West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

Approximately 50% of the Fort Clinton West MRS has been disturbed by development. The northwestern and southeastern extents of the MRS are undisturbed and consist of heavily forested areas and some steep terrain. Potential ecological receptors that may be present are described in Section 2.1.1.6.5. Because the central portion of the Fort Clinton West MRS is extensively developed, it is unlikely that the majority of the ecological receptors would rely on this central portion of the MRS for habitat.

2.8.1.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Fort Clinton West MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS given current and anticipated future land users. A statistical approach was taken for the characterization at the Fort Clinton West MRS, and a portion of the MRS was investigated by geophysical surveys and intrusive investigations.

2.8.1.2.1 Southeastern 1.7-Acre Portion

No MEC or MD was found in the southeastern 1.7-acre portion of the MRS. Based on the results of the SI and RI field investigations, it is unlikely that a MEC source or explosive safety hazard related to historical range activities is present in the southeastern portion of the Fort Clinton West MRS. Because no MEC source or explosive safety hazard was identified in the southeastern 1.7-acre portion of the MRS, there are no current receptor interactions or anticipated interactions under future land use. The revised CSM for MEC identified incomplete pathways for surface and subsurface soils for all receptors having access to the southeastern portion of the Fort Clinton West MRS (**Figure 2-10**).

2.8.1.2.2 Northwestern 12.7-Acre Portion

In the northwestern 12.7 acres of the Fort Clinton West MRS delineated within the Crows Nest impact area, three MEC items (UXO: two MKII hand grenades [unfuzed] and one 8-inch Butler projectile) and 32 MD items (2 MKII [empty] hand grenades, 29 unknown fragments, and one 8-inch Butler projectile [empty]) were found during the intrusive investigation. With confirmed UXO and the potential for additional UXO to be present, the pathways for all receptors are complete. A CSM diagram for the northwestern 12.7 acres of the Fort Clinton West MRS is provided in **Figure 2-11**.

2.8.2 Revised Munitions Constituents Conceptual Site Exposure Model

To supplement the historical data collected to evaluate MC during the SI, two sampling locations were selected to assess potential MC contamination in soil at the Fort Clinton West MRS associated with MEC and MD identified during the RI. Two incremental samples, comprised of 50 increments, were collected within 0.8-acre sampling units, strategically placed within the MRS in locations where UXO was found during the geophysical investigations.

The MC sampling results are discussed in Section 2.5.2. The complete analytical results and data validation reports are provided in **Appendix 2-J**. The analytical results were used to perform the HHRA and SLERA (see Section 2.6) and to update the preliminary CSM as needed.

2.8.2.1 Revised Munitions Constituents Exposure Pathway Analysis

The MC exposure pathway analyses for the Fort Clinton West MRS are summarized in this section. As previously described in Section 2.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. An exposure pathway for MC requires a source exposure medium (i.e., MC in soil), interaction (release mechanism and exposure route), and receptors. A pathway is considered complete when all components exist and imply potential risk. A pathway is considered potentially complete when data are required to determine whether the pathway is complete or incomplete. An incomplete pathway presents no associated risk and no further data are required.

2.8.2.1.1 Source

Southeastern 1.7-Acre Portion

Because there was no evidence of MEC or MD, soil staining, or a potential MC release in the southeastern portion of the MRS, a determination was made that an MC source and the potential risk of encountering MC are not present. Therefore, MC sampling was not conducted in the southeastern 1.7-acre portion of the Fort Clinton West MRS.

Northwestern 12.7-Acre Portion

Both UXO and MD were identified in the northwestern 12.7 acres of the Fort Clinton West MRS, and delineated within the impact area associated with the former targets at Crows Nest mountain. Although no soil staining was observed, MC sampling was conducted based on the confirmed UXO and MD to investigate whether a MC release occurred and whether further delineation was warranted. Data evaluation and the HHRA did not identify any COPCs or potential risks to human receptors. No explosives were detected in any of the samples, and detections of lead and mercury were below alternative screening levels and within published background levels. The risk from the one COPEC identified during the SLERA, due to an SQL that did not meet the selected ESV, was determined to be minimal. These findings are consistent with the analytical sampling performed to support the SI, which did not identify any MC above the SI screening levels. The data indicate that UXO, when present, is not a significant source of MC within the Fort Clinton West MRS and an MC risk is not present within the Fort Clinton West MRS.

2.8.2.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes an exposure route with a release mechanism for impacted media. The Fort Clinton West MRS is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. Once on the West Point installation, human and ecological receptors have unrestricted access to the MRS. A human or ecological receptor may encounter MC in soil through direct contact, including ingestion, inhalation, or dermal exposure routes.

Within the environment, fate and transport of MC in soil, if present, has the potential to be affected by secondary release processes such as wet/dry erosion, infiltration/leaching to groundwater, and food web interactions. These processes may result in the movement or transformation of MC within environmental media. Because an MC release has not been identified in any environmental media, no interactions are expected to exist at the Fort Clinton West MRS that would expose receptors to MC contamination.

2.8.2.1.3 Receptors

Potential receptors for MC at the Fort Clinton West MRS are the same as those presented in the revised MEC CSM in Section 2.8.1.1.3.

2.8.2.2 Munitions Constituents Exposure Pathway Conclusions

The analytical results from the two incremental samples and the risk assessment activities performed to support the RI were used to update the preliminary MC CSM for the Fort Clinton West MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users.

2.8.2.2.1 Southeastern 1.7-Acre Portion

Sampling for MC was not conducted in the southeastern 1.7 acres of the Fort Clinton West MRS during the SI or RI because MEC items, MD, soil staining, or visible evidence of a potential MC release were not found in the southeastern portion of the MRS. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources, and thus no potential risk, are known to exist in the southeastern 1.7-acre portion of the Fort Clinton West MRS (see **Figure 2-12**).

2.8.2.2.2 Northwestern 12.7-Acre Portion

Sampling for MC was conducted only within the northwestern 12.7-acre portion of the Fort Clinton West MRS where UXO and MD have been confirmed during the SI and/or RI. Explosives were not detected in any of the soil samples; however, the SQL for 2,6-DNT exceeded the project ESV, but not the NOAEL. Although detected, neither lead nor mercury was found in concentrations above alternative screening levels and/or the published background concentrations. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources, and thus no potential risk, are known to exist in the Fort Clinton West MRS. These findings are consistent with the preliminary CSM. **Figure 2-13** depicts the MC exposure pathways for the northwestern 12.7 acres of the Fort Clinton West MRS delineated in the Crows Nest impact area.

2.9 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT AND MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL UPDATE

2.9.1 Munitions and Explosives of Concern Hazard Assessment

The CERCLA process for responding to releases or potential releases of hazardous substances includes the development of site-specific risk assessments appropriate to the requirements of a site. The results of the risk assessments are used to help site managers decide whether a response action is required and to support the risk management decisions that are made through the remedy evaluation, selection, and implementation process.

The CERCLA methodology for human health chemical risk assessment was not designed to address explosive safety hazards at MEC sites. In October 2008, the Technical Working Group for Hazard Assessment, which included representatives from DoD, Department of the Interior, EPA, and others, made available the technical reference document *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). The document was designed to be used as the CERCLA hazard assessment methodology for MRSs where an explosive hazard exists from the known or suspected presence of MEC.

No MEC was identified in the southeastern 1.7-acre of the Fort Clinton West MRS during either the SI or RI field activities, and these results have been interpreted to indicate that no MEC source or explosive safety hazard is present. As a result, the project team determined that the calculation of a MEC HA score was not warranted for the southeastern 1.7-acre portion of the Fort Clinton West MRS.

The three UXO items that were identified during the RI are included in the MEC HA developed for the Artillery Firing Range North MRS (see Section 6.6.1). These items were found within the northwestern 12.7-acre portion of the Fort Clinton West MRS delineated within the Crows Nest impact area.

2.9.2 Munitions Response Site Prioritization Protocol Scoring Update

The results from the RI were used to reapply the MRSPP. Priority 1 indicates the highest potential hazard and priority 8 the lowest potential hazard. Using the MRSPP, only MRSs with CWM can be assigned a priority of 1 and no MRS with CWM can be assigned a priority of 8.

2.9.2.1 Southeastern 1.7-Acre Portion

The MRSPP forms for the southeastern 1.7-acre portion of the Fort Clinton West MRS not within the impact area are provided in **Appendix 2-K**. The MRSPP for the southeastern 1.7 acres indicates that there is no known or suspected hazard.

2.9.2.2 Northwestern 12.7-Acre Portion

The data and information relative to the northwestern 12.7-acre portion of the Fort Clinton West MRS are included in application of the MRSPP to the Artillery Firing Range North MRS (see Section 6.6.2).

2.10 SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI activities conducted at the Fort Clinton West MRS. The RI was conducted to determine the nature and extent of MEC and MC and to determine the potential hazards and risks posed to human health and the environment by MEC and MC. The RI also provided additional data to assist in determining what remedial alternatives, if any, are necessary. As a result of the characterization activities conducted at the Fort Clinton West MRS, the objectives of the RI have been satisfied.

2.10.1 Summary of Remedial Investigation Activities

The preliminary CSM for the Fort Clinton West MRS aided in developing data needs and DQOs as documented in the Final RI Work Plan (WESTON, 2011a). In general, the data needs and DQOs focused on characterizing the nature and extent of MEC and MC that may be present within the MRS because of intentional firing from the former Fort Clinton. The characterization activities to support the data needs and DQOs were used to gather information to evaluate whether there are unacceptable potential risks to human health and the environment associated with MEC and/or MC to determine whether further action is required under the CERCLA process.

UXO Estimator was used to develop a statistically based characterization strategy. Geophysical surveys were performed at the Fort Clinton West MRS between April and August 2011 to assess the nature and extent of MEC in the MRS. Both DGM (EM61-MK2) and mag and dig (White's all-metals detectors) surveys were performed as part of the RI field work. A total of 4.05 acres and 212 anomalies were investigated as a result of geophysical surveys.

MEC was observed in the Fort Clinton West MRS. A total of three UXO items were recovered during the RI, including two MKII hand grenades (unfuzed) and one 8-inch Butler projectile, which were recovered in subsurface soil between 3 and 8 inches bgs. A total of 32 MD items, including two MKII hand grenades (empty), 29 fragments from unidentified munitions, and an 8-inch Butler projectile (empty) were recovered between ground surface and to 12 inches bgs. The remaining 177 anomalies included 175 non-MD related materials classified as cultural debris and two seed items.

Two sampling locations were selected to assess potential MC contamination in soil by conducting incremental sampling at the Fort Clinton West MRS based on the identified UXO and the significant densities of MD. No other signs of a MC release (e.g., soil staining, broken/leaking munition) were observed during the RI. Fifty increments were collected within two 0.8-acre sampling units in the vicinity of detected UXO in the northwestern 12.7-acre portion of the MRS delineated within the Crows Nest impact area. The samples were collected and analyzed to identify the presence of MC (if any) and to fully characterize the nature and extent of MC. No explosives were detected in the samples; however, elevated SQLs for several explosive chemicals were further evaluated during the HHRA and SLERA. The HHRA and SLERA also addressed concentrations of lead and mercury that were observed.

2.10.2 Risk Assessment

The results of the HHRA showed that no MC was present that constituted a potential risk to human health. All explosives analytical results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs and were observed below the project screening levels selected to assess human health effects. Both lead and mercury were positively detected, but based on results of the HHRA, the surface soil incremental sample did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

There is little to no potential for adverse ecological impacts from explosives MC in surface soil at the Fort Clinton West MRS. Only the SQL for 2,6-DNT slightly exceeded the EPA conservative screening criterion. However, the SQLs for 2,6-DNT were below the less conservative alternative screening value obtained to assess the NOAEL. Additionally, 2,6-DNT was not detected in any samples collected at the program-level at other West Point MRSs, and toxicological information indicates that this compound would not be likely to persist in surface soil. Although both mercury and lead were positively detected at concentrations above the conservative project ESVs initially used for the point-by-point comparison, the concentrations were found to be below alternative ESVs that were available and/or within published background levels. Therefore, the risk of exposure to COPECs for ecological receptors at the Fort Clinton West MRS is considered to be minimal.

2.10.3 Revised Conceptual Site Model

A discussion of the preliminary CSM, based on the available data and historical information compiled prior to RI activities, is presented in Section 2.2.1. The information collected during the RI was used to update the CSM. The purpose of the CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and reasonably anticipated future land use activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, interaction (activity and access), and receptor.

The Fort Clinton West MRS is a portion of the Fort Clinton range fan. Concentrations of MEC and MD were not anticipated within the MRS because the impact area for the former range was located on Crows Nest mountain, and not included within the MRS boundaries, and the firing point is located east of the MRS boundary. Low concentrations of MEC, in particular UXO, might be located within the MRS as a result of misfires or undershots toward the impact area. It is possible that MEC and MD may have been transported in fill material and placed within the Fort Clinton West MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

A statistical approach was developed to assess the potential MEC density within the Fort Clinton West MRS. UXO Estimator was used to develop the appropriate coverage necessary to make high confidence assessments. MEC, including three UXO items, were identified in subsurface soil within the 4.05 acres where geophysical surveys and subsequent intrusive investigation of 212 anomalies were conducted. These results were then re-assessed in UXO Estimator, and the statistical upper bound density of MEC was determined to be 1.74 MEC/acre based on the percentage of area surveyed at the MRS and the actual intrusive investigation results, with an average density of 0.92 MEC/acre calculated across the MRS.

Qualitatively, all UXO and MD were found within the northwestern 12.7-acre portion of the MRS. Concentrations of MEC and MD were also observed in the MRSs adjacent to the Fort Clinton West MRS. The MEC and MD are attributed to the Crows Nest impact area. Based on the RI results from the Fort Clinton West MRS and the adjacent MRSs, specifically the Siege Battery and Artillery Firing Range MRSs, the southern boundary for the Crows Nest impact area was determined to extend to just northwest of Buckner Loop where it crosses through the Fort Clinton West MRS. A 12.7-acre portion of the Fort Clinton West MRS is included in the Crows Nest impact area. Removing the 12.7 acres from the Fort Clinton West MRS would reduce the total area for the MRS from 14.4 acres to 1.7 acres. The revised CSMs presented for the Fort Clinton West MRS address the northwestern 12.7 acres and the southeastern 1.7 acres separately.

2.10.3.1 Southeastern 1.7-Acre Portion

Although the UXO Estimator results indicate that a statistical potential for MEC may remain, no MEC source or MD was identified in the southeastern 1.7 acres of the Fort Clinton West MRS based on the SI and RI. Therefore, an explosive safety hazard is not anticipated to exist. The revised CSM for MEC identified incomplete pathways for all receptors having access to the southeastern 1.7-acre portion of the Fort Clinton West MRS.

2.10.3.2 Northwestern 12.7-Acre Portion

Based on the confirmed UXO recovered during the RI and the statistical potential for UXO to remain, the pathways for MEC exposure for all receptors were determined to be complete in the northwestern portion of the Fort Clinton West MRS included in the Crows Nest impact area delineation.

2.10.3.3 MC Sampling

Media sampling was performed at the Fort Clinton West MRS where a potential MC release could occur based on the presence of UXO identified during the RI. No MC was detected at that location that would pose risks to human or ecological receptors. The RI findings indicate that the MC exposure pathway is incomplete for human and ecological receptors.

2.10.4 Munitions and Explosives of Concern Hazard Assessment

An evaluation of the explosive hazard at the Fort Clinton West MRS was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). However, because no MEC was identified in the southeastern portion of the MRS, these results were interpreted to indicate that no MEC source or explosive safety hazard is present. As a result, the project team determined that the calculation of a MEC HA score was not warranted for the southeastern portion of the Fort Clinton West MRS.

The three UXO items that were identified during the RI are included in the MEC HA developed for the Artillery Firing Range North MRS (see Section 6.6.1). These items were found within the northwestern 12.7-acre portion of the Fort Clinton West MRS delineated within the Crows Nest impact area.

2.10.5 Uncertainties

The investigation coverage to characterize the nature and extent of MEC at the Fort Clinton West MRS was designed using UXO Estimator software. The selection of UXO Estimator and associated parameters, including a 95% confidence level that a maximum MEC density of 0.5 MEC/acre remains in the MRS, was based on the preliminary CSM. The RI results indicate that the potential MEC density is greater than what was preliminarily anticipated during the work planning phase. All MEC and MD were recovered in the northwestern portion of the MRS. The MEC and MD at the Fort Clinton West MRS can be attributed to the use of Crows Nest as an impact area during historical training activities. UXO Estimator was originally used because the MRS was considered a portion of a range fan; however, the RI findings indicated that an impact area exists within the MRS boundary. The CSM was revised to reflect the presence of an impact area.

Typically, UXO Estimator is not the most appropriate tool to develop a characterization approach for an impact area such as the one encountered in the Fort Clinton West MRS. However, the use of a transect and grid geophysical survey approach for the investigation coverage at the MRS allowed the successful delineation of the southern boundary of the Crows Nest impact area. Although UXO Estimator was used to develop the approach, the uncertainty of characterizing the nature and extent of MEC is considered low. Minimal uncertainty is associated with the Crows Nest impact area delineation based on the availability of additional geophysical and intrusive investigation results for adjacent MRSs.

2.10.6 Summary and Recommendations

Based on the results of the RI field activities, the following conclusions were determined for the Fort Clinton West MRS:

- A total of 4.05 acres were investigated at the MRS during the RI.
- Three subsurface UXO and 32 MD items were recovered on the ground surface and subsurface soil to 12 inches bgs in the northwestern 12.7-acre portion of the MRS. Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for the northwestern portion of the MRS.
- Because no MEC or MD was found in the southeastern 1.7-acre portion of the Fort Clinton West MRS and the DQOs for the project were met, an explosive safety hazard is not anticipated to exist in this portion of the MRS. Incomplete MEC pathways were identified for surface and subsurface soils for all receptors having access to the southeastern 1.7-acre portion of the MRS.
- MC pathways to potential receptors were determined to be incomplete.

The nature and extent of MEC and MC have been adequately characterized. It is recommended that the 12.7-acre northwestern portion of the Fort Clinton West MRS associated with the Crows Nest impact area be transferred to the Artillery Firing Range North MRS (WSTPT-001-R-02). The Artillery Firing Range North MRS consolidates the areas of the Main Post that have increased concentrations of MEC and MD associated with the Crows Nest impact area. The recommendations, which are further documented in **Table 2-15** and **Figure 2-9,** are as follows:

- Revise the Fort Clinton West MRS from 14.4 acres to 1.7 acres and maintain tracking under WSTPT-008-R-01.
- Transfer the northwestern 12.7-acre portion of the Fort Clinton West MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS.

Table 2-15 Fort Clinton West MRS Recommendations

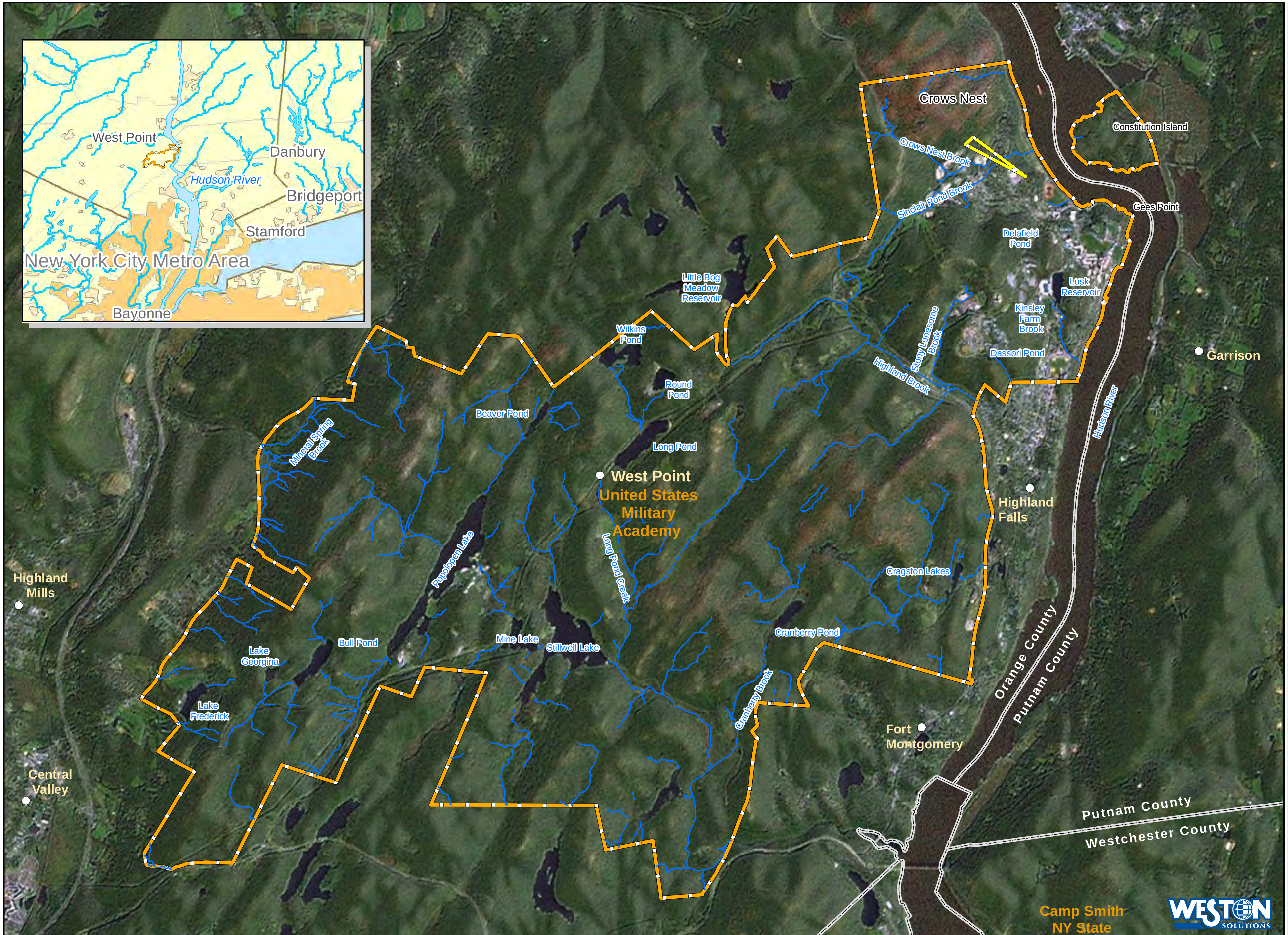
<table>
<tr><th colspan="2">Original Configuration</th><th colspan="2">Configuration Following Recommendations</th></tr>
<tr><th>MRS Name</th><th>Area (acres)</th><th>MRS Name</th><th>Area (acres)</th></tr>
<tr><td rowspan="2">Fort Clinton West
(WSTPT-008-R-01)</td><td rowspan="2">14.4 acres</td><td>Fort Clinton West
(WSTPT-008-R-01)</td><td>1.7 acres</td></tr>
<tr><td>Artillery Firing Range North
(WSTPT-001-R-02)</td><td>143.3 acres (includes 12.7 acres from within the original boundaries of the Fort Clinton West MRS)*</td></tr>
</table>

***** The Artillery Firing Range North MRS acreage is a combination of areas from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, and the Artillery Firing Range MRS that have increased concentrations of MEC and MD associated with the Crows Nest impact area (see Section 6).

Adjusted Fort Clinton West MRS (WSTPT-008-R-01)—Based on the conclusions, no further action under the MMRP is recommended for the remaining 1.7 acres of the Fort Clinton West MRS (WSTPT-008-R-01). Future phases of work for the Fort Clinton West MRS may include the preparation of a No Further Action Proposed Plan for public review followed by the issuance of a Decision Document.

Artillery Firing Range North MRS (WSTPT-001-R-02)—The Artillery Firing Range North MRS is discussed in Section 6. It is recommended that the Artillery Firing Range North MRS (the Crows Nest impact area) be further evaluated for potential action in an FS to address hazards related to the presence of MEC. Sections 2 through 5 present details about the Crows Nest impact area that was identified within the original boundaries of the Lusk Reservoir MRS, the Fort Clinton West MRS, the Siege Battery MRS, and the Artillery Firing Range MRS.

SECTION 2
FIGURES



Legend

Installation Boundary

Fort Clinton West MRS - 14.4 Acres

Streams

Imagery Source: ESRI, World Imagery
USAD FSA, NAIP 2009

N
W E
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0 1 2
Miles

Figure 2-1
Regional Location Map
Showing the Location of
Fort Clinton West MRS
U.S. Army Garrison West Point

WESTON SOLUTIONS

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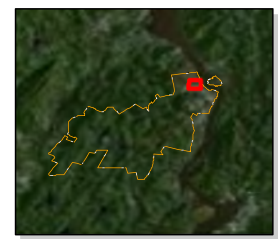
Legend

Fort Clinton West MRS - 14.4 Acres



Imagery Source: ESRI, Bing Mapping Service. 2011

0 175 350 Feet

Figure 2-2
Fort Clinton West MRS
(WSTPT-008-R-01)
U.S. Army Garrison West Point

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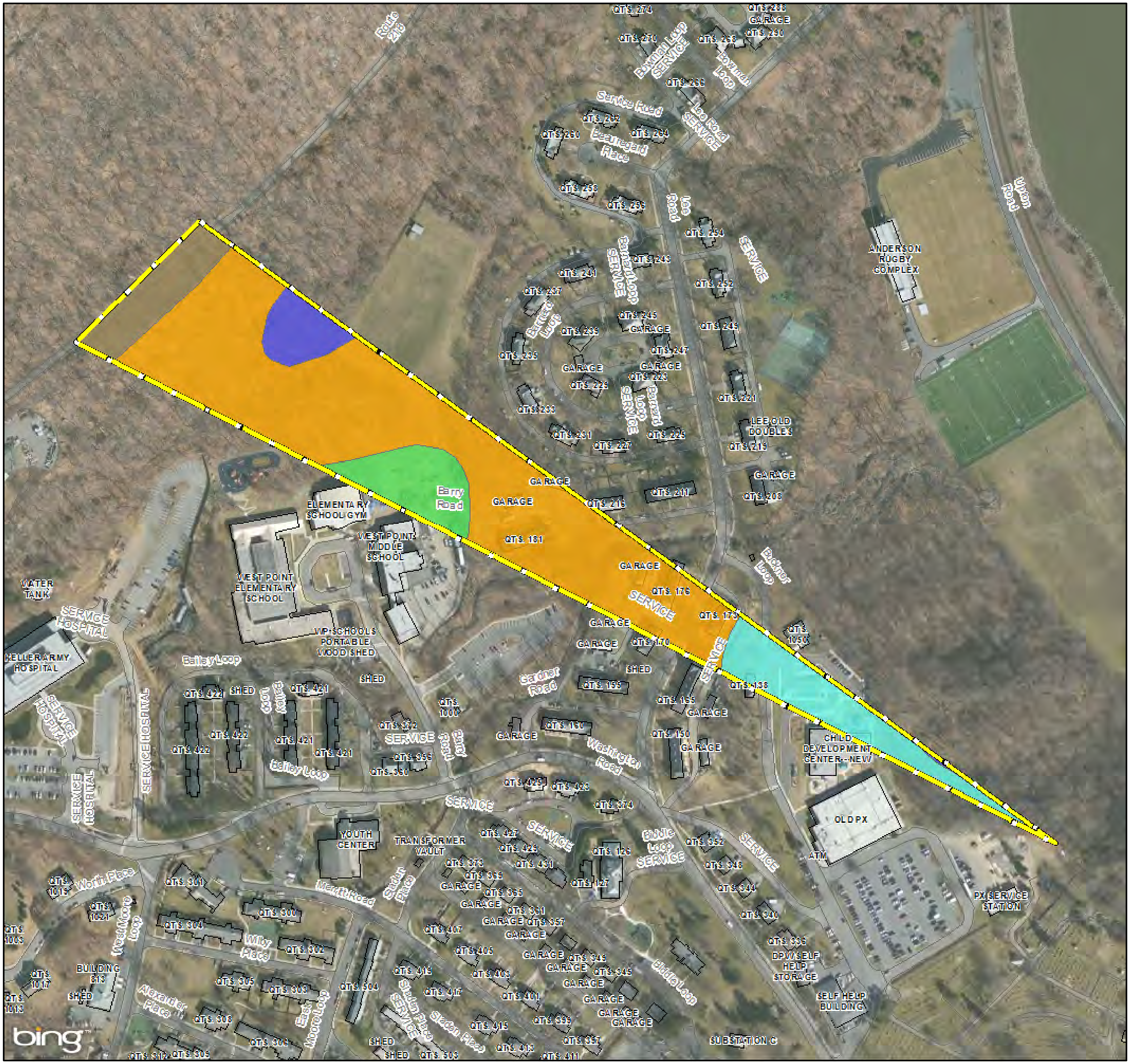
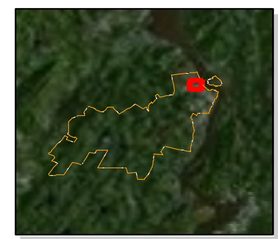


Legend

Fort Clinton West MRS - 14.4 Acres

Fort Clinton West Soil Series

- Hollis soils, sloping
- Rock outcrop-Hollis complex, sloping
- Rock outcrop-Hollis complex, moderately steep
- Swartswood gravelly loam, 3 to 8 percent slopes
- Udorthents, smoothed



Imagery Source: ESRI, Bing Mapping Service. 2011

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Figure 2-3
Fort Clinton West MRS
(WSTPT-008-R-01)
Soil Series
U.S. Army Garrison West Point

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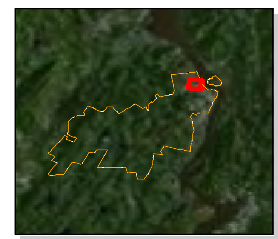
Legend

MC Sampling Location

Fort Clinton West MRS - 14.4 Acres

Visual Survey



Imagery Source: ESRI, Bing Mapping Service. 2011

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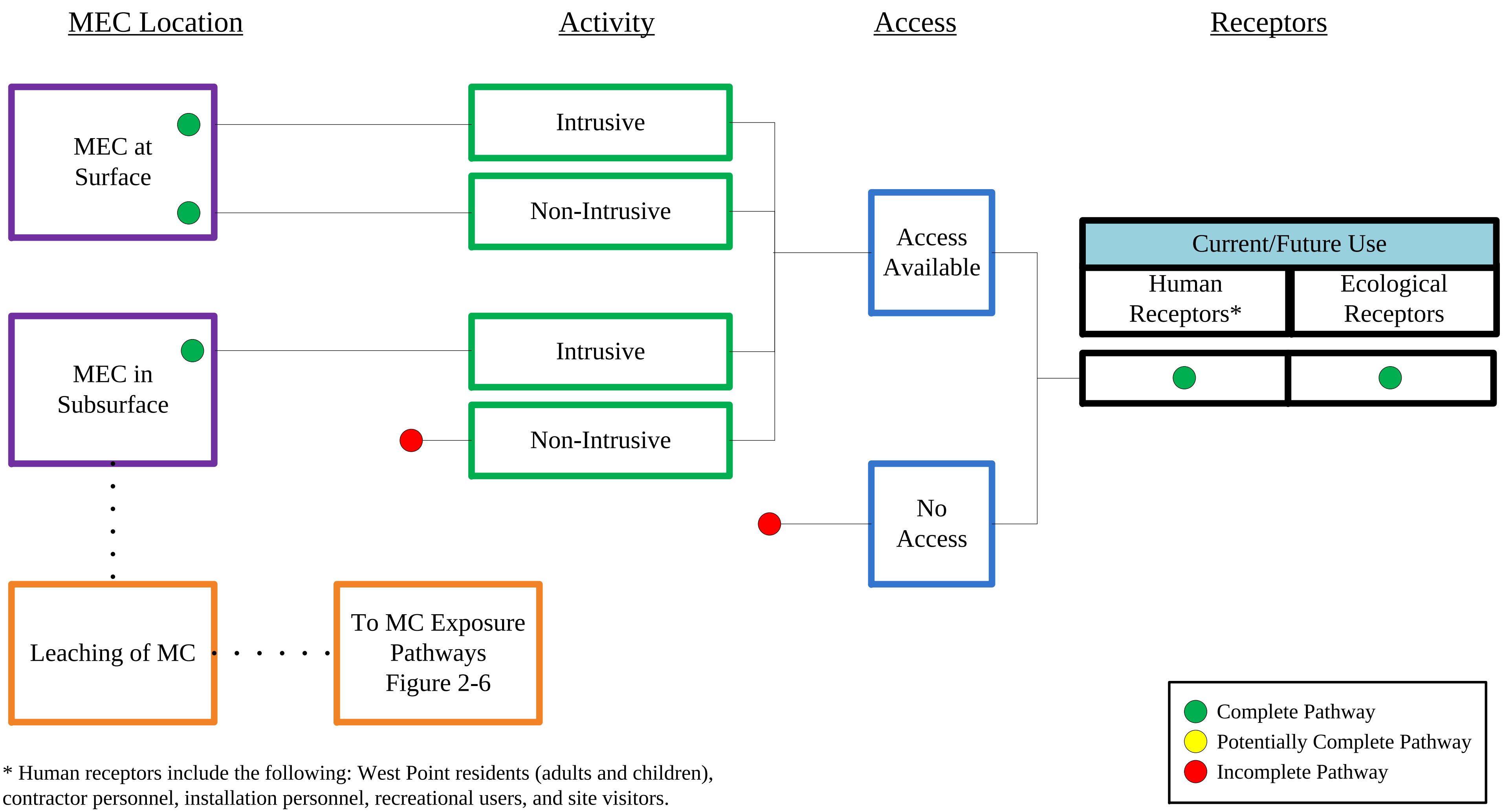
Figure 2-4
Fort Clinton West MRS
(WSTPT-008-R-01)
SI Results
U.S. Army Garrison West Point

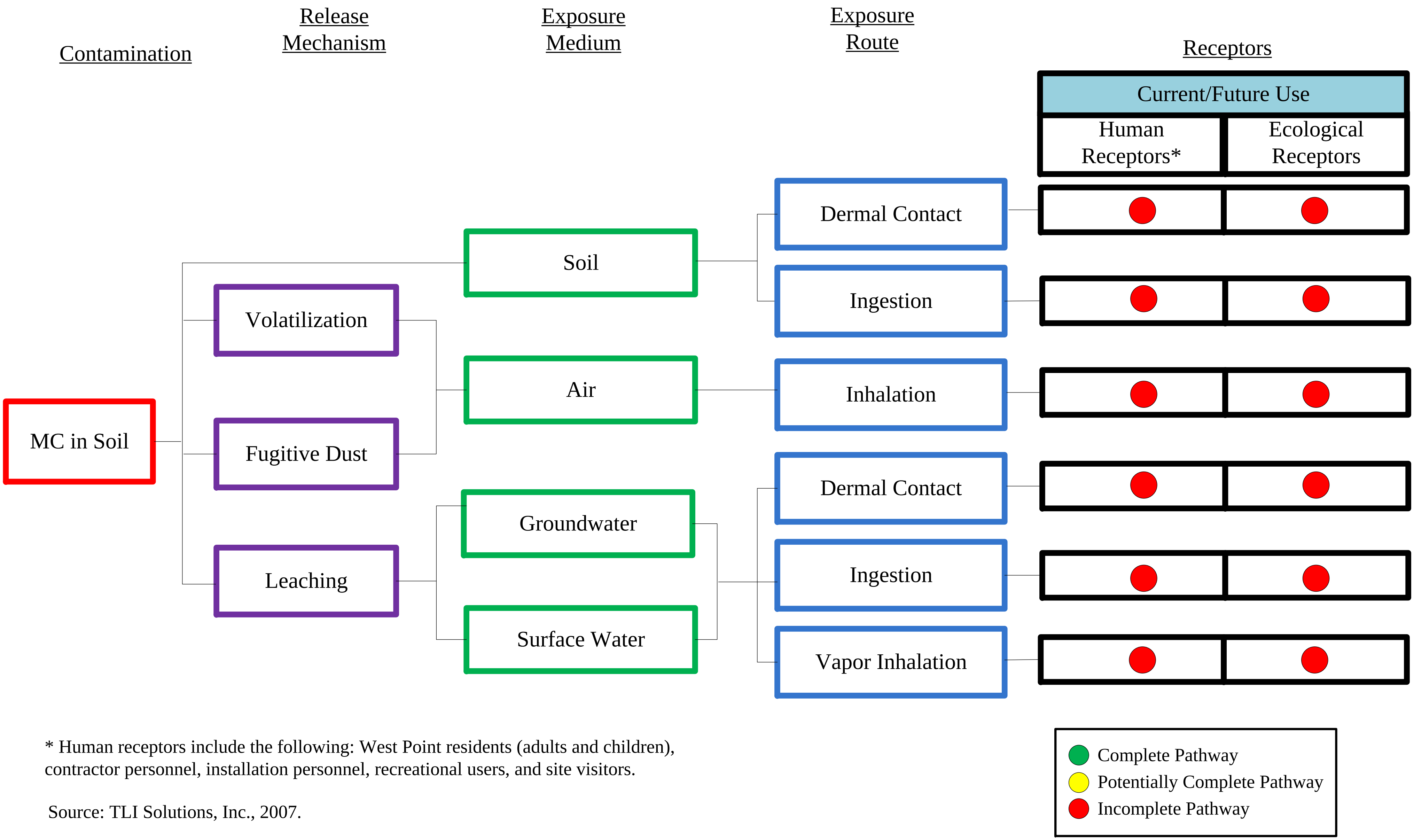
File: Y:\West_Point\mxd\RI\FCW_SI.mxd, 9/5/2013 10:43:22 AM, ricksc



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

Source: TLI Solutions, Inc., 2007.

Figure 2-5
SI Exposure Pathways for
Receptors to MEC, Fort Clinton West MRS



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

Source: TLI Solutions, Inc., 2007.

Figure 2-6
SI Exposure Pathways for
Receptors to MC, Fort Clinton West MRS

Fig 2-5 and Fig 2-6_FC_Exposure Pathways for MEC and MC.vsd

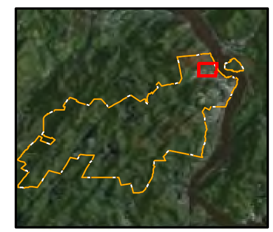
Figure 2-7
Fort Clinton West MRS
(WSTPT-008-R-01)
Grid and Transect Locations
U.S. Army Garrison West Point

Path: Y:\West_Point\mxd\RI\FCW_Grid_Transect_locs.mxd Author: ricksc 1/27/2014 3:04:51 PM

WESTON SOLUTIONS

Legend

- Fort Clinton West MRS - 14.4 Acres
- DGM Survey Area
- Mag and Dig Survey Area
- Mag and Dig Transects
- 8" Butler Projectile
- Frag
- 8" Butler Projectile (UXO)



Imagery Source: ESRI Mapping Service. 2013

N W E S

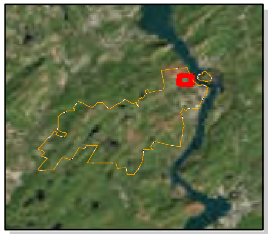
0 390
Feet

Figure 2-8
Fort Clinton West MRS
(WSTPT-008-R-01)
Dig Results
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\FCW_Dig_Result_Cultural_Debris.mxd, 12/19/2013 3:31:13 PM, ricksc

Legend

- Fort Clinton West (WSTPT-008-R-01) - 1.7 Acres
- Portion of Fort Clinton West (12.7 acres) transferred to Artillery Firing Range North MRS (WSTPT-001-R-02)
- Crows Nest Impact Area



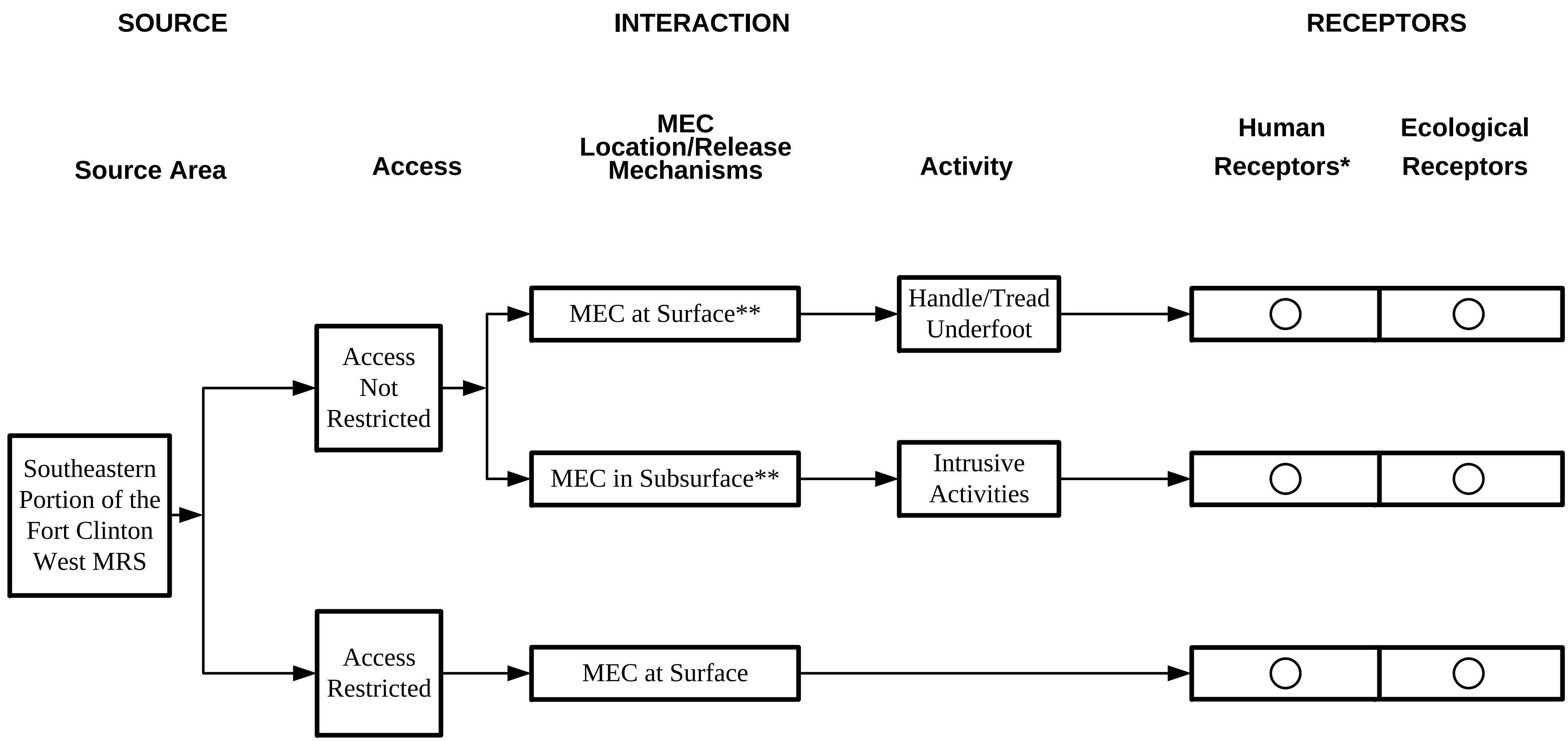
Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 175 350 Feet

Figure 2-9
Fort Clinton West MRS
Revised Boundaries
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\FCW_Revised_MRS.mxd, 11/3/2014 2:51:48 PM, ricksc



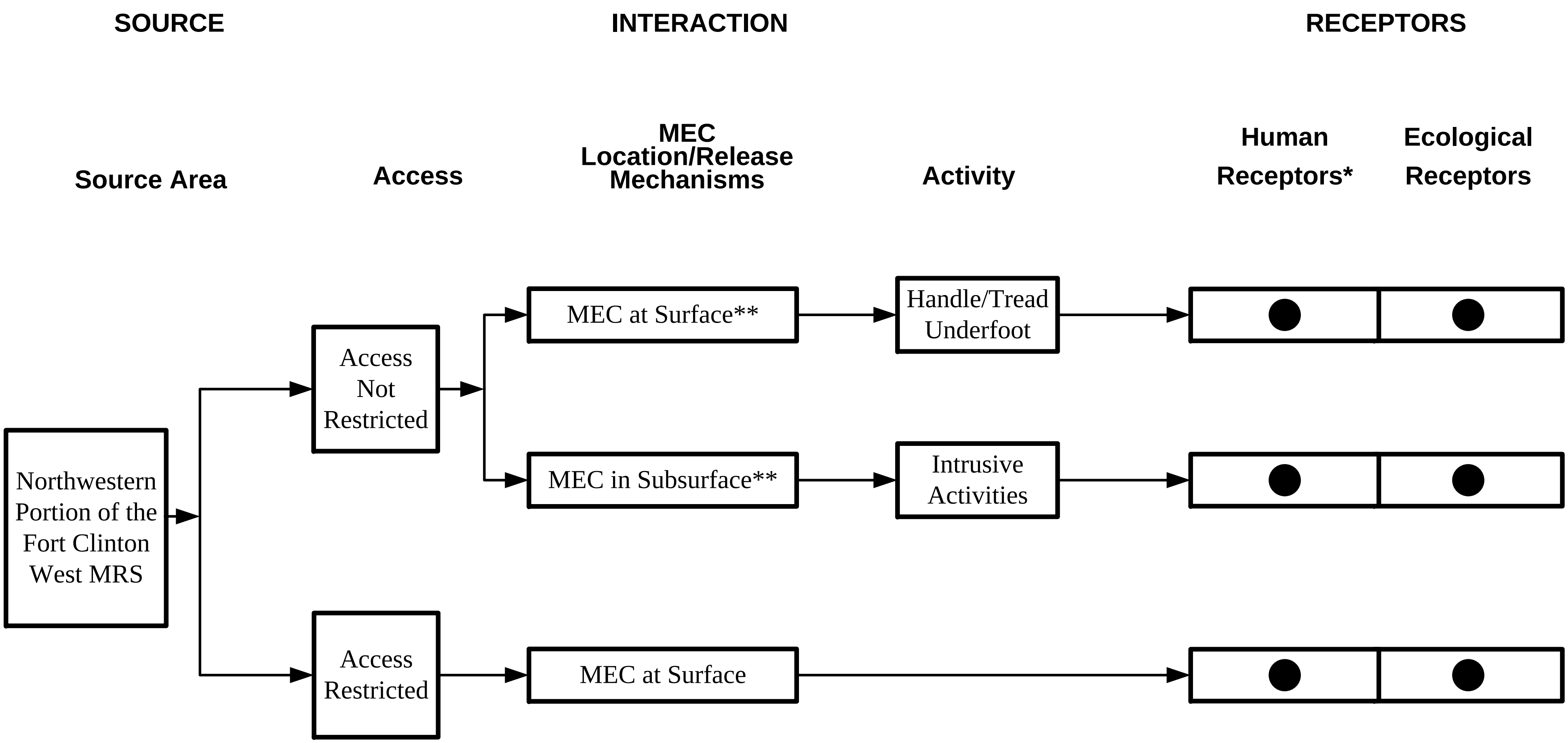
* Human receptors include the following: West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

** No MEC or MD was recovered during the RI.

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

Figure 2-10
RI Exposure Pathways for Receptors to MEC in the Southeastern 1.7-Acre Portion of the Fort Clinton West MRS

Fig 2-10_2-11_2-12_2-13_Fort Clinton_Exposure Pathways for MEC and MC.vsd

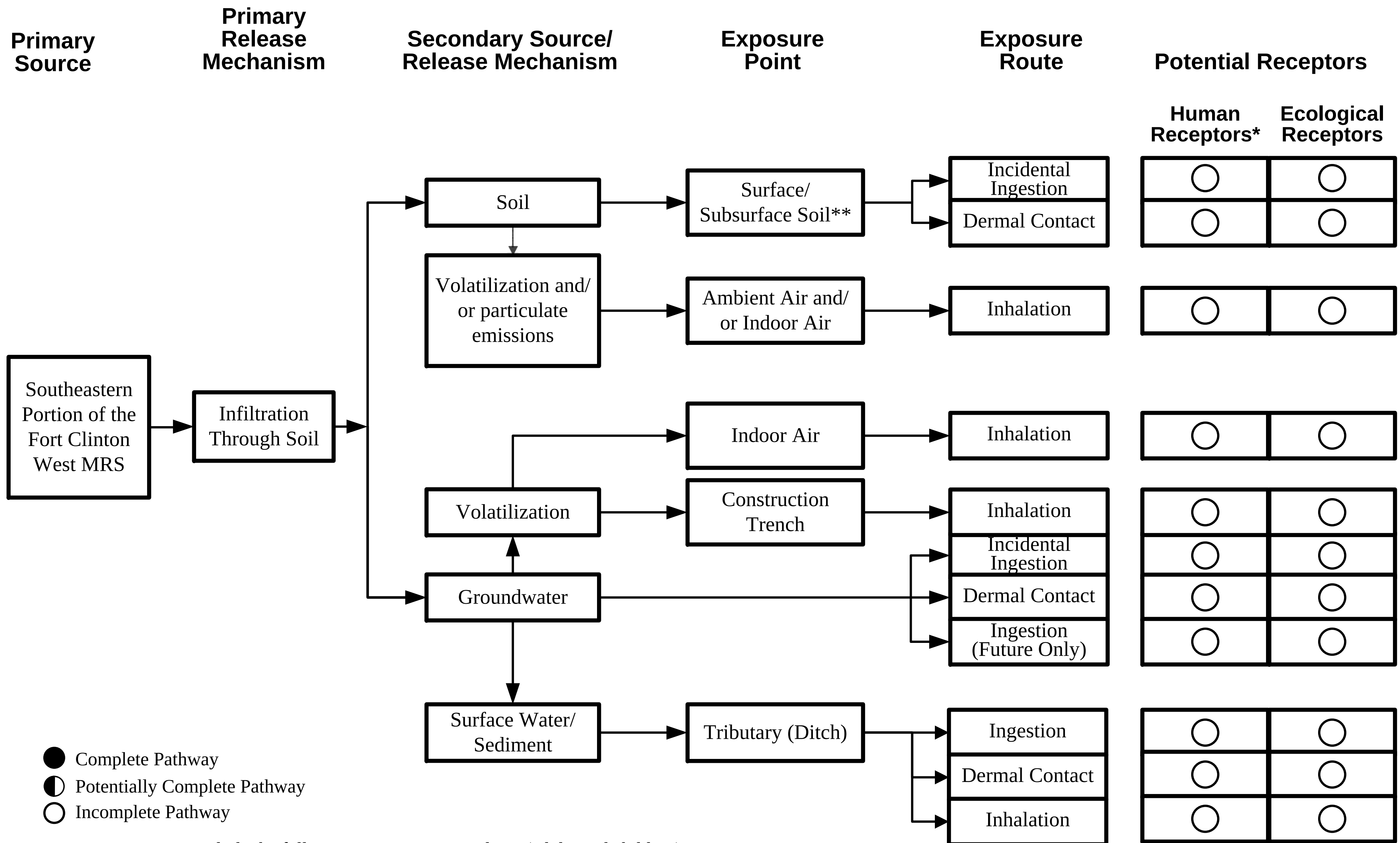


* Human receptors include the following: West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

** UXO was recovered between 3 and 8 inches bgs during the RI. MD was recovered at ground surface and to 12 inches bgs.

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

Figure 2-11
RI Exposure Pathways for Receptors to MEC in the
Northwestern 12.7-Acre Portion (Crows Nest Impact Area) of the Fort Clinton West MRS

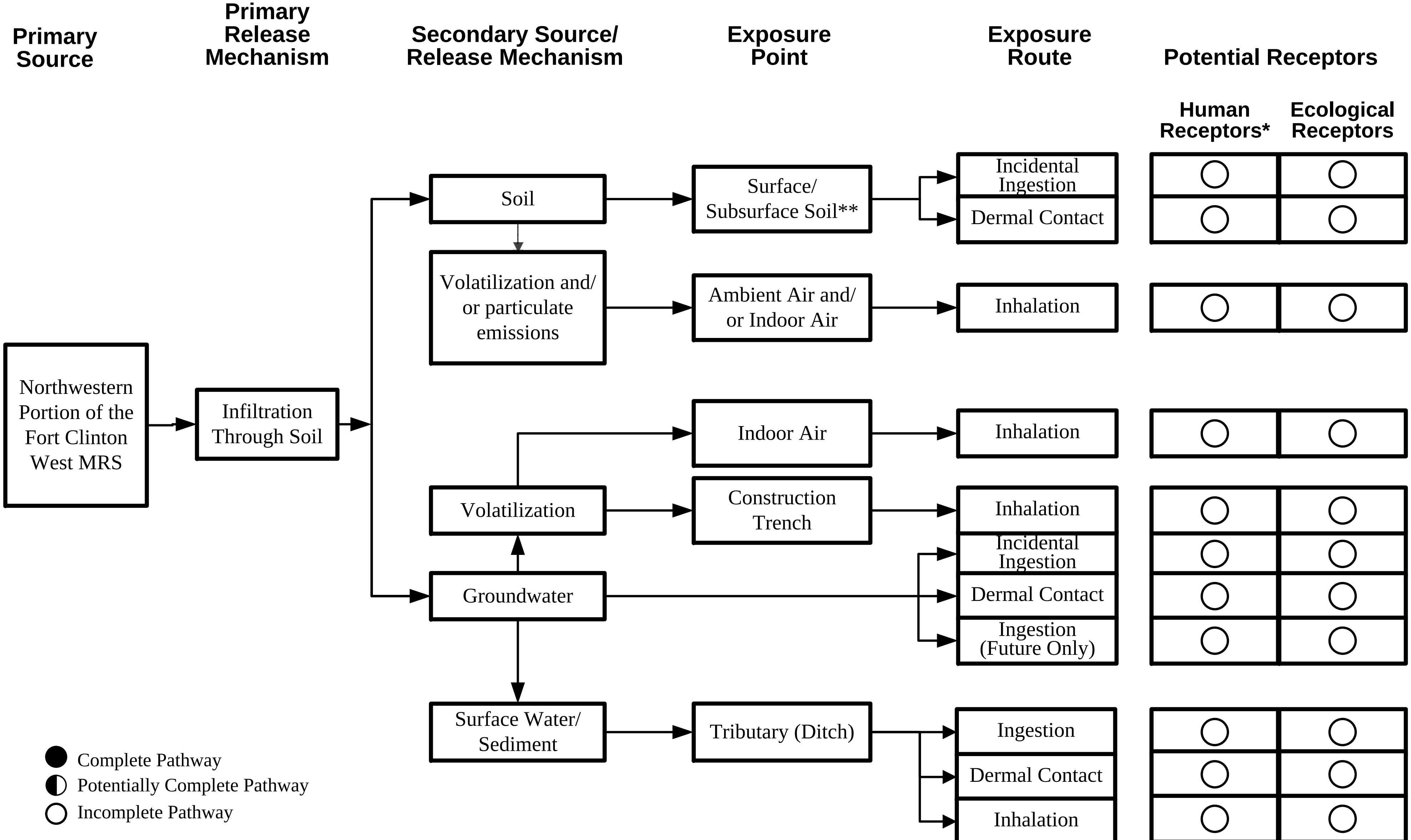


* Human receptors include the following: West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

** No MEC or MD was recovered during the RI.

Figure 2-12
RI Exposure Pathways for Receptors to MC in the Southeastern 1.7-Acre Portion of the Fort Clinton West MRS

Fig 2-10_2-11_2-12_2-13_Fort Clinton_Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** UXO was recovered between 3 and 8 inches bgs during the RI. MD was recovered at ground surface and to 12 inches bgs.

Figure 2-13
RI Exposure Pathways for Receptors to MC in the Northwestern 12.7-Acre Portion (Crows Nest Impact Area) of the Fort Clinton West MRS

3. SIEGE BATTERY MRS

3.1 INTRODUCTION

Section 3 presents the activities, results, and conclusions from the Military Munitions Response Program (MMRP) remedial investigation (RI) performed to characterize the Siege Battery munitions response site (MRS) tracked under WSTPT-015-R-01 in the Army Environmental Database – Restoration Module.

3.1.1 Site Description

The Siege Battery MRS (WSTPT-015-R-01), which encompasses a total of 179.3 acres[1] on the east and west banks of the Hudson River (**Figure 3-1**), is a former artillery firing range. The firing point for the range was located south of Gees Point and the Hudson River in the northeast corner of the West Point installation. The firing point for Seacoast Battery is included in the Siege Battery MRS. The eastern portion of the range fan (east bank of the Hudson River) extends onto a segment of Constitution Island, which is within the West Point installation boundary. The western portion of the Siege Battery MRS is located on the west bank of the Hudson River and includes a portion of the range fan that extends northward and terminates at the Crows Nest mountain in the northern extent of West Point (**Figure 3-2**). On the Main Post of the Siege Battery MRS, the majority of the range fan that is included within the MRS boundary overlaps with the Fort Clinton range fan. On Constitution Island, a small portion of the Seacoast Battery range fan overlaps with the Siege Battery range fan.

The boundaries of the Siege Battery MRS are not specific to streets or buildings. The portion of Siege Battery MRS on the west bank of the Hudson River is bordered by the river to the east and northeast. Approximately 86 structures and a small portion of the West Point Cemetery are

[1] The area for the Siege Battery MRS (WSTPT-015-R-01) reported in the SI was 179.3 acres (TLI, 2007), which was subsequently used in the Final RI Work Plan (WESTON, 2011a). During the RI, this area was determined to include portions of the Hudson River; therefore, the acreage was adjusted to 167.1 acres to align with the current land boundary. The 12.2 acres removed are assumed to be associated with the Siege Battery – TD – River MRS (WSTPT-016-R-01).

located within the boundaries of the western portion of the Siege Battery MRS. These structures include residential housing, a sewage treatment facility, Gillis Field House, Eisenhower Hall, and an amphitheatre on the western shore of the Hudson River. No structures are located within the Constitution Island portion of the Siege Battery MRS (**Figure 3-3**).

3.1.1.1 Climate

The climate of the region that includes West Point is characterized as a humid, continental climate. Summers are warm and have periods of high humidity. The semi-permanent Bermuda High brings south to southwest warm and humid air to the area. July is the hottest month, with a mean temperature of 86 degrees Fahrenheit (ºF); and the coldest month of the year is January, which has a mean temperature of 27 ºF. Winters are cold with extended periods of snow cover and are influenced by the cold Hudson Bay air masses. Most winters are characterized by one or more warm periods when soils nearly or completely thaw (Tetra Tech, Inc., 2011).

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 (Tetra Tech, Inc., 2011).

Thunderstorms occur approximately 20 times per year. Tornadoes occur at a frequency of 3 to 4 times a 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 the least amount (approximately 3.5 inches each month) occurring in January and February, and the most precipitation occurring in May (approximately 4.9 inches) (Tetra Tech, Inc., 2011).

3.1.1.2 Geology

West Point lies in the Hudson Highlands, a low, rugged mountain range, that forms a zone of folded and faulted metamorphic and igneous rocks subjected to extensive weathering and erosion. Precambrian-age granite, diorite, gneiss, and schist compose the majority of the crystalline bedrock underlying West Point. Granite, the most prevalent rock type in the bedrock, is typically medium-grained and composed of quartz, feldspar, and mica. Granite and pegmatite are igneous rocks that occur as dikes and sills within the gneiss. Igneous rocks on the West Point installation consist of plagioclase feldspar, hornblende, pyroxene, and biotite mica and quartz (Tetra Tech, Inc., 2011).

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 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 (Tetra Tech, Inc., 2011).

The faults mapped at the surface near and within the habitation area at West Point include the Long Pond, the Crown Ridge, and the Highland Brook faults. 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 (NY 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 between the Long Pond and Crown Ridge faults (Tetra Tech, Inc., 2011).

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 features are 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 primarily large boulders and clay, sand, and gravel deposited directly from glacial ice as it progressed or regressed across the area (Tetra Tech, Inc., 2011).

Site-specific geologic investigations were not conducted for the Siege Battery MRS, and information regarding site-specific geology is not available for the MRS**.** Regional geologic maps (Cadwell, 1989; Fisher et al., 1970) indicate that the bedrock geology of the Siege Battery MRS consists of the following:

- Biotite-quartz-plagioclase gneiss with subordinate biotite granitic gneiss, amphibolite, calcsilicate rock.
- Leucogranitic gneiss.
- Quartz plagioclase gneiss, which may contain pyroxenes, hornblende, biotite; locally interlayered with amphibolite; subordinate biotite mesoperthite gneiss.
- Rusty and gray biotite-quartz-feldspar gneisses; rusty facies containing variable amounts of garnet, sillimanite, cordierite, graphite, sulfides; minor marble and calcsilicate rock.

3.1.1.3 Topography

The topography of West Point is best described as having moderately steep hills and numerous escarpments. Slopes from 10 to 60% are common on the West Point 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 (Tetra Tech, Inc., 2011). The elevation ranges between 0 feet (0 meters) and 355 feet (108 meters) above mean sea level (amsl) on the Main Post portion of the Siege Battery MRS. On the Constitution Island portion of the MRS on the east side of the Hudson River, the shoreline includes steep cliffs ranging in elevation from 0 feet (0 meters) to 20 feet (6.1 meters). The maximum elevation within the Constitution Island portion of the MRS is approximately 100 feet (30.5 meters) amsl.

3.1.1.4 Soils

Eleven specific soil types, from six general soil map units, exist within the Siege Battery MRS based on the soils mapped within West Point (Tetra Tech Inc., 2011). The six units include the following: Charlton-Paxton, Chenango, Hollis, Otisville and Hoosic, Rock outcrop-Hollis, and Swartswood. **Figure 3-4** presents the location of each of the 11 specific soil types in the Siege Battery MRS. Because of the position of the Siege Battery MRS in the landscape, the 11 soil types in the MRS range from moderately well drained to excessively drained. Soil depths in the Siege Battery MRS range from shallow to deep.

3.1.1.5 Hydrology

3.1.1.5.1 Surface Water

No surface water bodies are located in the Siege Battery MRS. The following surface water bodies are located within a 3-mile radius of the MRS: the Hudson River, Crows Nest Brook, Sinclair Pond Brook, Delafield Pond, Lusk Reservoir, Kinsley Farm Brook, Stony Lonesome Brook, Highland Brook, Dassori Pond, and Cragston Lakes (see **Figure 3-1**).

3.1.1.5.2 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 West Point installation, but the deposits are thin and generally have fairly small well yields that average about 40 gallons per minute (gpm). 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 (Tetra Tech, Inc., 2011; TLI Solutions, Inc. [TLI], 2007). However, based on the geology, an unconsolidated aquifer does not exist within the Siege Battery MRS. Site-specific groundwater investigations were not conducted for the Siege Battery MRS.

3.1.1.6 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 in that five physiographic provinces—the Appalachian Plateaus, Folded Appalachians (Valley and Ridge), New England, Piedmont, and Coastal Plain—converge within a 35-mile radius of the West Point installation. West Point is located in the New England Province in an area known as the Hudson Highlands (Tetra Tech, Inc., 2011).

3.1.1.6.1 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

West Point installation. One of the 12 specially managed sites is Constitution Island, and a portion of the Siege Battery MRS is located on Constitution Island.

Constitution Island is the highest (maximum elevation 140 feet) and largest (177 acres) of the Hudson River's rocky islands. During the Revolutionary War, the island was occupied by American colonists who were fighting for emancipation from British rule. To establish defenses against the British, fortifications were constructed on the island in 1775, and then again in 1778. The remains of these fortifications are still present. Constitution Island supports a largely undisturbed matrix of forest, grassland, and wetlands. Contributing to its regional value, Constitution Island provides habitat for a number of sensitive fauna and flora species (Tetra Tech, 2011).

Forests cover most of Constitution Island. Crests support chestnut-oak forest, oak-pine woodland, or oak-heath rocky summit savanna; hollows support hemlock-hardwoods (mostly oaks); and lowlands support red maple swamp. Non-forest communities include patches of rocky summit grassland, steep riverfront cliffs, rocky intertidal shores, and areas frequently mowed or cleared of tall woody plants. A 1993 wetland inventory conducted on all West Point properties identified eight wetland habitats on the island. Contributing to its regional value, Constitution Island provides habitat for a number of sensitive fauna and flora species. The bald eagle (state threatened) is a frequent winter visitor. There have been sightings of least bitterns (state threatened), small-footed bat (state special concern), ospreys (state special concern), and spotted turtles (state special concern). Rare and unusual plants found on the island include prickly pear cactus (*Opuntia* sp.), cluster sedge (*Carex cumulata*), weak stellate sedge (*Carex seorsa*), pigmyweed (*Crassula (Tillaea) aquatica*), slender crabgrass (*Digitaria filiformis*), yellow harlequin (*Corydalis flavula*), small-flowered crowfoot (*Ranunculus micranthus*), violet wood-sorrel (*Oxalis violacea*), two-flowered bladderwort (*Uticularia biflora*), green-fruited clearweed (*Pilea fontana*), red-root cyperus (*Cyperus erythrorhizos*), sedge (*Carex seorsa*), and Long's bittercress (*Cardimine longii*) (Tetra Tech, 2011).

3.1.1.6.2 Wetlands

Approximately 1,010 acres of wetlands are located throughout West Point in association with streams, ponds, depressions, and seeps (Tetra Tech, Inc., 2011). Four wetlands areas totaling

2.24 acres are found in the portion of the Siege Battery MRS located on Constitution Island. Three of the four wetlands are classified as palustrine scrub shrub wetlands and total 2.12 acres. The fourth, a 0.12-acre wetland, is a palustrine forested wetland. There are no wetlands located within the western portion of the Siege Battery MRS.

3.1.1.6.3 Flora

Vegetation within the developed areas of the western portion of the Siege Battery MRS is limited to the mowed lawn and trees that are characteristic of developed, landscaped areas. Undeveloped areas within this part of the Siege Battery MRS are steep, heavily wooded terrain. The eastern portion of the Siege Battery MRS, located on Constitution Island, is undisturbed and heavily forested.

3.1.1.6.4 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 species of fish and invertebrate species (Tetra Tech, Inc., 2011). It is unlikely that the majority of these species are present in the developed areas of the Siege Battery MRS. The Constitution Island portion of the MRS may provide habitat for some of these species.

3.1.1.6.5 Ecological Receptors

Potential ecological receptors were provided by West Point and are presented in the overall conceptual site model (CSM) for West Point. The following list of ecological receptors was modified from the list of receptors in the overall CSM for West Point to include only those species that have the potential to exist within the Siege Battery MRS:

- Mammals: Small-footed bat and Indiana bat.
- Birds: Cooper’s hawk, Northern goshawk, sharp-shinned hawk, golden eagle, American bittern, red-shouldered hawk, whip-poor-will, common nighthawk, cerulean warbler, Peregrine falcon, common loon, bald eagle, yellow-breasted chat, least bittern, red-headed woodpecker, osprey, pied-billed grebe, vesper sparrow, and golden-winged warbler.
- Reptiles: Eastern wormsnake, spotted turtle, wood turtle, timber rattlesnake, Eastern hognose, and Eastern box turtle.

- Amphibians: Jefferson salamander, blue-spotted salamander, and marbled salamander.
- Insects, Dragonflies, and Damselflies: Lateral bluet, Needham's skimmer.
- S1* Plants: Virginia snakeroot, glomerate sedge, stripe-fruited sedge, and Carolina cranesbill.
- S2* Plants: Long's bittercress, midland sedge, slender crabgrass, violet wood sorrel, Carey's smartweed, and small-flowered crowfoot.
- S2S3* Plants: Cluster sedge, purple milkweed, Emmon's sedge, Bicknell's sedge, Bush's sedge, false hop sedge, weak stellate sedge, yellow harlequin, racemed pinweed, violet bush clover, slender knotweed, and gemmed bladderwort.

*Notes:

S1 = Critically imperiled in New York State because of extreme rarity (5 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.

An MRS-specific inventory of floral and faunal species was not conducted in the Siege Battery MRS. The *Integrated Natural Resources Management Plan for the United States Army Garrison – West Point* (Tetra Tech, Inc., 2011) contains an extensive list of species that have been documented at West Point.

3.1.1.7 Sensitive Environmental Resources within the MRS

Weston Solutions, Inc. (WESTON®) submitted a request for review by the New York Natural Heritage Program (NYNHP) to determine whether there are records of any known rare, threatened, and endangered species or species of special concern located within or near the West Point MRSs. In response, the 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 the 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 remaining species have the potential to occur within the Siege Battery MRS. However, because the western portion of the MRS is extensively developed, it is unlikely that these species would rely on this portion of the MRS for habitat. The undeveloped portion of the Siege Battery MRS on Constitution Island may provide potential habitat for these species; however, the NYNHP did not identify any federally-listed threatened or endangered plant species in any of the West Point MRSs.

3.1.1.8 Cultural and Archaeological Resources

Because West Point is one of the older training grounds in the United States that is still intact, it contains numerous cultural, archaeological, and historical sites. Several areas containing historical debris, such as bottles and broken dishes, were found within the western portion of the Siege Battery MRS. A small portion of the West Point Cemetery also is located in the western portion of the Siege Battery MRS. In addition, the site of a Revolutionary War encampment (see **Figure 3-3**) is present along the shoreline of Constitution Island (TLI, 2007; WESTON, 2011a).

3.1.1.9 Current and Projected Land Use

Most of the land area on the Main Post is highly developed or is considered undevelopable because of steep slopes. West Point is divided into four land use zones based on the functional categories that reflect the West Point missions (Tetra Tech, Inc., 2011):

- Cadet Use: Academic, intramural athletic, billeting, and parading.
- Cadet Support: Intercollegiate athletic fields and some cadet support facilities.
- Post Support: Housing, commercial, and service support to staff and faculty, non-West Point military personnel, and military retirees.
- Recreational, Industrial, Field Training: Building and storage area support for industrial operation, field training areas, recreation areas, and open space.

The Siege Battery MRS includes each of the four land use zones. The MRS is used for Residential and Military Academy housing, classrooms, and recreation. A solid waste landfill (Post School Landfill) is located in the western portion of the Siege Battery MRS. The Target Hill wastewater treatment plant is located on the western portion of Siege Battery MRS adjacent to the railroad grade. Constitution Island, which is part of the West Point Reservation and is located entirely within a Recreational, Industrial, Field Training area, is used for recreational activities. Recreational activities within the Siege Battery MRS include hiking, bird watching, and cross-country skiing. Hunting and trapping are not permitted within the MRS or in the vicinity (Tetra Tech, Inc., 2011). No changes to the current land uses are anticipated.

3.1.2 Previous Investigations

3.1.2.1 Historical Information

The Siege Battery was constructed in approximately 1845 on the site of Battery Sherburne, at what is now called Trophy Point. Battery Sherburne was built in 1778 and contained two iron six-pounders on garrison carriages and eight iron six-pounders on stocked or field carriages. Six-pounders fired solid metal artillery munitions that did not contain any explosive material. Construction of the Siege Battery is believed to have destroyed all traces of Battery Sherburne. A photograph of the Siege Battery taken in 1869 depicts a variety of 20- and 30-pounder Parrott rifles, and various mortars. During the latter part of the 19th century, the Siege Battery was renamed Battery Schofield and was used for training with Parrott rifles. Between 1876 and 1889, several guns burst at the Siege Battery, including a 4.5-inch rifled gun and two 30-pounder Parrott guns. The battery of 30-pounder Parrott guns was condemned in 1889, and was then replaced by a battery of old 4.5-inch rifled guns (TLI, 2006).

In 1891, the armament of the Siege Battery consisted of six 4.5-inch rifled cast-iron siege guns, three 10-inch smooth bore siege mortars, and three 8-inch smooth bore siege mortars. In 1892, the three 8-inch mortars were removed and replaced with three 10-inch smooth bore mortars. Additionally, six 3.2-inch rifles were mounted on the wooden carriages of the 3-inch rifles and used for drill practice. Although the 4.5-inch guns remained in position, their replacement with four new 5-inch steel breech-loading guns and two 7-inch steel breech-loading howitzers had begun. By 1898, two 5-inch breech-loading siege rifles were in use (TLI, 2006).

A complete new Siege Battery, consisting of four 5-inch breech-loading rifles and two 7-inch breech-loading howitzers, a complete battery of six 7-inch steel breech-loading mortars, and two 3.2-inch guns, was received in 1899. All of the weapons were in use by 1906. The target for the guns used at the Siege Battery was on Crows Nest mountain, an approximate 2,000-yard distance. Full charges were not used in any of the guns. The targets for the mortars were anchored in the Hudson River. Heavy ordnance at the battery could not be fired with full-service charges because of the close range of the targets (TLI, 2006).

Use of the Siege Battery ended between 1906 and 1910, when Battery Schofield came into service. During the fall and spring of 1907-08, an additional battery of two 6-inch disappearing coastal defense guns was constructed immediately in front and just north of the Siege Battery. Battery Schofield had no magazine or shell rooms, but instead had a 16-foot by 12-foot storeroom between the guns. These 6-inch guns were used for sub-caliber practice, using a floating target towed back and forth across the Hudson River between Storm King Mountain on the west side of the Hudson River and Cold Spring, which is in the east bank of the Hudson River. Practice from the battery occurred in April and October, but full charges were not used in any of the guns (TLI, 2006).

The exact year in which firing from the battery ceased is not clear. Both the Siege Battery and Battery Schofield appear on a West Point map dated 1935. A map from 1937 indicates the Siege Battery had been replaced by an amphitheatre, but Battery Schofield remained. By 1939, a map indicates that both batteries had been replaced by the amphitheatre, which is still present today and is used periodically for outdoor entertainment as the Trophy Point Amphitheatre. This change in historical use of the Siege Battery MRS is supported by the Annual Report from 1937 that states that the construction of an amphitheatre near Battle Monument had been completed during that year at a cost of $5,000. However, according to the 1950 Annual Report, the 6-inch guns and disappearing carriages at Battery Schofield were used until 1946. They were declared obsolete in January 1950 and were later transferred to the West Point Museum for exhibit (TLI, 2006).

The site of the former Seacoast Battery structure, of which no traces remain, is located under the North Dock parking lot in the southern extent of the Siege Battery MRS. Additionally, most of the former Seacoast Battery range fan is included in the Siege Battery MRS because the direction of fire from the Seacoast Battery was towards the north. Thus, munitions formerly used at the Seacoast Battery may be present within the Siege Battery MRS.

Several unexploded ordnance (UXO) investigations and removals have been conducted in relation to the Storm King site, located due north of West Point within what is currently Storm

King State Park. The recovered UXO is believed to be associated with testing activities from the West Point Foundry (located upstream of West Point along the Hudson River in Cold Spring, New York, and sometimes referred to as the Putnam County or Cold Spring Foundry). UXO identified at the Storm King site could also have been fired from several locations within West Point at targets on Crows Nest mountain, resulting in overshots that landed in the Storm King area (ATI, 2006). Historical documentation indicates that former munitions training at West Point included firing in the direction of Crows Nest from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and the Redoubt No. 2 MRS (TLI, 2006 and 2007). Therefore, UXO similar to the type of UXO identified at the Storm King site and at Crows Nest during historical surveys and removals may also be present in these MRSs (see Section 6.1.2 for details regarding historical investigations related to Crows Nest).

3.1.2.2 Geophysical Survey at West Point Elementary School

In September 2000, a digital geophysical mapping (DGM) project was conducted during the construction of a gymnasium at the West Point Elementary School, which is located just east of the current MRS boundary and (falls within the Artillery Firing Range MRS). As a follow-up to the geophysical study, an anomaly investigation and removal was conducted in 2001. Three ordnance or ordnance-related items were identified – a 6.5-inch projectile, rifled; a portion of an 8-inch Parrott round; and a fragment from an 8-inch Parrott round. According to the report compiled following the study, “scouring and deformation on the rear of the 6½-inch projectile indicate it might have deflected at a shallow angle.” In addition, the report stated the two 8-inch Parrott fragments appeared to fit together even though they were recovered over 75 feet apart. These two fragments fitting together may indicate that the projectile exploded in the area (TLI, 2006). Although the location from which these items were fired could not be determined, there is historical documentation of Parrott rifle use at the Siege Battery (see Section 3.1.2.1), which had a firing direction towards Crows Nest. Parrott rounds and Parrott fragments may also be indicative of former testing activities that involved firing from the nearby West Point Foundry (east side of the Hudson River) towards targets on Crows Nest mountain north of where the Siege Battery MRS boundary terminates. The foundry was the primary supplier of heavy cannon, including the Parrott gun, to Union land and naval forces during the Civil War (Smithsonian, 2013).

3.1.2.3 Site Inspection Report and Results

The site inspection (SI) field activities at the Siege Battery MRS, which were conducted in spring 2006, included visual surveys along approximately 40 linear miles, 2.7 miles (1.1 acres) of geophysical mapping, and the collection of one sediment sample and seven surface soil samples for munitions constituents (MC) analysis (TLI, 2007).

During the visual survey, each team member walked individual transects, nominally spaced at 10- to 50-foot intervals (based on terrain, ground cover, and vegetation), to identify and record all munitions and explosives of concern (MEC), munitions debris (MD), and munitions-related materials. Hand-held Global Positioning System (GPS) units were used to track the visual survey transects, and a waypoint was logged when items were observed. GPS units were accurate to within 15 to 40 feet, depending on satellite availability and tree canopy. In addition, Schonstedt magnetic locators and handheld electromagnetic metal detectors were used during the visual survey to aid in the identification of metallic items at ground surface. At times it was necessary to extend the visual surveys beyond the boundaries of the MRS. Work outside the MRS boundaries was required for several reasons, including attempts to accurately locate firing points, the need to circumvent unsafe terrain or dense vegetation, and the need to access sites from outside locations (TLI, 2007). The visual survey coverage and sample locations are presented in **Figure 3-5**.

Generally, the visual surveys were divided into three sections: (1) Constitution Island; (2) the eastern portion (which is located to the southeast of the North Athletic Field MRS and includes the area between the North Athletic Field MRS and the Hudson River); and (3) the western portion (which is located to the northwest of the North Athletic Field MRS) (**Figure 3-3)**. Within the portion of the Siege Battery MRS located on Constitution Island, one UXO item, a 3-inch Stokes mortar round with missing tail boom/exhaust vents and fuze missing, and 17 MD items, including one partial Mark IV fuze for a 3-inch Stokes mortar round and 16 fragments, were observed during the visual surveys. Nine of the 16 fragments were related to military munitions. No munitions-related items were found in the eastern portion of the Siege Battery MRS. However, metal debris was found that was related to the construction of the railroad and the drainage culverts that empty into the river. Extensive visual surveys were conducted in the portion of the Siege Battery MRS located to the north and west of Townsley Road and throughout the area surrounding the Lee Housing Area, which is also south of the Crows Nest area. The area was littered with extensive amounts of MD consisting primarily of fragments from Civil War Era munitions. The largest piece of MD was located at the top of the hill just east of Lee Gate at the northern traverse of the area. It was approximately 13.5 inches long and approximately 1 inch thick. An expended .30 caliber Remington 17 round was also identified (TLI, 2007).

Geophysical mapping was conducted over the central portion of the Siege Battery MRS, located between the Target Hill MRS and the Lee Housing Area, and the area between the West Point Cemetery and the wastewater treatment plant. Geophysical mapping identified 397 subsurface anomalies. A geophysical survey that included a portion of the Siege Battery MRS was conducted in April 2001. This survey identified 1,539 anomalies within the study area; however, the number of anomalies located within the Siege Battery MRS is not known. The U.S. Army Engineering and Support Center in Huntsville, Alabama, evaluated the data for the geophysical survey and recommended that West Point conduct sampling in the area to determine whether the anomalies were ordnance related (TLI, 2007).

One sediment sample (USMA-SB-SD001) and seven surface soil samples were collected within the Siege Battery MRS. Two surface soil samples (USMA-SB-SO001 and USMA-SB-SO002) were collected on Constitution Island. Surface soil sample USMA-SB-SO007 was collected from the eastern portion of the Siege Battery MRS, and the remaining samples were collected around the Lee Housing Area. The sediment and surface soil samples were analyzed for Target Compound List (TCL) explosives and a subset of the Target Analyte List (TAL) metals. Metals were selected for analysis based on the metals known to be associated with the munitions historically used at West Point. The sediment and surface soil samples were analyzed for antimony, copper, iron, lead, mercury, potassium, and zinc. The analytical results for seven TAL metals and TCL explosives were compared, for evaluation purposes only, against U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for residential soils (current screening levels at that time), where available.

Trace amounts of several explosives were detected in the surface soil samples. The concentrations were below the corresponding EPA Region 9 PRGs and applicable laboratory reporting limits. The other explosive compounds included in the analyses were not detected at the Siege Battery MRS, and explosives were not detected in the sediment sample.

The SI Report (TLI, 2007) provided the following findings for the Siege Battery MRS:

- 1,3,5-Trinitrobenzene was detected in three samples: USMA-SB-SO001 at 0.11 milligram per kilogram (mg/kg), USMA-SB-SO002 at 0.11 mg/kg, and USMA-SB-SO004 at 0.023 mg/kg, all of which are below the EPA Region 9 PRG of 1,800 mg/kg. These samples were collected from Constitution Island and near the MRS boundary along Highway 218.
- 2,4-Dinitrotoluene was detected in USMA-SB-SO007 at 0.10 mg/kg, which is below the EPA Region 9 PRG of 120 mg/kg. This sample was collected from the eastern portion of the MRS near the estimated location of the firing point for the battery.
- 2,6-Dinitrotoluene was detected in sample USMA-SB-SO005 at 0.035 mg/kg, which is below the EPA Region 9 PRG of 61 mg/kg. This sample was collected on the hillside between the Lee Housing Area and the Target Hill MRS.
- 4-Amino-2,6-dinitrotoluene was detected in sample USMA-SB-SO004 at 0.20 mg/kg. This sample was collected from near the western boundary of the Siege Battery MRS in proximity to Highway 218. There was no established EPA Region 9 PRG for this specific isomer at the time of the SI; however, the detected levels are well below the EPA Region 9 PRG for aminodinitrotoluene, which is used as the standard for comparison.
- 4-Nitrotoluene was detected in sample USMA-SB-SO007 at 0.11 mg/kg, which is below the EPA Region 9 PRG of 12 mg/kg. This sample was collected from the eastern portion of the MRS near the estimated location of the firing point for the battery.
- Copper, iron, lead, mercury, potassium, and zinc were all detected in the samples collected within the Siege Battery MRS. In addition, a trace amount of antimony was identified in two samples. The concentrations were below the applicable screening values with the exception of iron. Iron was detected in samples USMA-SB-SO001 at 47,700 mg/kg and USMA-SB-SD001 at 24,800 mg/kg. The EPA Region 9 PRG for iron is 23,000 mg/kg. Sample USMA-SB-SO001 was collected on Constitution Island at the location where a cast iron fragment was found. Sample USMA-SB-SD001 was collected from a drainage located downgradient of the Lee Housing Area and to the west of the Target Hill MRS. It is possible that the iron content associated with sample USMA-SB-SO001 was the result of iron being leached from the MD at the Siege Battery MRS. However, the iron content of sample USMA-SB-SD001 is probably the result of the naturally occurring iron in area soils. Based on the geology of the area, which includes the presence of rocks with a highly oxidized iron content, it is assumed that the level of iron in the soil is the result of local geologic conditions. Background data regarding the naturally occurring level of iron in the soil were not available from West Point.

Based on the results of the SI, which identified MEC on Constitution Island, the Siege Battery MRS was recommended for further investigation of MEC and MC.

3.1.2.4 Munitions Response Site Prioritization Protocol Scoring

The Munitions Response Site Prioritization Protocol (MRSPP) reflects the statement in 10 United States Code (U.S.C.) §2710(b)(2) that the priority assigned should be based on the overall conditions at each location, taking into consideration various factors relating to safety and environmental hazard potential. As required under 10 U.S.C. §2710(b)(1), the priority assigned to each MRS will be included with the inventory information made publicly available. The requirement for an inventory of MRSs known or suspected of containing UXO, discarded military munitions (DMM), or MC is found at 10 U.S.C. §2710(a). The assigned priority will be reviewed annually and updated to reflect new information that becomes available.

The MRSPP was applied to the Siege Battery MRS following the SI. The Siege Battery MRS was assigned a Priority 3 (out of 8) based on the potential explosive hazard identified during construction activities. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with chemical warfare materiel (CWM) can be assigned to Priority 1, and no MRS with CWM can be assigned to Priority 8. The MRSPP was reapplied based on the RI results and is presented in Section 3.9.2.

3.1.3 Remedial Investigation Report Organization

Section 3 is organized as follows:

- Section 3.1 provides the purpose and scope of the project, a description and history of the MRS, and a summary of the previous investigations.
- Section 3.2 includes a discussion of the preliminary CSM, preliminary remediation goals, data needs, and data quality objectives (DQOs) used to develop the RI.
- Section 3.3 provides details on the approach, methods, and procedures used to characterize MEC.
- Section 3.4 provides the details of the MC sampling.
- Section 3.5 provides the results of the RI characterization activities.

- Section 3.6 presents the results of human health and ecological baseline risk assessment activities for MC and also presents the preliminary identification of potential applicable or relevant and appropriate requirements (ARARs).
- Section 3.7 addresses the MEC and MC fate and transport processes.
- Section 3.8 presents the revised CSM developed for the MRS based on the RI findings.
- Section 3.9 addresses the MEC hazard assessment and the reapplication of the MRSPP to the Siege Battery MRS based on the data collected during the RI.
- Section 3.10 presents the RI summary and conclusions.

The references cited in Section 3 are provided in Section 8.

3.2 PROJECT REMEDIAL RESPONSE OBJECTIVES

The goal of the RI was to characterize the nature and extent of potential MEC and MC and to assess the hazards and the baseline risks to human health or the environment from MEC and MC. The overall RI approach included the following:

- Developing DQOs and data needs through the Technical Project Planning (TPP) process.
- Performing mag and dig and digital geophysical mapping (DGM) surveys.
- Intrusively investigating the anomalies detected during the mag and dig and DGM surveys.
- Removing and disposing of the recovered MEC and material documented as safe (MDAS).
- Conducting MC sampling at the Siege Battery MRS based on the presence of a known artillery firing range fire point.
- Reporting results through the TPP process throughout the RI to gain stakeholder concurrence.
- Revising the CSM and reapplying the MRSPP based on the RI data collected.
- Submitting the RI Report.

The specific processes and procedures used to conduct this investigation are detailed in the *Final Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison*

West Point, West Point, NY (Final RI Work Plan) (WESTON, 2011a). The characterization approach follows the methods presented and approved in the TPP 1 and TPP 2 meetings (see Section 3.2.2). The investigation methods are summarized in Sections 3.3 and 3.4 of the RI Report, and the RI results are presented in Section 3.5.

3.2.1 Preliminary Conceptual Site Model

3.2.1.1 Development of a Conceptual Site Model

The CSM is used as a planning tool to integrate MRS information from a variety of sources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process for further data collection or action. The CSM development should be viewed as a process that reflects the progress of activities at an MRS from initial assessment through closeout. The CSM is divided into three primary components: potential sources, interactions, and receptors for MEC and/or MC, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. Each component is described below:

- Sources — Sources are those areas where MEC or MC has entered (or may enter) the physical system. An objective of the RI is to detect and delineate sources using geophysical surveys and intrusive investigations.

- Interactions — The hazard from MEC and the risk from MC are a result of direct human contact through an activity. Interactions describe ways that receptors come into contact with a MEC and/or MC source. For MC, interactions can include physical transportation of the contaminant and transfer from one media to another through various processes such that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. For MEC, movement is not typically significant, and interaction will occur only at the source area, limited by access and activity. There can be movement of MEC through natural processes such as frost heave and soil erosion.

- Receptors — A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use because receptors are determined on that basis. Receptors include human receptors, such as West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors, and ecological receptors.

The preliminary CSM for the Siege Battery MRS was based on the information collected during the SI (TLI, 2007). Based on the SI results, MEC exposure pathways are complete because MEC and MD were observed at the Siege Battery MRS. The primary exposure mechanism for human and ecological receptors to surface MEC is through handle/tread underfoot. In addition, a subsurface pathway may occur because biota may nest or burrow at the Siege Battery MRS (TLI, 2007). **Figure 3-6** depicts the MEC exposure pathways for the Siege Battery MRS based on the results of the SI.

Based on the results of SI soil sampling, only iron was identified above the EPA Region 9 PRGs (screening levels current at time) at the Siege Battery MRS. Therefore, the exposure pathways for MC in soil to all human and ecological receptors were considered complete (TLI, 2007). **Figure 3-**7 depicts the SI exposure pathways for receptors to MC at the Siege Battery MRS.

The CSM is updated as new data and information become available. The data collected during the RI were used to revise the preliminary CSM developed following the SI, and the revised CSM is presented in Section 3.8.

3.2.2 Technical Project Planning

Prior to the initiation of RI field activities, representatives and stakeholders from the U.S. Army Corps of Engineers (USACE), West Point, EPA, New York State Department of Environmental Conservation (NYSDEC), WESTON, and TLI participated in two TPP meetings. TPP 1 was conducted on July 29, 2010. At this meeting, the MRS summary and the RI approach, objectives, planning documentation, and field investigation and reporting requirements were discussed.

TPP 2 was conducted on February 3, 2011. The project stakeholders reviewed the Draft Final RI Work Plan and identified and discussed project goals and DQOs. Details regarding the implementation of the MMRP RI were presented and discussed among the group. Based on the results of the second meeting, specific details of the investigation approach for the Siege Battery MRS, including coverage area, survey type (grid versus transect), and quantities, were determined. The results from the TPP 2 meeting were integrated into the Siege Battery MRS DQOs and presented in the Final RI Work Plan (WESTON, 2011a).

3.2.3 Data Quality Objectives

The data needs and DQOs were determined at the planning stage and are discussed in more detail in the Final RI Work Plan (WESTON, 2011a). The data needs include characterization of the nature and extent of MEC and MC at the Siege Battery MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of the data generated for its intended use; and the ability to infer valid assessments from the data. The DQO process includes the following seven steps:

1. **State the problem:** Provide a concise description of the problem.
2. **Identify the decisions:** Develop decision statements to solve the problem.
3. **Identify inputs to the decision**: Identify information and measurements needed to make the decisions.
4. **Define study boundaries:** Identify conditions such as spatial and temporal boundaries.
5. **Develop a decision rule:** Qualify the decisions to understand data needs.
6. **Specify tolerable limits on decision errors:** Develop performance criteria.
7. **Optimize the design:** Design an effective data collection strategy based on the previous steps.

3.2.3.1 Siege Battery Data Quality Objectives

The following DQOs were developed specifically for the Siege Battery MRS and were agreed upon by the stakeholders during the TPP sessions:

1. **State the problem:** This MRS is associated with the former Siege Battery range fan. The target area for this range was located north of West Point and not in this MRS. MEC and MD were observed in the MRS; however, the approximate density of MEC has not been verified. MC may also be present if a MEC release is detected within the MRS.

   A former firing point is also located within the MRS. There is a potential for MC to be present at this location because of former training activities. Burial of unused munitions was sometimes practiced during training. Buried MEC may be present at the firing point. Target butts for the former 1,000-yard rifle range were located within the MRS. No evidence of the target butts was identified during the SI visual surveys. The area in which these target butts may have been located has been developed for residential and Military Academy housing, classrooms, and recreation.

2. **Identify the decisions:** The primary decisions for this MRS include:

   - Determine the approximate MEC density in the MRS based on UXO Estimator coverage requirements.

   - If a MEC release is observed in the MRS, characterize the nature and extent of MEC and evaluate MC.

   - Characterize the nature and extent of MC if it is detected at the firing point.

- Detect and investigate the potential burial features associated with munitions disposal at the firing point.
- Delineate potential MC if evidence of small arms range target butts is observed.

3. **Identify inputs to the decision:** Several inputs will be acquired during the course of the RI to support the decision. UXO Estimator requires that 5.86 acres be investigated to determine at a 95% confidence level that less than 0.5 MEC/acre is present within the MRS. DGM and mag and dig surveys will be performed along transects and in grids to accomplish the UXO Estimator requirements. All anomalies will be investigated. Intrusive results for MEC, MD, and non-MD will be evaluated in the project Geographic Information System (GIS). If a MEC release is detected, discrete or incremental soil and sediment sampling will be performed to determine whether MC is present. Incremental sampling will be performed at the firing point to determine the nature and extent of potential MC. DGM and intrusive investigations as necessary will be used to detect burial features at the firing point.

4. **Define study boundaries:** The Siege Battery MRS is 179.3 acres (acreage assumed in the Final RI Work Plan), and the two parts of the MRS are divided by the Hudson River. The eastern portion of the MRS is located on Constitution Island, and the western portion is located in the main part of the Garrison. The MRS surrounds the Target Hill MRS and part of the North Athletic Field MRS. The northern MRS boundary intersects with the operational range area. The extent of potential MEC and MC observed during the RI will be delineated using DGM, mag and dig, discrete MC sampling, and incremental MC sampling; however, operational range areas will not be accessed.

5. **Develop a decision rule:** The results of the RI at the Siege Battery MRS will be used to:

   - Assess, based on intrusive anomaly investigations, whether MEC density is less than 0.5 MEC/acre in the MRS.
   - Reassess the characterization approach if MEC density is found to be greater than 0.5 MEC/acre or if the CSM is not valid.
   - Determine whether MC is present at the firing point and fully characterize the nature and extent of MC.
   - Determine whether MEC burial features are present at the firing point and determine the nature and extent of MEC at burial sites.

6. **Specify tolerable limits on decision error:** It is anticipated that a low density of MEC exists at this MRS because of its location near the firing point of the overall range fan. The characterization approach will confirm that less than 0.5 MEC/acre is present at the MRS. If there is less than 0.5 MEC/acre within the MRS, no additional MEC investigations will be required to validate MEC density. If MEC is identified during intrusive work within the MRS, additional sampling may be warranted to achieve the desired confidence level. Additional sampling will be performed only if the MRS is still assumed to have a low density of MEC consistent with the CSM for the MRS. Additional coverage requirements will be determined by UXO Estimator.

7. **Optimize the design:** DGM surveys using a Geonics EM61-MK2 and mag and dig surveys using White's XLT all-metals detectors will be performed across the required 5.86 acres consistent with UXO Estimator assumptions. This includes eight 100-foot by 100-foot grids and approximately 3.5 miles of transects. Mag and dig surveys will be used in areas inaccessible to the DGM instrumentation. All anomalies will be investigated to determine the approximate MEC density.

3.3 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN

This section provides the comprehensive approach, methods, and operational procedures used for the MEC characterization performed at the Siege Battery MRS. The RI field activities were conducted between April 12 and August 11, 2011 (see **Table 3-1**).

Table 3-1 Siege Battery RI Field Activities

RI Field Activity	Dates
Location Surveying and Mapping	04/12/11 to 04/13/11
DGM Survey	04/20/11
Mag and Dig Survey	06/21/11 to 08/03/11
Intrusive Investigation	06/21/11 to 08/03/11
MC Sampling	08/08/11 to 08/11/11

3.3.1 Investigation Coverage Requirements

UXO Estimator (Version 2.2) is a software package developed by USACE to assist in designing field sampling plans to determine the MEC density for MRSs and to analyze field data after the data have been collected. UXO Estimator calculates the amount of acreage within an MRS that needs to be investigated to determine that a specific MEC density is present across the MRS to a preselected confidence level. The software inputs include the size of the MRS, the anticipated MEC density, and the confidence level to which the anticipated MEC density is to be tested.

A 0.5 MEC/acre density and a 95% statistical confidence at which to test the MEC density hypothesis were selected for the Siege Battery MRS. The 0.5 MEC/acre density was chosen by the project team during the project planning phase based on the historical use and munitions previously found in and surrounding the Siege Battery MRS, and the guidelines provided in the help menu of the UXO Estimator software. Based on these factors, at least 5.86 acres would require investigation to be 95% confident that there are less than 0.5 MEC/acre at the Siege Battery MRS.

UXO Estimator provides a quantitative assessment of the upper bound MEC density. In the case of the Siege Battery MRS, this upper bound density is 0.5 MEC/acre, which means that the MEC density can range from 0 MEC/acre to 0.5 MEC/acre if no MEC is recovered in the MRS. As part of the post-results analysis, qualitative assessments using information from the revised CSM should be conducted to determine the actual MEC density within this range.

3.3.1.1 Data Collection and Site Coverage

To achieve the investigation coverage calculated by UXO Estimator, geophysical surveys were performed at pre-planned transect and grid locations across the Siege Battery MRS based on the Final RI Work Plan (WESTON, 2011a). Both DGM and analog surveys were performed to locate surface and subsurface anomalies for further investigation along the transects and/or grids within the MRS. Both methods of anomaly detection were employed to maximize the coverage based on the MRS accessibility and terrain. A total coverage of 5.88 acres was performed at the Siege Battery MRS, which exceeded the amount of coverage required based on the initial UXO Estimator calculation. Two transects were specifically placed and investigated in the vicinity of the Siege Battery firing points. The following sections detail the geophysical investigations performed as part of the RI.

3.3.1.1.1 Location Surveys and Mapping

Location surveys and mapping activities were conducted within the Siege Battery MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Surveying was performed by Beatty & Watson, a New York-licensed surveyor. The location surveys and the mapping task included the following:

- Establish site control relative to North American Datum 1983 (NAD 83), Universal Transverse Mercator (UTM) coordinate system, in units of U.S. Survey Feet.
- Install DGM survey control and mark out with survey nails.

The survey control locations used during the DGM surveys are listed in **Appendix 3-A**.

3.3.1.1.2 Mag and Dig Surveys

UXO Technicians traversed 2.99 miles of pre-planned transects using GPS as a navigational aid. Each transect was 10 feet wide, equating to a total of 3.62 acres. Additionally, 1.57 acres of mag and dig grids were surveyed within the Siege Battery MRS. UXO Technicians used analog instrumentation (White's XLT all-metals detectors) to detect anomalies. Mag and dig transects were selected for because the terrain and vegetation would have limited the ability to perform DGM surveys. Eight of the 18 mag and dig transects, and all five mag and dig grids were located within the northern and northwestern sections of the Siege Battery MRS. Additional mag and dig transects investigated included four transects located in the areas south and southwest of the Target Hill MRS, two transects located in the vicinity of the firing point, and four transects located on Constitution Island. **Figure 3-8** and **Appendix 3-B** present the survey locations within the MRS.

3.3.1.1.3 Digital Geophysical Mapping Surveys

Three grids, each measuring 100 feet by 100 feet, were placed in accessible locations of the MRS. Grid locations were adjusted in the field to avoid obstructions that might affect data quality or coverage. Once the general locations of the DGM grids were established, the surveyor set survey control at regular intervals to be used for digital data positioning. DGM surveys were then performed using a Geonics EM61-MK2 with line and fiducial navigation and positioning. DGM surveys were conducted within the Siege Battery MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Any obstructions, such as trees or large boulders, were documented in field notes.

DGM surveys of approximately 0.69 acre were completed at the Siege Battery MRS. **Appendix 3-B** presents the survey locations within the MRS. Tests for instrumentation detection capabilities and functionality were conducted for the Siege Battery MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a).

Geophysical System Verification

The Geophysical System Verification (GSV) approach was used to monitor and verify the geophysical equipment functionality during the DGM surveys. The GSV approach includes an

Instrument Verification Strip (IVS) and a blind seeding program to monitor the sensor detection performance throughout the duration of the DGM survey effort. IVS-specific data and results are provided in **Appendix 3-C**.

Instrument Verification Strip

The IVS was installed near current H-Block Field and linearly seeded with five items, including one small industry standard object (ISO), two medium ISOs, one inert 37 millimeter (mm) projectile, and one inert 75mm projectile. Item types were confirmed with the USACE Quality Assurance (QA) Geophysicist prior to construction. **Table 3-2** lists the IVS seed items and descriptions.

Table 3-2 Instrument Verification Strip Seed Items and Descriptions

IVS Seed Item Type	Northing	Easting	Orientation	Depth	Description
Small ISO[a] (1 inch by 4 inches)	15033479.01	1921684.05	Horizontal	4.2 inches	Part Number[b]: 44615K466 ASTM Specification: A53/A773.
Medium ISO[a] (2 inches by 8 inches)	15033473.57	1921675.82	Horizontal	7.7 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.
37mm projectile	15033467.92	1921667.50	Horizontal	4.3 inches	Inert projectile.
75mm projectile	15033462.55	1921659.03	Horizontal	10.7 inches	Inert shrapnel projectile.
Medium ISO[a] (2 inches by 8 inches)	15033457.11	1921650.70	Horizontal	6.8 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.

Notes:
a - ISOs are schedule 40 pipe nipples, threaded on both ends, made from black welded steel and manufactured to an American Society for Testing and Materials (ASTM) specification.
b - Part number from the McMaster-Carr catalog.

The items were seeded linearly over 70 feet and were spaced 10 feet apart horizontally (least favorable orientation) with the long axis aligned parallel to the ground surface. Item types were confirmed with the USACE QA Geophysicist prior to construction. After IVS construction, a DGM survey was performed to demonstrate the instrument functionality and to verify that the seed item responses were consistent with the instrument response curves calculated for the EM61-MK2. All responses matched the appropriate response curves based on the seed item type and depth. IVS-specific data and results are provided in **Appendix 3-C**.

The IVS and unseeded test strip were visited daily before and after the DGM surveys and intrusive investigations. Both the EM6-MK2 and White's XLT were tested at the IVS. The results of this survey were then compared to the seed item response baseline and sensor response curves to determine that the geophysical equipment was operating properly.

The pre- and post-survey IVS results for the days that DGM data were collected at the Siege Battery MRS are presented in **Table 3-3**. The results collected for each day of DGM at the IVS show agreement and repeatable results for the series of seeds. The seed items placed within the IVS were observed in the geophysical data with signals consistent with the sensor response curves developed for the EM61-MK2. All peak responses from the seed items were observed to be greater than the least favorable orientation response and to have consistent responses between the surveys. These results demonstrate that the digital geophysical equipment was functioning within a tolerable range to achieve detection performance metrics. Photographs of the equipment are provided in **Appendix 3-D**.

Table 3-3 Instrument Verification Strip Results

Item Description	Small ISO	Medium ISO	37mm Projectile	75mm Projectile	Medium ISO
Item Depth (inches)	4.2	7.7	4.3	10.7	6.8
Least favorable orientation response (mV)	10.8	64.2	14.8	60.6	73.4
IVS Date	**Response (mV)**				
20 April 2011 AM Pre-Survey	26	110.9	44.09	85.13	85.11
20 April 2011 PM Post-Survey	25.97	107.89	43.06	82.82	85.62

Blind Seeding

A seeding program was instituted in the geophysical survey grids to provide ongoing monitoring of the geophysical instrumentation detection performance. Seeds were blind to the geophysical data collection teams. After the medium ISO seed items were initially placed within the DGM grids, the locations and depths of the items were surveyed. All blind seed items were observed in the geophysical data with a signal consistent with the sensor response curves developed for the EM61-MK2, and within the 3.25-feet offset metric established in the project-specific measurement quality objectives (MQOs).

The seeds were recovered by the UXO teams during intrusive investigations. **Table 3-4** lists the depth, type, geophysical response, and offset of the seed items placed within the DGM grids. The location and depth of the seeds items were surveyed by Beatty & Watson.

Table 3-4 Blind Seeding Results

Grid	Item	Depth (inches)	Orientation	Target ID	Status	Peak Response (mV)	Offset (inches)
SB-03	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	SB-03-200	Recovered	97.10	0
SB-05	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	SB-05-030	Recovered	81.30	0
SB-09	Medium ISO (2-inch x 8-inch pipe)	3	Horizontal	SB-09-112	Recovered	100.5	1

3.3.2 Data Processing and Quality Control

The EM61-MK2 data were imported into the Geonics® DAT61MK2 software for pre-processing. DAT61MK2 is used to convert the raw binary sensor data into a Geosoft®-compatible XYZ data file. Each XYZ file contains data for each of the four time gates recorded, the position, and the time stamp associated with each reading. Digital data were processed by the Site Geophysicist using Geosoft's Oasis montaj software. The IVS and quality parameters that were monitored and assessed daily during data processing included:

- Coverage.
- Velocity.
- Sample separation.
- Noise.
- Function tests: static, static response, and cable connection tests.

Instrument functionality tests were conducted before and after DGM surveying adjacent to the IVS located at H-Block Field. The Static Test and Static Response Test involved collecting non-dynamic data for a period of 1 minute without and with a small ISO item, respectively. Tests for the EM61-MK2 show background noise levels ranging from 0.5 to 2.2 standard deviations, with minimum and maximum readings between -6 millivolts (mV) and 2 mV. The Static Spike Test measurements range from a minimum value of 38 mV to a maximum value of 46 mV with a standard deviation between 0.66 and 1.86. Static Response Test data for the EM61-MK2 show consistent response values within the ±20% metric over the test object in pre- and post-survey tests. The project metric for test data was established at a standard deviation of less than 2.5. No anomalous data spikes or outside interference was observed during the static instrument tests.

Background noise was evaluated for each dataset by windowing a section of the data and generating statistics using the UX-Process quality control (QC) module. Statistics calculated for Siege Battery MRS DGM data are presented in **Table 3-5**. Channel 2 was then gridded using a grid cell size of 0.25 feet with a search radius of 2 feet and blanking distance of 2.25 feet.

Table 3-5 DGM Data Parameters

Data Metric		Mean Sample Separation (ft)	Mean Velocity (mph)	Background Noise (mean)	Background Noise (standard deviation)
	DQO	**< 0.5 ft**	**< 3 mph**	**MRS Specific**	**< 2.5**
Grid ID	SB-03	0.32	2.15	0.36	1.427
	SB-05	0.3	2.0	0.69	1.85
	SB-09	0.32	2.13	0.39	0.96

Anomalies were selected from the Channel 2 gridded data using the Blakely Test target selection algorithm. A target threshold value of 7.2 mV on Channel 2, as approved by the USACE QA Geophysicist, was used to select the initial target list. This threshold was based on the sensor response curve for a 75mm projectile at a depth of 3 feet in the least favorable (horizontal) orientation. Target review consisted of manually evaluating all selected targets and removing or merging multiple targets associated with large anomalies. Processing parameters are listed in **Table 3-6**.

A target decay analysis was run to remove targets that had an atypical decay between the four time gate channels. An atypical decay is observed when an anomaly signal does not decrease through time, but instead shows an increase in any of the subsequent time gate channels. The most common causes of atypical decay are due to external radio frequency interferences or rough terrain encountered during data collection. **Appendix 3-B** presents the DGM data results with target locations.

Table 3-6 EM61-MK2 Data Processing Parameters

Process	Parameter
Drift – Non-Linear Drift Correction Filter (UCEDRIFT.GX)	Window Length: 100 % lowest values ignored: 10% % highest values ignored: 70% All data channels were processed using the same parameters.
Statistical Evaluation of Background Noise	Windowed section of background/using UX-Process QA/QC module to evaluate standard deviation and mean noise values.
Grid	Cell Size: 0.25 ft Blanking Distance: 2.25 ft Search Radius: 2 ft
Blakely Peak Picking Algorithm	Smooth Filter: 3 Normal Peak Detection Grid Value Cutoff: EM 7.2 mV
Target Decay Analysis	Performed based on each data channel.
Target Review	Performed.

All data related to DGM surveys were managed using Geosoft® Oasis montaj software. All spatial data were managed using a GIS, and are stored in Environmental Systems Research Institute® (ESRI)-compatible GIS formats, primarily ArcInfo coverage and ArcView shape files. All DGM data were provided electronically to the USACE QA Geophysicist for QA.

3.3.2.1 Anomaly Investigation Activities

A total of 241 anomalies were selected as part of the DGM data analysis. The anomalies were compiled into a dig list. The dig list data were logged into a hand-held computer and managed using WESTON's RespondFast® UXO Investigation software. Each of the anomalies was reacquired and intrusively investigated. Anomaly reacquisition was performed using a Trimble S8® Robotic Total Station (RTS) for navigation to the precise location of each target. A reacquisition team navigated to the location and marked it with a non-metallic pin flag designated by the unique anomaly ID. A total of 632 anomalies were detected during the mag and dig surveys. Dig lists developed following digital data analysis are presented in **Appendix 3-E**.

3.3.2.2 Anomaly Investigation Procedures

Intrusive investigations were conducted at the locations of the 873 anomalies detected as part of the geophysical surveys in accordance with the Final RI Work Plan (WESTON, 2011a), including the approved Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) and the Explosives Site Plan (ESP). Intrusive investigations at selected anomaly locations were performed to positively identify and recover MEC, material potentially presenting an explosive hazard (MPPEH), and MD. All recovered items were treated as MPPEH and were subject to field inspection to determine the nature of recovered anomalies. All items were verified free of explosives hazards prior to being relocated for future disposal.

The Senior UXO Supervisor (SUXOS) conducted oversight of all intrusive investigations, and the UXO Quality Control Specialist (UXOQCS) conducted daily QC following target reacquisition and intrusive investigation as documented in the Daily Reports for the RI (see **Appendix 3-F)**.

UXO Technicians began the anomaly investigations by sweeping a 3-foot radius around the pin flag with a White's XLT all-metals detector to focus the excavation at the peak response. The offset and northing and easting position of the peak response were recorded for each anomaly. Intrusive operations at each anomaly location were performed using hand tools. The UXO Technicians excavated at the location of the highest detector response until the source of the anomaly was found. The target location was considered clear when a signal source was no longer detected after removal of the conductive item, or the source of the signal was identified to be associated with a cultural feature such as a fence or building.

The exclusion zones during the intrusive operations were based on the project munition with the greatest fragmentation distance, which is a 75mm high explosive (HE) projectile. The minimum separation distance for nonessential personnel was 238 feet.

The dig teams used the personal hand-held computers with RespondFast UXO Investigation software to electronically log the target characteristics real-time in the field. Characteristics logged in RespondFast include item category, item type, depth, dig data, and final disposition.

The results of the intrusive investigation are provided in the expanded dig lists in **Appendix 3-E.** Photographs of the anomaly reacquisition process are provided in **Appendix 3-D.**

3.3.2.2.1 Inspection of Munition-Related Items

Munitions-related items underwent a three-step inspection process during the intrusive investigations. Munitions-related items were inspected in the grid by a UXO Technician II and then a Technician III and were classified as MPPEH or MD. After the Technician III inspected the item, the item underwent a third inspection by the SUXOS, with verification by the UXOQCS, to determine the final disposition. The item was then determined to be MD or material documented as an explosive hazard (MDEH). The items classified as MDEH were to be disposed of by detonation. At the Siege Battery MRS, no items were classified as MDEH.

MD was recovered from the grids, certified and verified as free from explosives, and stored in a locked container as MDAS. The items classified as MDAS pose no explosive hazard and were transported to a collection point for final disposal. A final inspection was conducted immediately prior to the transfer of MDAS to the West Point Recycle Center. Certified MDAS was transferred to the West Point Recycle Center with the completed DoD Form 1348-1A, signed by the SUXOS to certify that the material listed had been thoroughly inspected and, to the best of the SUXOS's knowledge and belief, was inert and/or free of explosives or related materials.

After the DoD Form 1348-1A was verified and signed by the UXOQCS, a copy was maintained and the original accompanied the MDAS to its final disposition at the West Point Recycle Center. Copies of the forms are provided in **Appendix 2-G**.

3.3.2.2.2 Intrusive Investigation Quality Control

In accordance with the Final RI Work Plan, the UXOQCS inspected at least 10% of the dig locations using a White's XLT all-metals detector to determine whether the removal was effective. The UXOQCS joined the intrusive team and inspected all digs made during one day. The results of the QC inspections for the intrusive investigation are provided in the UXOQCS reports (**Appendix 3-F**).

3.4 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS CONSTITUENTS

3.4.1 Purpose of Munitions Constituent Sampling

Characterization activities for MC were conducted in accordance with the Final RI Work Plan, specifically the UFP-QAPP and the MC Sampling Methodology Memorandum. Based on the

MC Sampling Methodology Memorandum, sampling activities would be performed at locations based on information obtained during the MEC investigation activities. MC investigations would be initiated if the following criteria were encountered:

- Further investigation of MC at currently unknown but potential MEC releases (i.e., concentrated munitions use areas) identified during the geophysical surveys conducted as part of the West Point RI.
- Further investigation of MC at known former artillery range firing points that potentially contain MC.
- MC sampling at individual MEC item locations where soil staining or visible evidence of a potential MC release is observed.

Incremental sampling for MC in surface soil was performed at the Siege Battery MRS firing point, located at the southern extent of the MRS (**Figure 3-8**), where MC may have been released from firing activities even though MEC was not found at this location. Soil sampling was also performed at the Siege Battery MRS during the RI to further investigate MC based on SI recommendations. In addition, MD was identified during the RI geophysical surveys, and a potential impact area was identified that extends across the boundaries of the Siege Battery MRS with the Fort Clinton West, Lusk Reservoir, and Artillery Firing Range MRSs. The results of the MC characterization are reported in Section 3.5.2.

3.4.2 Remedial Investigation Munitions Constituent Sampling

An RI MC sampling scheme based on historical data was developed prior to field work, and was presented in the Final RI Work Plan. However, following the intrusive investigation at the Siege Battery MRS, the MRS-specific sampling scheme was revised to account for the results of the investigation and to ensure that the MC sampling was conducted in the most appropriate locations of the Siege Battery MRS. On August 8, 2011, representatives from U.S. Army Corps of Engineers, Baltimore District (CENAB), West Point, NYSDEC, WESTON, and TLI participated in a MC Sampling Methodology Memorandum teleconference meeting. The purpose of this meeting was to bring all of the stakeholders together to discuss the proposed revisions to the MMRP RI MC sampling approach outlined in the MC Sampling Methodology Memorandum (**Appendix 3-H**), which specifically addresses the Siege Battery MRS, and to gain approval from the group to implement sampling.

The locations of the sampling units in the Siege Battery MRS, as presented in the MC Sampling Methodology Memorandum, were established based on the location of the MEC and/or MD identified within the Siege Battery MRS and the adjacent Fort Clinton West MRS during the SI and RI. The acreage associated with each sampling unit was determined based on the density and distribution of MEC and MD identified. The number of increments collected from within each sampling unit was based on the USACE Interim Guidance Document 09-02, *Implementation of Incremental Sampling of Soil for Military Munitions Response Program* (USACE, 2009). Therefore, the following sampling was proposed in the MC Sampling Methodology Memorandum:

- Seven 0.8-acre sampling units (plus one field duplicate) would sufficiently cover the areas where MEC and/or MD were identified, with one of the sampling units placed along the border with the Fort Clinton West MRS. The 0.8-acre sampling unit size was based on the average size of a residential lot, but enlarged slightly to encompass the distribution of MEC and/or MD within the impact area. Fifty increments were proposed for collection within each of the sampling units established in the impact area.
- The results of the intrusive investigation did not alter the MC sampling scheme outlined in the Final RI Work Plan for the Siege Battery firing point. A single 0.5-acre sampling unit (plus one field duplicate) for the firing point was established prior to the field work based on the historical location of the Siege Battery, and this sampling unit sufficiently encompassed the area of concern at the firing point. Thirty increments were proposed for collection within the 0.5-acre sampling unit located at the Siege Battery firing point.

At the conclusion of the meeting, representatives from CENAB, West Point, NYSDEC, WESTON, and TLI agreed upon the proposed sampling scheme.

Once the locations of the sampling units had been identified, as depicted on **Figure 3-8**, the increment locations were selected using a random number generator. The increment coordinates for each incremental sample were loaded into GPS units as waypoints for the field team and were also printed on the aerial maps that were used in the field. The field maps showing the locations of the planned incremental samples within the sampling units are included in **Appendix 3-I**.

One field team, consisting of two environmental scientists and one UXO Technician II, performed incremental sampling at the Siege Battery MRS. The field team each increment in accordance with the waypoint data that were loaded into the GPS unit prior to field activity. The sample team used a hand-held GPS unit to navigate to each increment location, or used a measuring tape to locate a specific offset, and placed numbered pin flags at each increment location. Sample increments were then collected by field personnel travelling a meandering path. Field personnel confirmed the collection of each increment in the field logbook according to the numbered flags in the sampling unit. The sample team did not record the specific path travelled to collect increments.

Once a surface soil increment area was located, the UXO Technician II performed anomaly avoidance using a metal detector. After the area was deemed safe, the environmental scientists collected a soil sample using a Multi-Incremental Sampling Tool (MIST) and placed the sample in a plastic resealable bag. If an area could not be cleared by the UXO Technician II, or if rocks or other debris were in the way, the field team sampled an area 1 meter away. There were no cases in which the location had to be eliminated because of UXO clearance issues. For some locations, surface features, such as tree roots, rocky areas, standing water, or steep drop-offs, were found at an increment location that had been selected by the random number generator prior to mobilization. In these cases, the incremental sample was collected as close as possible to the original location. The direction and the distance the incremental sample was moved were noted in the field logbooks included in **Appendix 3-I**. All incremental samples were surface samples and were collected from a depth of 0 to 3 inches. Sufficient sample mass, approximately 1 kilogram, was obtained for each sampling unit. Once all the increments were placed in the plastic resealable bag, the soil contents were labeled, homogenized, sealed, placed on ice, and shipped to the laboratory for analysis. The incremental samples were collected using new, clean, dedicated, and disposable equipment; therefore, no investigation-derived waste (IDW) (solid or liquid) was generated.

All increments were collected at the surface of the soil; there was no subsurface soil sampling at the Siege Battery MRS. The incremental sample and field duplicate collected at the firing point were analyzed for explosives only. The remaining incremental samples were analyzed for metal analytes in addition to explosives. **Table 3-7** summarizes the incremental sampling at the Siege Battery MRS.

Table 3-7 Incremental Sample Summary at the Siege Battery MRS

MRS	No. of Incremental Samples (Sample Numbers)	Size of Incremental Sampling Unit (acres)	No. of Increments	Analysis
Siege Battery (firing point)	1 sample (plus 1 field duplicate): WPR07-SS01 and WPR07-SS02 (field duplicate)	0.5	30	Explosives
Siege Battery	6 samples total: WPR16-SS31 WPR16-SS32 WPR16-SS33 WPR16-SS34 WPR16-SS35 WPR16-SS36	0.8	50	Explosives and Metals
Fort Clinton West/Siege Battery	1 sample (plus 1 field duplicate)*: WPR03-SS26 and WPR03-SS27(field duplicate)	0.8	50	Explosives and Metals

*Samples WPR03-SS26 and WPR03-SS27 (field duplicate) are discussed in both Section 2 and Section 3 related to characterization of the Fort Clinton West MRS and the Siege Battery MRS because the sampling unit is located within both MRSs.

3.4.3 Analytical Laboratory and Analyses

Explosives were analyzed in surface soil for the incremental sample located at the Siege Battery firing point, and explosives and metals were analyzed in the remaining samples. Compounds potentially associated with each part of the Siege Battery MRS were evaluated for MC sampling. Because of the time period during which munitions were used at the MRS, specific nomenclature for the munitions was not available in the historical records; therefore, generic MC information was compiled. The explosives used in the greatest quantity at the Siege Battery MRS were trinitrotoluene (TNT) and nitroglycerin. These explosives are insoluble in water and do not hydrolyze, volatilize, or bioconcentrate under normal environmental conditions. They also have average adsorption coefficients, suggesting that they will reasonably adsorb to soil and sediments and maintain low soil mobility. In addition, the volatilization rate from soil is extremely low. Therefore, TNT, its breakdown products, and nitroglycerin are anticipated to remain in the environment and are good indicators of explosives at the Siege Battery MRS. **Table 3-8** lists the specific explosive compounds and metals included in the analysis of the soil samples.

Table 3-8 Explosives and Metals Analyzed in Surface Soil Samples from Siege Battery MRS

Analyte*	Notes
Explosives*	
Nitroglycerin	Known MC associated with munitions
Pentaerythritol tetranitrate (PETN)	Not associated with munitions used at the Siege Battery MRS; however, trace amounts of this explosive were detected during the SI in soil samples collected within the MRS.
2,4,6-Trinitrotoluene (TNT)	Known MC associated with munitions
2,4-Dinitrotoluene (2,4-DNT)	Breakdown product of TNT
2,6-Dintrotoluene (2,6-DNT)	Breakdown product of TNT
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	Breakdown product of TNT
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	Breakdown product of TNT
Metals	
Lead	Known MC associated with munitions
Mercury	Known MC associated with munitions

*Explosives were analyzed using EPA Method SW-846 535A/8330B; lead was analyzed using EPA Method SW-846 3010A/3050B/6010B; and mercury was analyzed using EPA Method SW-846 3050B/7471B.

Soil samples were submitted for analysis to a DoD Environmental Laboratory Accreditation Program (ELAP)-certified and National Environmental Laboratory Accreditation Conference (NELAC)-accredited laboratory, TestAmerica, Inc., located in South Burlington, VT. The laboratory provided a Level IV data package for validation that met the reporting requirements of *DoD Quality System Manual for Environmental Laboratories Version 4.2* (QSM 4.2) (DoD, 2010). The Level IV data package included all elements required to perform a full data validation, such as sample and QC data, chromatograms, raw data, instrument printouts, chain of custody records, log pages, and instrument calibration data. Samples were analyzed in accordance with the requirements of the analytical method, method-specific requirements of DoD QSM 4.2, and the project's Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) to ensure that sample results met project requirements for quality and technical competency. The analytical laboratory results are provided in **Appendix 3-J.**

Data validation was manually performed by an independent third party, MEC^{x}, LP, for 100% of the sample results.

Explosives data were validated in accordance with the following requirements:

- Method 8330B, Nitroaromatics, Nitroamines, and Nitrate Esters by High Performance Liquid Chromatography (HPLC) (EPA, 2006a).
- Validation of Data, Nitroaromatics and Nitroamines by HPLC, SW-846 Method 8330A (SOP HW-16, Rev. 2) (EPA Region 2, 2006).

- Data Validation Procedure for Explosives, Nitroaromatics, and Nitroamines (DVP-16, Rev. 0) (MEC^x, LP, 2009).
- Standard Operating Procedure for Routine Validation of High Explosive (HE) Analytical Data (SOP-5164, Rev. 0) (Los Alamos National Laboratory [LANL], 2008).
- *Final Uniform Federal Policy Quality Assurance Project Plan, Remedial Investigation for Military Munitions Response Program Sites, U.S. Army Garrison West Point, West Point, NY* (UFP-QAPP) (WESTON, 2011b), as presented in Appendix J of the *Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (WESTON, 2011a).
- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

Metals data were validated in accordance with the following requirements:

- Method 6010B, Inductively Coupled Plasma-Atomic Emission Spectrometry (EPA, 1996).
- Validation of Metals for the Contract Laboratory Program (CLP) based on SOW ILMO5.3 (SOP Revision 13) (EPA, 2006b).
- Data Validation Procedure for Metals (DVP-5, Rev. 0 and DPV-21, Rev. 0) (MEC^x, LP, 2009).
- *Final Uniform Federal Policy Quality Assurance Project Plan, Remedial Investigation for Military Munitions Response Program Sites, U.S. Army Garrison West Point, West Point, NY (UFP-QAPP)* (WESTON, 2011b), as presented in Appendix J of the *Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (WESTON, 2011a).
- *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004).

3.4.4 Screening Levels

The MC sample analysis results were compared against two sets of screening levels, human health soil screening values and soil ecological screening values (ESVs), which were defined in the Final RI Work Plan prior to the RI field work for the Siege Battery MRS. To facilitate RI data evaluation and comparisons, the Final RI Work Plan list of selected ESVs was expanded to include all potential ESVs available from various sources.

For human health soil screening values, Oak Ridge National Laboratory (ORNL) regional screening levels (RSLs) for residential soils and NYSDEC soil cleanup objectives (SCOs) for residential and unrestricted use were compared for each analyte. The ORNL RSLs, which are updated by ORNL (EPA, 2012) semi-annually, are now used by EPA as risk-based screening benchmarks (in place of the EPA Region 9 PRGs that were used in the SI).

For ESVs, NYSDEC, EPA ecological soil screening level (Eco-SSL), EPA Region 5 ecological screening level (ESL), ORNL Benchmark 1, and ORNL Benchmark 2 were compared for each analyte. For analytes for which there was no benchmark available (NBA) in the screening values listed in the RI Work Plan, additional research was conducted to identify ESVs. Publications, including U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) and scientific reports written by Efroymson et al. (1997a and 1997b) and Kuperman et al. (2006), were evaluated.

The screening values referenced in this section are deemed to-be-considered information (TBCs), except for NYSDEC SCOs, which are considered ARARs, as discussed in Section 3.6.3. **Table 3-9** lists the analyte and the lowest of the human health and ecological screening values used for sample comparison. MC sampling and analytical results are described in Section 3.5.2.

Table 3-9 Screening Levels for Explosives and Metals

Analyte	Human Health Soil Screening Value	Human Health Soil Screening Value Method Used	Ecological Soil Screening Value	Ecological Soil Screening Value Method Used[4]
Explosives (µg/kg)				
Nitroglycerin	610	ORNL Residential RSL[1]	3,000	USACHPPM[5]
Pentaerythritol tetranitrate (PETN)	NBA	NBA	170,000	USACHPPM[6]
2,4,6-Trinitrotoluene (TNT)	3,600	ORNL Residential RSL	70	USACHPPM[7]
2,4-Dinitrotoluene (2,4-DNT)	1,600	ORNL Residential RSL	1,280	EPA Region 5 RSL[3]
2,6-Dintrotoluene (2,6-DNT)	1,030	NYSDEC Unrestricted Use SCO[2]	32.8	EPA Region 5 ESL
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[8]
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[8]

Table 3-9 Screening Levels for Explosives and Metals (Continued)

Analyte	Human Health Soil Screening Value	Human Health Soil Screening Value Method Used	Ecological Soil Screening Value	Ecological Soil Screening Value Method Used[4]
Metals (mg/kg)				
Lead	63	NYSDEC Unrestricted Use SCO	63	NYSDEC
Mercury	0.18	NYSDEC Unrestricted Use SCO	0.18	NYSDEC

Notes:
[1] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (April 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.
[2] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html
[3] EPA. 2003. Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels - http://www.epa.gov/reg5rcra/ca/ESL.pdf
[4] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the following hierarchy was used to select the screening value: EPA Eco-SSL, EPA Region 5 ESL, ORNL Benchmark 1, ORNL Benchmark 2.
[5] USACHPPM, 2000.
[6] USACHPPM, 2001a.
[7] USACHPPM, 2001b.
[8] USACHPPM, 2005.
NBA = no benchmark available
µg/kg =microgram/kilogram
mg/kg = milligrams/kilogram

3.5 REMEDIAL INVESTIGATION RESULTS

This section presents the results of the RI MEC characterization (Section 3.5.1) and of the MC characterization (Section 3.5.2).

3.5.1 Results for Munitions and Explosives of Concern Characterization

As described in Section 3.3, the characterization performed at the Siege Battery MRS during the RI involved the following tasks:

- Mag and dig and DGM surveys.
- Digital data processing, analysis, and anomaly selection.
- Anomaly reacquisition.
- Intrusive investigation of detected anomalies.

The following paragraphs detail the results of these activities.

3.5.1.1 Geophysical Survey Results

A total of 5.88 acres within the Siege Battery MRS were investigated using DGM and mag and dig surveys. The mag and dig surveys were conducted over 5.19 acres using a White's XLT all-metals detector. All anomalies (a total of 632) detected were investigated by UXO Technicians to determine the anomaly source. A total of 0.69 acres of DGM surveys were performed using a man-portable EM61-MK2 sensor in cart mode. A total of 241 anomalies were selected from the DGM data for intrusive investigation. The intrusive investigation results of the 873 anomalies are discussed in the following subsection.

3.5.1.2 Intrusive Investigation Results

No MEC was observed in the Siege Battery MRS. A total of 646 MD items were recovered at depths ranging between the ground surface and 12 inches below ground surface (bgs). The MD was recovered from two concentrated areas—Constitution Island and the northwestern extent of the MRS where the boundary abuts the Crows Nest area. One MD fragment was located on the Main Post outside the area of concentrated MD associated with the Crows Nest area. The MD recovered from the Siege Battery MRS included the following items:

- Southeastern Main Post Portion
  - 1 fragment from unknown munitions
- Northwestern Main Post Portion (Crows Nest impact area)
  - 615 fragments from unknown munitions
  - One empty hand grenade (MKII)
  - One 3.5-inch cannonball (solid shot)
  - One 6-inch cannonball (solid shot)
  - One 8-inch Butler projectile
  - One 5.3-inch Parrott type II bottle top
  - One 10-inch Parrott type II bottle top
- Constitution Island
  - 24 fragments from unknown munitions.

The remaining non-MD-related material included 217 items classified as cultural debris, 7 no contacts, and 3 quality control seeds. These items were recovered between the surface and 16 inches bgs. **Figure 3-9** and **Figure 3-10, and Appendix 3-B** show the locations of the items recovered from the Siege Battery MRS. **Table 3-10** summarizes the MD recovered from the Siege Battery MRS. The complete dig list is provided in **Appendix 3-E**.

Table 3-10 MD Summary at the Siege Battery MRS

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-03-062	MD	Fragment	07/08/11	12	1.00	1
SB-03-074	MD	Fragment	07/08/11	3	0.5	1
SB-05-024	MD	Fragment	07/08/11	7	3.00	1
SB-05-028	MD	Fragment	07/08/11	4	3.00	1
SB-05-036	MD	Fragment	07/08/11	4	2.00	1
SB-05-040	MD	Fragment	07/08/11	3	0.5	1
SB-05-051	MD	Fragment	07/08/11	1	0.5	1
SB-05-063	MD	Hand Grenade MKII (empty)	07/08/11	1	1.00	1
SB-05-071	MD	Fragment	07/08/11	8	0.5	1
SB-05-072	MD	Fragment	07/08/11	6	0.1	1
SB-09-061	MD	Fragment	07/05/11	2	0.5	1
SB-09-103	MD	Fragment	07/05/11	4	1.00	1
SB-09-116	MD	Fragment	07/05/11	1	0.5	1
SB-09-118	MD	Fragment	07/05/11	2	0.5	1
DGM Grid Subtotal						**14**
SB-T01	MD	Fragment	07/06/11	2	1.00	1
SB-T01	MD	Fragment	07/06/11	5	3.00	2
SB-T01	MD	Fragment	07/06/11	3	4.00	2
SB-T01	MD	Fragment	07/06/11	1	2.00	1
SB-T01	MD	Fragment	07/06/11	6	2.00	2
SB-T01	MD	Fragment	07/06/11	4	2.00	1
SB-T01	MD	Fragment	07/06/11	5	1.00	1

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-T01	MD	Fragment	07/06/11	5	3.00	2
SB-T01	MD	Fragment	07/06/11	1	3.00	1
SB-T01	MD	Fragment	07/06/11	2	2.00	1
SB-T01	MD	Fragment	07/06/11	1	2.00	2
SB-T01	MD	Fragment	07/06/11	5	3.00	2
SB-T01	MD	Fragment	07/06/11	3	3.00	2
SB-T01	MD	Fragment	07/06/11	2	4.00	2
SB-T01	MD	Fragment	07/11/11	4	3.00	1
SB-T01	MD	Fragment	07/11/11	4	1.00	1
SB-T01	MD	Fragment	07/11/11	5	2.00	1
SB-T01	MD	Fragment	07/11/11	4	3.00	2
SB-T01	MD	Fragment	07/11/11	3	4.00	2
SB-T01	MD	Fragment	07/11/11	1	1.00	1
SB-T01	MD	Fragment	07/11/11	2	1.00	1
SB-T01	MD	Fragment	07/11/11	1	1.00	2
SB-T01	MD	Fragment	07/11/11	6	5.00	2
SB-T01	MD	Fragment	07/11/11	2	5.00	2
SB-T01	MD	Fragment	07/11/11	1	2.00	1
SB-T01	MD	Fragment	07/11/11	3	2.00	1
SB-T01	MD	Fragment	07/11/11	2	3.00	2
SB-T01	MD	Fragment	07/11/11	6	3.00	1
SB-T01	MD	Fragment	07/11/11	5	3.00	1
SB-T01	MD	Fragment	07/11/11	2	2.00	1
SB-T01	MD	Fragment	07/11/11	4	6.00	2
SB-T01	MD	Fragment	07/11/11	6	2.00	1
SB-T01	MD	Fragment	07/11/11	4	3.00	2
SB-T01	MD	Fragment	07/11/11	5	2.00	2
SB-T01	MD	Fragment	07/11/11	1	2.00	1
SB-T01	MD	Fragment	07/11/11	5	3.00	2
SB-T01	MD	Fragment	07/11/11	2	2.00	2
SB-T01	MD	Fragment	07/11/11	3	2.00	2
SB-T01	MD	Fragment	07/11/11	5	2.00	2
SB-T01	MD	Fragment	07/11/11	5	2.00	1
SB-T01	MD	Fragment	07/11/11	2	1.00	1
SB-T01	MD	Fragment	07/11/11	1	3.00	2
SB-T01	MD	Fragment	07/11/11	2	3.00	2
SB-T01	MD	Fragment	07/11/11	6	4.00	2
SB-T01	MD	Fragment	07/11/11	0	1.00	1
SB-T01	MD	Fragment	07/11/11	4	3.00	1
SB-T01	MD	Fragment	07/11/11	1	4.00	2
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	6	2.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	1	2.00	1

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	2	3.00	2
SB-T02	MD	Fragment	07/06/11	1	2.00	1
SB-T02	MD	Fragment	07/06/11	5	2.00	1
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	5	2.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	5	2.00	1
SB-T02	MD	Fragment	07/06/11	2	3.00	2
SB-T02	MD	Fragment	07/06/11	3	3.00	2
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	1	2.00	1
SB-T02	MD	Fragment	07/06/11	4	1.00	1
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	6	4.00	2
SB-T02	MD	Fragment	07/06/11	6	2.00	2
SB-T02	MD	Fragment	07/06/11	8	2.00	1
SB-T02	MD	Fragment	07/06/11	2	2.00	2
SB-T02	MD	Fragment	07/06/11	5	1.00	1
SB-T02	MD	Fragment	07/06/11	2	2.00	2
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	6	2.00	1
SB-T02	MD	Fragment	07/06/11	2	4.00	2
SB-T02	MD	Fragment	07/06/11	3	1.00	1
SB-T02	MD	Fragment	07/06/11	4	1.00	1
SB-T02	MD	Fragment	07/06/11	5	1.00	1
SB-T02	MD	Fragment	07/06/11	1	2.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	3	4.00	2
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	4	3.00	2
SB-T02	MD	Fragment	07/06/11	1	1.00	1
SB-T02	MD	Fragment	07/06/11	5	4.00	2
SB-T02	MD	Fragment	07/06/11	8	1.00	1
SB-T02	MD	Fragment	07/06/11	6	2.00	2
SB-T02	MD	Fragment	07/06/11	4	1.00	1
SB-T02	MD	Fragment	07/06/11	5	4.00	2
SB-T02	MD	Fragment	07/06/11	2	1.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	1
SB-T02	MD	Fragment	07/06/11	6	3.00	2
SB-T02	MD	Fragment	07/06/11	1	1.00	1

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-T02	MD	Fragment	07/06/11	3	2.00	1
SB-T02	MD	Fragment	07/06/11	4	1.00	1
SB-T02	MD	Fragment	07/06/11	5	3.00	2
SB-T02	MD	Fragment	07/06/11	2	2.00	1
SB-T02	MD	Fragment	07/06/11	2	1.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	2
SB-T02	MD	Fragment	07/06/11	6	1.00	1
SB-T02	MD	Fragment	07/06/11	4	1.00	1
SB-T02	MD	Fragment	07/06/11	5	1.00	1
SB-T02	MD	Fragment	07/06/11	2	2.00	2
SB-T02	MD	Fragment	07/06/11	1	3.00	2
SB-T02	MD	Fragment	07/06/11	1	2.00	1
SB-T02	MD	Fragment	07/06/11	4	2.00	2
SB-T02	MD	Fragment	07/06/11	5	1.00	1
SB-T02	MD	Fragment	07/06/11	3	1.00	1
SB-T03	MD	Fragment	07/06/11	5	2.00	1
SB-T03	MD	Fragment	07/06/11	4	2.00	1
SB-T03	MD	Fragment	07/06/11	1	2.00	1
SB-T03	MD	Fragment	07/06/11	2	2.00	1
SB-T03	MD	Fragment	07/12/11	2	6.00	1
SB-T03	MD	Fragment	07/12/11	3	5.00	1
SB-T03	MD	Fragment	07/12/11	4	7.00	1
SB-T03	MD	Fragment	07/12/11	2	6.00	1
SB-T03	MD	Fragment	07/12/11	1	6.00	1
SB-T03	MD	Fragment	07/12/11	1	5.00	1
SB-T03	MD	Fragment	07/12/11	2	4.00	1
SB-T03	MD	Fragment	07/12/11	2	5.00	1
SB-T03	MD	Fragment	07/12/11	2	3.00	1
SB-T03	MD	Fragment	07/12/11	2	4.00	1
SB-T03	MD	Fragment	07/12/11	5	6.00	1
SB-T03	MD	Fragment	07/12/11	1	2.00	1
SB-T03	MD	Fragment	07/12/11	2	2.00	1
SB-T03	MD	Fragment	07/12/11	5	5.00	1
SB-T09	MD	Fragment	07/12/11	2	4.00	1
SB-T09	MD	Fragment	07/12/11	5	5.00	1
SB-T09	MD	Fragment	07/12/11	1	4.00	1
SB-T12[a]	MD	Fragment	06/21/11	2	2.00	1
SB-T15[a,b]	MD	Fragment	06/29/11	2	3.00	3
SB-T16[a,b]	MD	Fragment	06/29/11	4	2.00	2
SB-T16[a,b]	MD	Fragment	06/29/11	2	4.00	3
SB-T16[a,b]	MD	Fragment	06/29/11	1	1.00	1
SB-T16[a,b]	MD	Fragment	06/29/11	5	2.00	2
SB-T16[a,b]	MD	Fragment	06/29/11	7	2.00	2

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-T16[a,b]	MD	Fragment	06/29/11	6	3.00	3
SB-T17[a,b]	MD	Fragment	06/29/11	2	5.00	4
SB-T17[a,b]	MD	Fragment	06/29/11	8	1.00	1
SB-T17[a,b]	MD	Fragment	06/29/11	4	4.00	3
Mag and Dig Transect Subtotal						**200**
SB-02	MD	Fragment	08/02/11	2	8.00	3
SB-02	MD	Fragment	08/02/11	0	9.00	4
SB-02	MD	Fragment	08/02/11	3	6.00	2
SB-02	MD	Fragment	08/02/11	0	12.00	3
SB-02	MD	Fragment	08/02/11	2	5.00	3
SB-02[a]	MD	Fragment	08/02/11	4	9.00	4
SB-02	MD	Fragment	08/02/11	5	8.00	3
SB-02	MD	Fragment	08/02/11	2	7.00	4
SB-02	MD	Fragment	08/02/11	0	3.00	1
SB-02	MD	Fragment	08/02/11	5	10.00	2
SB-02	MD	Fragment	08/03/11	6	20.00	5
SB-02	MD	Fragment	08/03/11	6	11.00	2
SB-02	MD	Fragment	08/03/11	3	8.00	3
SB-02	MD	Fragment	08/03/11	2	14.00	5
SB-02	MD	Fragment	08/03/11	4	4.00	2
SB-02	MD	Fragment	08/03/11	2	8.00	4
SB-02	MD	Fragment	08/03/11	5	2.00	2
SB-02	MD	Fragment	08/03/11	0	6.00	3
SB-02	MD	Fragment	08/03/11	1	8.00	2
SB-04	MD	Fragment	08/02/11	2	3.00	2
SB-04	MD	Fragment	08/02/11	2	4.00	2
SB-04	MD	Fragment	08/02/11	6	5.00	2
SB-04	MD	Fragment	08/02/11	2	2.00	2
SB-04	MD	Fragment	08/02/11	0	6.00	2
SB-04	MD	Fragment	08/02/11	1	3.00	2
SB-04	MD	Fragment	08/02/11	0	2.00	2
SB-04	MD	Fragment	08/02/11	6	6.00	2
SB-04	MD	Fragment	08/02/11	2	5.00	2
SB-04	MD	Fragment	08/02/11	0	6.00	2
SB-04	MD	Fragment	08/02/11	3	3.00	2
SB-04	MD	Fragment	08/02/11	9	3.00	2
SB-04	MD	Fragment	08/02/11	9	6.00	1
SB-04	MD	Fragment	08/02/11	9	1.00	2
SB-06	MD	Fragment	06/22/11	0-12	98.00	13
SB-07	MD	8" Butler Projectile	07/07/11	8	187.00	1
SB-07	MD	Fragment	07/07/11	0-12	249.00	167
SB-08	MD	Fragment	08/01/11	6	6.00	2
SB-08	MD	Fragment	08/01/11	2	2.00	1

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-08	MD	Fragment	08/01/11	2	4.00	1
SB-08	MD	Fragment	08/01/11	5	3.00	2
SB-08	MD	Fragment	08/01/11	5	3.00	3
SB-08	MD	Fragment	08/01/11	0	5.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	5	1.00	2
SB-08	MD	Fragment	08/01/11	8	7.00	2
SB-08	MD	Fragment	08/01/11	3	4.00	2
SB-08	MD	Fragment	08/01/11	5	6.00	2
SB-08	MD	Fragment	08/01/11	4	2.00	2
SB-08	MD	Fragment	08/01/11	3	7.00	2
SB-08	MD	Fragment	08/01/11	3	1.00	2
SB-08	MD	Fragment	08/01/11	0	4.00	2
SB-08	MD	Fragment	08/01/11	4	4.00	2
SB-08	MD	Fragment	08/01/11	6	3.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	9	4.00	2
SB-08	MD	Fragment	08/01/11	2	2.00	2
SB-08	MD	Fragment	08/01/11	6	6.00	2
SB-08	MD	Fragment	08/01/11	6	3.00	2
SB-08	MD	Fragment	08/01/11	5	3.00	2
SB-08	MD	Fragment	08/01/11	6	5.00	2
SB-08	MD	Fragment	08/01/11	7	4.00	2
SB-08	MD	Fragment	08/01/11	2	3.00	2
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	Fragment	08/01/11	2	3.00	2
SB-08	MD	Fragment	08/01/11	4	5.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	3	3.00	2
SB-08	MD	Fragment	08/01/11	8	4.00	2
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	Fragment	08/01/11	0	3.00	2
SB-08	MD	Fragment	08/01/11	6	4.00	2
SB-08	MD	Fragment	08/01/11	0	4.00	2
SB-08	MD	Fragment	08/01/11	0	3.00	2
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	Fragment	08/01/11	3	6.00	2
SB-08	MD	Fragment	08/01/11	0	2.00	2
SB-08	MD	Fragment	08/01/11	0	1.00	2
SB-08	MD	Fragment	08/01/11	2	7.00	2
SB-08	MD	Fragment	08/01/11	6	3.00	2
SB-08	MD	Fragment	08/01/11	2	3.00	2
SB-08	MD	Fragment	08/01/11	2	5.00	2
SB-08	MD	Fragment	08/01/11	1	5.00	2

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
SB-08	MD	Fragment	08/01/11	0	3.00	2
SB-08	MD	Fragment	08/01/11	0	4.00	2
SB-08	MD	Fragment	08/01/11	4	4.00	2
SB-08	MD	Fragment	08/01/11	4	4.00	2
SB-08	MD	10" Parrott Type II Bottle Top	08/01/11	6	223.00	1
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	5	3.00	2
SB-08	MD	Fragment	08/01/11	8	4.00	2
SB-08	MD	Fragment	08/01/11	3	4.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	6	3.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	6	4.00	2
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	Fragment	08/01/11	2	3.00	2
SB-08	MD	Fragment	08/01/11	0	3.00	2
SB-08	MD	Fragment	08/01/11	12	4.00	2
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	Fragment	08/01/11	4	3.00	2
SB-08	MD	Fragment	08/01/11	3	3.00	2
SB-08	MD	Fragment	08/01/11	0	3.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	6" Cannonball (solid shot)	08/01/11	6	24.00	1
SB-08	MD	Fragment	08/01/11	4	4.00	2
SB-08	MD	Fragment	08/01/11	6	4.00	2
SB-08	MD	Fragment	08/01/11	3	4.00	2
SB-08	MD	5.3" Parrott Type II Bottle Top	08/01/11	6	51.00	1
SB-08	MD	Fragment	08/01/11	2	4.00	2
SB-08	MD	Fragment	08/01/11	0	4.00	2
SB-08	MD	Fragment	08/01/11	7	4.00	2
SB-08	MD	Fragment	08/01/11	5	4.00	2
SB-08	MD	3.5" Cannonball (Solid Shot)	08/01/11	6	6.00	1
SB-08	MD	Fragment	08/01/11	4	3.00	2
SB-08	MD	Fragment	08/01/11	12	4.00	2
SB-08	MD	Fragment	08/01/11	9	4.00	2
SB-08	MD	Fragment	08/01/11	6	4.00	2
SB-09	MD	Fragment	07/06/11	4	5.00	1
SB-09	MD	Fragment	07/06/11	3	5.00	1
SB-09	MD	Fragment	07/06/11	2	5.00	1
SB-09	MD	Fragment	07/06/11	1	5.00	1

Table 3-10 MD Summary at the Siege Battery MRS (Continued)

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (pounds)	Quantity
Mag and Dig Grid Subtotal						**432**
Total Siege Battery MRS MD						**646**

Notes:
[a] Item recovered outside of the Crows Nest impact area.
[b] Item recovered on Constitution Island.

3.5.1.3 Geophysical Survey and Intrusive Investigation Analysis

The Siege Battery MRS is part of a surface danger zone for a former range. The geophysical transect and grid surveys performed within the MRS were used to assess the nature and extent of MEC and MD. A majority of MD recovered within the Siege Battery MRS are fragments from former munitions use. Several projectiles were also recovered in this MRS. The MD recovered during the RI field activities was concentrated in the northwestern Main Post portion of the MRS. Only one MD item was observed in the southeastern Main Post portion. The northwestern Main Post portion is closer to the range impact area where MEC and MD are most likely to be encountered. The southeastern Main Post portion is located closer to the range firing point where MEC and MD are less likely to be encountered. An additional 24 MD items were identified on the Constitution Island portion.

The southeastern Main Post portion of the MRS has been developed with buildings, athletic facilities, parking areas, and roadways more than the northwestern Main Post portion. MEC and MD might have been covered or moved during construction activities. The nature and extent of MD observed and delineated at the Siege Battery MRS is consistent with the survey results in adjacent MRSs. An elevated MEC and MD density similar to that observed in the northwestern portion of the Siege Battery MRS was also observed in the adjacent Fort Clinton West, Lusk Reservoir, and Artillery Firing Range MRSs. A reduced amount of MEC and MD was found in the portions of the Siege Battery MRS and of adjacent MRSs closer to the range firing point.

Based on the observed density, distribution, and the type of MD, the source of these items is attributed to the historical firing at targets on Crows Nest mountain. The collective RI characterization strategy using geophysical transects and grids allowed the successful delineation of the southern boundary of the Crows Nest impact area.

In accordance with the DQOs, the RI field results were also evaluated using the UXO Estimator *Analyze Field Data Module*. The following inputs were assessed in UXO Estimator:

- **Total number of acres in MRS:** 179.3 acres (acreage assumed in the Final RI Work Plan)
- **Number of acres investigated:** 5.88 acres
- **Number of MEC recovered in the investigated area:** 0 MEC recovered.
- **Specify the MEC target density per acre (same value used to develop DQOs):** 0.5 MEC/acre
- **Specify the desired upper confidence level (same value used to develop DQOs):** 95% confidence

The UXO Estimator calculations were initially designed to evaluate the entire 179.3-acre MRS. As stated in Section 3.1.1 the acreage of the Siege Battery MRS was revised to 167.1 acres. However, because the original input (in the Final RI Work Plan) was 179.3 acres, this acreage was used in the UXO Estimator calculations. UXO Estimator calculated a statistical upper bound MEC density of 0.496 MEC/acre at a 95% confidence level based on the RI field results. The calculated average MEC density across the MRS based on the UXO Estimator results is 0.164 MEC/acre.

It is statistically possible that MEC may be present across the entire MRS. However, based on the results of the geophysical transect and grid characterization and because no MEC and only one MD was recovered in the southeastern main post portion of the MRS, there are no MEC anticipated in this portion of the MRS. The southeastern Main Post portion of the MRS is closer to the range firing point where MEC and MD are less likely to be encountered. The MD items recovered in the MRS were concentrated in the northwestern Main Post portion of the MRS where it is more likely additional MD and potential MEC are present because of the proximity to the range impact area. These results are consistent with the RI findings in adjacent MRSs. The CSM for the Siege Battery MRS is discussed further in Section 3.8.

3.5.1.4 Additional Findings

During the spatial assessment of geophysical RI findings, it was determined that the area reported in the SI for the Siege Battery MRS of 179.3 acres (TLI, 2007), which was subsequently used in the Final RI Work Plan (WESTON, 2011a), was not accurate. During the RI, the reported area of 179.3 acres was determined to include portions of the Hudson River; therefore, the acreage was adjusted to 167.1 acres to align with the current land boundary. The 12.2 acres removed are assumed to be associated with the Siege Battery – TD – River MRS (WSTPT-016-R-01).

3.5.2 Results for Munitions Constituents Characterization

Sampling was conducted at the Siege Battery MRS to further investigate MC based on the SI recommendations and the presence of MEC and MD that pose a potential source for MC and that were identified during the SI and RI. The potential for MC at the firing point was also investigated. As depicted on **Figure 3-8**, six incremental samples were collected from the impacted portion of the Siege Battery MRS (WPR16-SS31, WPR16-SS32, WPR16-SS33, WPR16-SS34, WPR16-SS35, and WPR16-SS36), and one incremental sample (plus one field duplicate) was collected from the boundary of the Siege Battery MRS where it abuts the Fort Clinton West MRS (WPR03-SS26 and WPR03-SS27 [field duplicate]). Additionally, one incremental sample (plus one field duplicate) was collected and analyzed at the Siege Battery firing point (sample WPR07-SS01 and WPR07-SS02 [field duplicate]). The field duplicates (split) were collected for QC purposes. Each incremental sample and field duplicate, collected from the impact area in the northwestern portion of the MRS, was comprised of 50 increments distributed over a 0.8-acre sampling unit area. At the firing point, the incremental sample and field duplicate was comprised of 30 increments collected over a 0.5-acre sampling unit area.

The incremental samples were collected and analyzed to identify the presence of MC (if any) and to fully characterize the nature and extent of MC. The incremental samples were collected using new, clean, dedicated, and disposable equipment; therefore, no IDW (solid or liquid) was generated. Analytical results for the Siege Battery MRS are provided in **Table 3-11**.

3.5.2.1 Explosives

There were no reported detections of explosives for the samples collected from the MEC- and/or MD-impacted portions of the Siege Battery MRS within the range or at the firing point. The analytical result for nitroglycerin in one sample was reported with a UJ qualifier, which indicates that the analyte was not detected above the reported sample quantitation limits (SQLs). However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. The analytical results for the remainder of the explosives included U qualifiers for each reported value, indicating that the explosive was analyzed for, but was not detected, above the reported SQL (**Table 3-11**). Data qualifiers are discussed in more detail in Section 3.5.2.3.2.

Section 3.6 presents the analytical results in comparison to the human health and ecological screening values (**Table 3-9**) used to establish baseline risks to potential human and ecological receptors from MC.

3.5.2.2 Metals

Lead and mercury were the only metals suspected to be MC associated with the recovered MD within the Siege Battery MRS. Both analytes were positively detected by the laboratory in all samples (see **Table 3-11**):

- Lead ranged from 45 mg/kg to 150 mg/kg. Only one result, the maximum exceedance, was qualified with a J, indicating the result was an estimated quantity.
- Mercury ranged from 0.064 mg/kg to 0.24 mg/kg. All results were J qualified, indicating the results were estimated quantities.

Data qualifiers are discussed in more detail in Section 3.5.2.3.2. Section 3.6 presents the analytical results in comparison to the human health and ecological screening values (see **Table 3-9**) used to establish baseline risks to potential human and ecological receptors from MC.

3.5.2.3 MC Data Quality

An assessment of data quality for MC sampling was conducted in accordance with the Final RI Work Plan (WESTON, 2011a) and the UFP-QAPP (WESTON, 2011b). Field QC samples were collected and analyzed to assess the quality of the data resulting from the field sampling program at a program-wide level for the MMRP RI at West Point. Additionally, as discussed in Section 3.4.3, 100% of the MC data results were validated by an independent third party, MEC^{x}, LP.

Field QC samples specified in the UFP-QAPP include rinsate, field blanks, field duplicates, and triplicates. Field duplicates, which consist of one soil sample split into two parts with each aliquot analyzed by the laboratory for the identical parameters, are collected to estimate sampling and laboratory analysis precision, including sample homogeneity. Precision is measured using routine and duplicate sampling results and is expressed as the relative percent difference (RPD). Calculation of the RPD is described in the UFP-QAPP.

Table 3-11 Analytical Results for Soil Sampling for MC Siege Battery MRS, U.S. Army Garrison West Point, MMRP Remedial Investigation

Sample ID:	WPR03-SS26		WPR03-SS27		WPR16-SS31		WPR16-SS32		WPR16-SS33		WPR16-SS34		WPR16-SS35		WPR16-SS36		WPR07-SS01		WPR07-SS02	
Lab Sample ID:	200-6475-1		200-6475-2		200-6513-1		200-6513-2		200-6513-3		200-6513-4		200-6513-5		200-6513-6		200-5727-1		200-5727-2	
Sample Type:	Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil	
Date Sampled:	8/8/2011		8/8/2011		8/10/2011		8/10/2011		8/10/2011		8/11/2011		8/11/2011		8/11/2011		6/21/2011		6/21/2011	
Parcel:	Fort Clinton West/Siege Battery		Fort Clinton West/ Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery	
Comments:			Field Duplicate QC Sample of SS26														Firing Point		Field Duplicate QC Sample of SS01	
EXPLOSIVES in µg/kg	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.	Result	Qual.
2,4,6-Trinitrotoluene	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U
4-Amino-2,6-dinitrotoluene	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U
2-Amino-4,6-dinitrotoluene	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U
2,6-Dinitrotoluene	14	U	14	U	46	U	14	U	68	U	14	U	14	U	14	U	14	U	14	U
2,4-Dinitrotoluene	28	U	28	U	28	U	28	U	28	U	29	U	28	U	29	U	29	U	29	U
PETN	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U
Nitroglycerin	1300	UJ	550	U	550	U	540	U	580	U	550	U	540	U	550	U	1400	U	1400	U
METALS in mg/kg																				
Lead, Total	150	J	130		45		96		91		140		100		79		--		--	
Mercury, Total	0.24	J	0.20	J	0.064	J	0.15	J	0.12	J	0.18	J	0.23	J	0.12	J	--		--	

Notes:

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).

U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

QC = quality control

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

-- = not analyzed

Matrix spike/matrix spike duplicate (MS/MSD) samples are the introduction of a known concentration of a compound into a sample to provide information about the effect of the sample matrix on the extraction and/or measurement methodology. MS/MSDs are reviewed as part of the data validation process and are discussed in the data validation narrative.

3.5.2.3.1 Field QC Samples and Sampling QC

Field QC samples were collected and assessed during the MMRP RI at West Point at a program-level based on the sample delivery groups submitted to the laboratory for analysis. Some MRSs had one or very few soil samples, and samples were batched together where possible. Field duplicates were collected at the Siege Battery MRS and represent field QC for other MRSs at West Point because of the similarities in past munitions use, soil types, and land use.

High-quality MC data were collected at the Siege Battery MRS as evidenced by the following parameters employed to assess data usability:

- Precision is represented as the RPD between measurements of an analyte in duplicate samples, or as the RSD when the number of samples exceeds two. The RPD and RSD were evaluated as part of the data validation task during the RI. Sample WPR03-SS27 was collected as a field duplicate of sample WP03-SS26 from the sampling unit placed at the boundary of the Siege Battery MRS where it abuts the Fort Clinton West MRS. Additionally, sample WPR07-SS02 was collected as a field duplicate of sample WPR07-SS01, from the sampling unit at the firing point at the Siege Battery MRS. Neither pairing of samples was observed to have reportable detects of explosive chemicals. Sample WPR03-SS26 had one explosive compound reported with an elevated SQL. Therefore, the RPDs were not calculated for explosives. Metals were analyzed only in the impact area primary and duplicate sample pairing, and were detected in both samples. The lead RPD was within the UFP-QAPP control limit of ±20% for analytes with concentrations >5X the limit of quantitation. The mercury RPD was within the control limit of <50% specified in the UFP-QAPP. Overall precision was assessed by evaluating the RSD between primary and replicate incremental samples, which accounts for both field and laboratory processing/analytical error. Incremental replicates were not collected specifically from the Siege Battery MRS. However, incremental samples, including a primary and two replicates, were collected from a sampling unit placed at a firing point in the Artillery Firing Range MRS (WPR01-SS06, WPR01-SS07, and WPR01-SS08). These samples were submitted in the same sample delivery group representing field QC at the program-level (see Section 5.5.2). None of the three samples had reportable detects of explosive chemicals; therefore, the RSD could not be calculated and quantitatively evaluated. The data do not indicate a concern about the sampling or laboratory precision. See **Appendix 3-J** for the data validation reports.

- Accuracy was ensured by selecting appropriate data collection instruments, having clearly delineated instructions for their correct use, and following the sampling plan discussed in Section 3.13 of the Final RI Work Plan (WESTON, 2011a), the MC Sampling Methodology Memorandum (**Appendix 3-H**), and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No deviations from the sampling plan were documented during the RI field activities **(Appendix 3-F)**. Rinsate and field blanks were not obtained during the soil investigation because of the use of new, clean, dedicated disposable equipment (i.e., scoops, aluminum pans, and sterile gloves).

- Data representativeness at the Siege Battery MRS was accomplished by implementing the approved sampling procedures discussed in Section 3.13 of the Final RI Work Plan, the MC Sampling Methodology Memorandum (**Appendix 3-H**), and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No significant deviations from the sampling procedures were documented during the RI field activities (**Appendix 3-F and Appendix 3-I)**. Incremental sampling reduces data variability and increases sample representativeness. Increment placement within the sampling unit and collection along a random meandering path was inconsistent with the approach detailed in the Final RI Work Plan that stated, "Increments will be collected using a systematic random approach." However, the simple random approach for sampling unit design that was employed is an equivalent approach supported by industry and USACE guidance, and all increment locations were sampled. Therefore, the impact to data usability relative to representativeness is considered minimal.

- Completeness was achieved because the number of locations (**Figure 3-8**) sampled equaled the number of planned sample locations as discussed in the Final RI Work Plan and in the MC Sampling Methodology Memorandum provided in **Appendix 3-H**.

- Comparability of data sets generated for the project was obtained through the implementation of, and adherence to, the standard sampling procedures discussed in Section 3.13 of the Final RI Work Plan, the MC Sampling Memorandum (**Appendix 3-H**), and the UFP-QAPP (Appendix J) of the Final RI Work Plan. A review of the field daily reports (**Appendix 3-F**) indicated no deviations from standard sample management procedures.

The high-quality data meet the data quality objectives of the RI established in the Final RI Work Plan and provided in Section 3.2.4 of the RI Report. These data are sufficient to support the risk assessment and the evaluation of alternatives.

3.5.2.3.2 Data Validation Results

The data validation guidelines are listed in Section 3.4.3. The data validation package for the Siege Battery MRS, including the validation report narratives for the MRS analytical results and a glossary of QA/QC terms and data qualifier codes, is provided in **Appendix 3-J**. The data validation guidelines ensure that all data meet uniform requirements for accuracy and determine the validity of the data. If the data quality parameters for the MRS-specific analyses did not meet the criteria of the EPA and DoD Quality Systems Manual (QSM) Version 4.2 or the laboratory standard operating procedure (SOP), a discussion of the implications regarding the guidelines was included in the data validation narrative.

No major issues were identified during data validation. The results for the incremental sample collected along the boundary of the Siege Battery MRS and Fort Clinton West MRS showed one nondetect with an elevated SQL. This nitroglycerin value was qualified as UJ due to poor photodiode array spectral match, which is a method routinely used for further identification of any detection above the limit of quantitation. A validation note consisting of an “H8” code was added to the UJ qualifier verifying that the analyte was not confirmed on a second dissimilar column or that the diode array spectrums did not match the library. These UJ values are considered estimated, but still usable, data, which meet all remaining acceptance criteria. Some sample results were below the detection limit and had an elevated intercolumn RPD; as a result, they were qualified with a nondetect, U. Some data were qualified with a J because of detections reported between the detection limit and the SQL, or confirmed results with a relatively high intercolumn RPD. These J values are considered estimated values but are still usable data. Using J values for risk assessment is consistent with the allowable use of J qualified data as discussed in the *Guidance for Data Useability for Risk Assessment (Part A)* (EPA, 1992).

Overall, the data validation showed that the data received from the laboratory were valid. The preceding data usability assessment (Section 3.5.2.3.1) determined the data are usable for assessing the environmental conditions related to MC. Sufficient usable data were available for the Siege Battery MRS to meet the objectives of the RI and to complete the risk assessment.

3.6 RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS

3.6.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was performed for the Siege Battery MRS. Based on the revised CSM in Section 3.8, the potential human receptors include West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

3.6.1.1 Data Evaluation

Data were collected to assess the firing point and range floor impact area independently at the Siege Battery MRS. At the firing point, sampling consisted of one incremental sample (plus 1 field duplicate) collected from an area historically defined as an artillery firing point. This sample consisted of a 0.5-acre sampling unit from which 30 increments were collected and analyzed for explosives (**Figure 3-8**). Within the northwestern Main Post portion of the Siege Battery MRS downrange of where MD was positively identified, seven incremental samples were collected. Each sampling unit was 0.8 acre, and each incremental sample consisted of 50 increments. **Table 3-11** presents the validated analytical results for the Siege Battery MRS surface soil incremental samples. No explosives were detected above the SQLs. However, because elevated SQLs were reported for nitroglycerin in one sample, and positive detections of both lead and mercury were observed, a human health risk evaluation was initiated as a conservative measure.

A discussion of the results in relation to human health screening levels and rural background levels (for metals) is provided in the following subsections.

3.6.1.2 Selection of Chemicals of Potential Concern

Typically, soil chemicals of potential concern (COPCs) are identified by comparing the maximum detected concentration of each chemical with the recommended human health screening value. The analytical results for the surface soil incremental samples collected from the Siege Battery MRS showed all U and UJ values for explosives, indicating the analytes were not detected above their reported SQLs. The laboratory would have reported detects below the screening level, even if they were estimated values (J), and none was reported. All mercury results analyzed in downrange samples were estimated and reported as J values. One of the positive results for lead from the downrange samples collected was estimated and is reported as a J value.

To be conservative, a screening was performed to ensure the protectiveness of the SQLs and to evaluate the positive metals detections. As presented in **Table 3-12**, the recommended human health screening value is the lowest human health NYSDEC value (NYSDEC, 2006). If a NYSDEC value was not available, the ORNL residential RSL (EPA, 2012) was used. For COPC screening purposes, noncarcinogenic RSLs were adjusted to correspond to a target hazard quotient (THQ) of 0.1 rather than 1. Thus, chemicals with additive effects were not prematurely eliminated during screening. If RSLs were available for carcinogenic and noncarcinogenic endpoints and both ingestion and inhalation exposure routes, the lower (i.e., more stringent) value was used for the screening comparison.

The results presented in **Table 3-12** indicate that no chemicals had SQLs above the recommended screening level used to assess baseline risk to human health. The nitroglycerin SQL exceeded its benchmark when using the risk-based screening level at a THQ of 0.1 (610 µg/kg). However, no other chemicals were detected (i.e., no additive effects from multiple chemicals). Therefore, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg, which is above the nitroglycerin maximum SQL of 1,400 µg/kg.

For metals detected at the Siege Battery MRS, lead was detected at concentrations greater than the recommended human health screening level (i.e., NYSDEC Unrestricted Use SCO, 63 mg/kg). However, as presented in **Table 3-12**, the values were less than the ORNL residential soil RSL and NYSDEC residential SCO value of 400 mg/kg. The difference between the two NYSDEC values is that the Unrestricted Use screening is for the protection of public health and ecological resources due to the presence of contaminants in the soil. Therefore, the NYSDEC residential SCO value is appropriate to use as an alternative screening number for the human health risk evaluation and supports the future use of the MRS. Furthermore, the lead arithmetic mean (104 mg/kg) was consistent with the rural maximum concentration background level of 112 mg/kg reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table D1, August 2005 (NYSDEC, 2005).

Analyte	ORNL Residential RSL[a]	NYSDEC Residential SCO[b]	NYSDEC Unrestricted Use SCO[b]	Recommended Human Health Screening Value[c]	WPR03-SS26 200-6475-1 8/8/2011 Fort Clinton West/ Siege Battery	WPR03-SS27 (Duplicate of SS26) 200-6475-2 8/8/2011 Fort Clinton West/ Siege Battery	WPR16-SS31 200-6513-1 8/10/2011 Siege Battery	WPR16-SS32 2006513-2 8/10/2011 Siege Battery	WPR16-SS33 200-6513-3 8/10/2011 Siege Battery	WPR16-SS34 200-6513-4 8/11/2011 Siege Battery	WPR16-SS35 200-6513-5 8/11/2011 Siege Battery	WPR16-SS36 200-6513-6 8/11/2011 Siege Battery	WPR07-SS01 200-5727-1 6/21/2011 Siege Battery (Firing Point)	WPR07-SS02 (Duplicate of SS01) 200-5727-2 6/21/2011 Siege Battery (Firing Point)	HH COPC?
Explosives (µg/kg)															
2,4,6-Trinitrotoluene	3,600 n	NBA	NBA	3,600 n	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	No
4-Amino-2,6-Dinitrotoluene	15,000 n	NBA	NBA	15,000 n	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	No
2-Amino-4,6-Dinitrotoluene	15,000 n	NBA	NBA	15,000 n	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	No
2,6-Dinitrotoluene	6,100 n	NBA	1,030	1,030	14 U	14 U	46 U	14 U	68 U	14 U	14 U	14 U	14 U	14 U	No
2,4-Dinitrotoluene	1,600 c	NBA	NBA	1,600 c	28 U	28 U	28 U	28 U	28 U	29 U	28 U	29 U	29 U	29 U	No
PETN	12,000 n	NBA	NBA	12,000 n	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1,700 U	1,700 U	No
Nitroglycerin	610 n	NBA	NBA	610 n	1300 UJ	550 U	550 U	540 U	580 U	550 U	540 U	550 U	1,400 U	1,400 U	No [d]
METALS (mg/kg)															
Lead, Total	400	400	63.00	63	150 [f] J	130 [f]	45	96 [e]	91 [e]	140 [f]	100 [e]	79 [e]	--	--	No
Mercury, Total	1.00 n	0.81	0.18	0.18	0.24 [e] J	0.20 [e] J	0.064 J	0.15 J	0.12 J	0.18 [e] J	0.23 [e] J	0.12 J	--	--	No

[a] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (May 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.

[b] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html

[c] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the ORNL Benchmark was used.

[d] When using the ORNL RSL values, noncarcinogens were reduced by an order of magnitude to yield a risk-based screening level with a THQ of 0.1 to address the additivity of noncancer effects when there is exposure to multiple chemicals. However, because no other chemicals were detected, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg.

[e] Exceeded recommended human health screening value but were within the rural background range of concentrations obtained from New York Department of Environmental Conservation. 2005. Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D. August 2005.

[f] The lead arithmetic mean for the Siege Battery and Fort Clinton West site is 104 mg/kg, which is below the rural maximum concentration of 112 mg/kg.

c = Cancer effects at a target risk of 1.0E-06.
µg/kg = Micrograms per kilogram.
n = Noncancer effects, at a target hazard quotient of 0.1.
NBA = No benchmark available.
RSL = Regional screening level.
SCO = Soil cleanup objectives.
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).
U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis using photo diode array confirmed that the analyte was not present.

Highlighting indicates that the detected result is equal to or exceeds the Recommended Human Health Screening Value.

Mercury was detected at concentrations greater than the recommended human health screening level (i.e., NYSDEC Unrestricted Use SCO, 0.18 mg/kg) in 4 out of 8 samples (includes a primary and field duplicate pair) as presented in **Table 3-12**. However, the values were less than the maximum background level of 0.30 mg/kg established for soils by NYSDEC (NYSDEC, 2005). In addition, mercury concentrations were less than the ORNL residential soil RSL and NYSDEC residential SCO value of 1.0 mg/kg and 0.81 mg/kg, respectively. Although lead and mercury were detected in samples collected in the Siege Battery MRS, the analytes were not detected at levels that would pose a potential risk to human health.

3.6.1.3 Human Health Risk Assessment Summary and Conclusions

No UXO or DMM was recovered during the RI. All munitions-related items detected during the RI at the Siege Batter MRS were MD. The sample results for explosives were qualified as U or UJ, indicating the chemicals were not detected above their reported sample quantitation limits. Lead and mercury were detected in samples collected from the Siege Battery MRS. Based on the results of the HHRA, the surface soil incremental samples did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

3.6.2 Ecological Risk Assessment

A focused Screening Level Ecological Risk Assessment (SLERA) was completed to assess the potential adverse impacts on the current and future ecological receptors exposed to MC in areas where MD were identified at the Siege Battery MRS. The assessment endpoint for the SLERA is the protection of local populations and communities of biota from exposure to explosive and metal chemicals of potential ecological concern (COPECs) in soil. The revised CSM for the Siege Battery MRS is presented in Section 3.8.

3.6.2.1 Ecological Screening Values

Average concentrations of chemicals detected in the soil at the Siege Battery MRS (based on incremental sampling) were compared to conservative ESVs selected to assess the baseline risks during the RI. All chemicals detected in soil at concentrations greater than ESVs were considered to potentially adversely impact ecological receptors and were identified as COPECs. The ecological screening values are presented in **Table 3-9** and **Table 3-13.**

The ESVs used for comparison to chemicals detected in soil samples were obtained from the NYSDEC Remedial Program SCOs, EPA EcoSSLs, EPA Region 5 Resource Conservation and Recovery Act (RCRA) ESLs, information obtained from select ORNL guidance, and additional appropriate guidance, as necessary. The primary source for the recommended screening value was the NYSDEC value. If an NYSDEC value was not available, ecological screening values were selected in accordance with the hierarchy listed above.

If no value was established in the hierarchy presented in the Final RI Work Plan, additional research was conducted to identify ESVs during the development of the SLERA. ESVs were obtained for the following analytes: nitroglycerin, PETN, 2,4,6-trinitrotoluene, 4-amino-2,6-dinitrotoluene, and 2-amino-4,6-dinitrotoluene (**Table 3-13**).

3.6.2.2 Habitat and Receptors

The Siege Battery MRS, which is composed of 167.1 acres, is located on the western shore of Hudson River and on Constitution Island. Once on post, access to the former range area is unrestricted. A portion of the former range area, located on the western shore of the Hudson River within the Siege Battery MRS and extending in a northwesterly directly towards the Crows Nest, has been disturbed by the development of West Point and residential housing. There are, however, pockets of heavily forested, undisturbed land. The area on Constitution Island is undisturbed and access to the island is restricted. Four wetland areas totaling 2.24 acres are located on Constitution Island.

Table 3-13 Screening Level Ecological Risk Assessment Results for Soil

Analyte	Recommended Ecological Screening Value	Firing Point Sample Number	Maximum Detected Incremental Sample Value at the Firing Point	MEC Release Area Sample Number	Maximum Detected Incremental Sample Value at the MEC Release Area[g]	Maximum Background Screening Value[h]	COPEC?
Explosives (µg/kg)							
2-Amino-4,6-dinitrotoluene	9,000[a,b]	all samples	23 U	WPR03-SS29	23 U	N/A	N
4-Amino-2,6-dinitrotoluene	9,000[a,b]	all samples	23 U	all samples	23 U	N/A	N
2,4-Dinitrotoluene	1,280[c]	all samples	29 U	multiple samples	29 U	N/A	N
2,6-Dinitrotoluene	32.8[c]	all samples	14 U	WPR16-SS33	68 U (34)	N/A	Y
Nitroglycerin	3,000[a,d]	all samples	1,400 U	WPR03-SS26	1,300 UJ	N/A	N
PETN	170,000[a,e]	all samples	1,700 U	all samples	1,700	N/A	N
2,4,6-Tinitrotoluene	70[a,f]	all samples	14 U	all samples	14 U	N/A	N
Metals (mg/kg)							
Lead, Total	63[f]	---	---	WPR03-SS26	150 J	112	Y
Mercury, Total	0.18[f]	---	---	WPR03-SS26	0.24 J	0.3	Y

Notes:
µg/kg = micrograms per kilogram.
mg/kg = milligrams per kilogram.
[a]µg/kg/d = micrograms per kilogram per day, no observed adverse effect level (NOAEL).
[b]USACHPPM, 2005.
[c]EPA, 2003.
[d]USACHPPM, 2000.
[e]USACHPPM, 2001a.
[f] USACHPPM, 2001b.
[g]Second value is half of the detection limit.
[h]NYSDEC, 2005.
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).
U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

Ecological receptors that could potentially be exposed to MC associated with the Siege Battery MRS include terrestrial plants; terrestrial invertebrates; and terrestrial avian and mammalian species, including herbivores, omnivores, and carnivores. A list of potential ecological receptors is presented in Section 3.1.1.6.5.

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River. Although the Hudson River borders the MRS, the river is excluded from the Siege Battery MRS boundary. A portion of the Siege Battery MRS is within the Constitution Island Special Natural Area, as designated by West Point (Tetra Tech, 2011).

3.6.2.3 Screening of Chemicals of Potential Ecological Concern

The maximum detected values for incremental samples at the Siege Battery MRS were compared to appropriate ESVs. One sample was collected at the historical firing point of the Siege Battery MRS (WPR07-SS01) along with a field duplicate sample (WPR07-SS02). The firing point is located adjacent to the parade grounds in the center of the West Point campus. All explosive compounds were reported for both the incremental sample and the field duplicate as nondetect values with SQLs less than the respective ESVs.

Within the northwestern portion of the Siege Battery MRS where MD was identified during the RI, seven incremental samples (WPR16-SS31 through WPR16-SS36) were collected, which included one sample (WPR03-SS26) and field duplicate (WPR03-SS27) from a sampling unit placed along the shared boundary with the Fort Clinton West MRS, where UXO was recovered. Explosives were not detected in any of the samples; however, the compound 2,6-dinitrotolutene was reported with SQLs ranging from 14 µg/kg to 68 µg/kg. Of the eight samples, two samples had SQLs greater than the ESV of 32.8 µg/kg (Region 5 RCRA Ecological Screening Levels [EPA, 2003]). Because all samples collected from West Point MRSs where RIs were conducted had results for 2,6-DNT that were reported as qualified nondetects (U or UJ), half of the reported sample SQL was compared to ecological screening values. Using this approach, half the reported SQL in one of the two samples (34 µg/kg) still slightly exceeded the ESV. However, this result is less than the alternative no observed adverse effect level (NOAEL) value of 700 µg/kg for ingestion exposure for mammals (USACHPPM, 2006).

No munitions that would constitute a source for 2,6-DNT were observed at the firing point where the incremental sample was collected. 2,6-DNT was not positively detected in any of the MC samples collected from the MRSs included in the MMRP RI at West Point. Therefore, it is highly unlikely that 2,6-DNT is present related to historical activities at the Siege Battery MRS. Furthermore, even if a release to surface soil at this MRS had occurred, 2,6-DNT is unlikely to persist in the environment because this compound readily breaks down in the presence of oxygen and sunlight, and is highly water soluble (Agency for Toxic Substances and Disease Registry [ATSDR], 1998).

Lead was detected in all of the samples collected from the former range area at concentrations ranging from 45 mg/kg and 150J mg/kg, which exceed the screening level of 63 mg/kg (NYSDEC Unrestricted Use SCO) (**Table 3-13**). The result for one of the eight samples was J qualified, indicating that the associated value is an estimated quantity. However, the presence of lead does not present an unacceptable risk to the environment because the detected lead concentrations were less than the alternative ORNL benchmark of 500 mg/kg. Additionally, the majority of the detected concentrations of lead (5 of 8) were less than the rural maximum concentration of 112 mg/kg as reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table D1, August 2005 (NYSDEC, 2005).

Mercury was detected in all samples collected from the former range area at concentrations ranging from 0.064J mg/kg and 0.24J mg/kg, which exceed the screening level of 0.18 mg/kg (NYSDEC Unrestricted Use SCO) (**Table 3-13**). All of the eight mercury results were J qualified, which indicates that mercury was positively identified, and the associated values are estimated quantities. However, the presence of mercury does not present an unacceptable risk to the environment because the results are within the rural background range of concentrations. The range for the rural background mercury concentrations is 0.01 to 0.30 mg/kg, as reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report* *on the Statewide Rural Surface Soil Survey,* Appendix D, Table D1, August 2005 (NYSDEC, 2005).

3.6.2.4 Uncertainty Assessment

The 2,6-DNT concentration is listed as a nondetect/estimated value (UJ), but the SQL exceeds the established conservative ESV. Therefore, it is unclear whether 2,6-DNT is present and poses a quantifiable risk of exposure to ecological receptors within the Siege Battery MRS. Based on the secondary spectral analysis performed by the laboratory, which confirmed that no explosives were present, and on the screening-level evaluation results presented above, the uncertainty associated with the elevated SQLs is considered minimal.

3.6.2.5 Summary of Risk

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River. Although the Hudson River borders the MRS, the river is excluded from the Siege Battery MRS boundary. The ecological habitat at the firing point and former range area where MD was found is not considered to be of high quality because of the development in these areas. Therefore, it is expected that potential ecological receptors would use other habitats within the surrounding area. Four wetlands are located within the Siege Battery MRS, in addition to the nearby river habitat (Hudson River). A portion of the Siege Battery MRS is within the Constitution Island Special Natural Area, as designated by West Point. A number of rare plant species are present within the Constitution Island area of the Siege Battery MRS.

There is little to no potential for adverse ecological impacts from MC in surface soil at the Siege Battery MRS because the results of the chemical analyses indicated that no explosives were detected in the soil samples. The SQL for 2,6-DNT was greater than the conservative ESVs, which may be of concern; however, the SQL value is less than the alternative NOAEL value (**Table 3-9** and **Table 3-13)**. An elevated SQL for 2,6-DNT is not considered a potential risk to ecological receptors because there was no evidence of military munitions within the incremental sampling unit at the firing point. In addition, 2,6-DNT was not positively detected in any of the program-level MC samples collected at West Point to support the ongoing RIs, and the toxicological information indicates that 2,6-DNT would not be likely to persist in surface soil. The uncertainty associated with the estimated SQLs observed using Method 8330B analysis was minimized by obtaining secondary confirmation by spectral analysis that this compound was not present. Although both lead and mercury were detected in all incremental samples collected within the northwestern portion of the Siege Battery MRS observed to be impacted by UXO and MD, the concentrations detected were within expected background values.

Therefore, the risk of exposure to COPECs for ecological receptors at the Siege Battery MRS is considered to be minimal.

3.6.3 Preliminary Identification of Applicable or Relevant and Appropriate Requirements

A preliminary identification of ARARs is conducted during RI characterization. The ARARs are used as a “starting point” in determining remedial action objectives and the protectiveness of a remedy to be assessed in a feasibility study (FS).

As the RI/FS process continues, the list of ARARs is further refined. The ARARs are used to establish the appropriate extent of cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative.

Pursuant to Section 300.400(g) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a list of ARARs and other to be considered advisories, criteria, and guidance (TBCs) is developed for a site or sites to identify the requirements that may apply to response actions. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the NCP provide that the development and evaluation of remedial actions must include remedial alternatives to attain ARARs and to ensure protection of public health and the environment.

ARARs are defined as follows:

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

First, it is determined whether a requirement is applicable to the site. If a requirement is not applicable, then it is determined whether the requirement is relevant and appropriate. The procedure for determining whether a requirement is relevant and appropriate is a two-step process. First, to determine relevance, it is evaluated whether the requirement addresses problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made about whether the requirement would also be well-suited to the conditions of the site. In some cases, only a portion of a requirement would be both relevant and appropriate. Once a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR. The results of the selection process for the Siege Battery MRS are provided in **Table 3-14**.

"Applicable requirements" and "relevant and appropriate requirements" are considered to have the same weight under CERCLA. Section 121(d) of CERCLA requires the attainment of federal ARARs and of state ARARs if the state environmental or facility siting laws are promulgated, are more stringent than federal laws, and are identified by the state in a timely manner.

CERCLA and the NCP also identify the TBC category, which includes nonpromulgated federal and state criteria, advisories, and guidance documents, which are also considered. TBCs do not have the same status as ARARs; however, if no ARAR exists for a substance or particular situation, TBCs may be used to ensure that a remedy is protective.

Table 3-14 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments (Applicable or Relevant and Appropriate)
Action-Specific			
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	*Applicable* Identify when military munitions become a solid waste; and, if these wastes are also hazardous under this subpart or 40 CFR Part 261, identify the management standards that apply to these wastes.
NY Division of Water - Classes and Standards of Quality and Purity and EPA National Pollutant Discharge Elimination System	6 NYCRR §750-1.5 and 40 CFR Part 122.26	Establishes water quality standards, including classifications of New York waters and water quality criteria to protect the ground and surface water resources; and controls stormwater and effluent discharges, including toxic substances, into State waters.	*Relevant and Appropriate* For remedial alternatives where soil excavation activities are performed and require stormwater management. Construction activities disturbing one or more acres of soil must be authorized under the NY General Permit for Stormwater Discharges from Construction Activities.
Hazardous Waste Manifest System and Related Standards For Generators, Transporters and Facilities	6 NYCRR Part 372	Establishes standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its record keeping requirements.	*Applicable* In the event that hazardous waste is generated as part of a remedial alternative; for example, if MEC were removed and would need to be shipped (by a party other than the Army) as hazardous waste.
Waste Transporter Permits	6 NYCRR Part 364	Protects the environment from mishandling and mismanagement of regulated waste transported from the site of generation to the site of ultimate treatment, storage, or disposal.	*Applicable* To any off-site transport and disposal of classified hazardous wastes, if generated as part of remedial alternative.
Air Quality Classifications and Standards	6 NYCRR Part 257-1.3 and 257-1.4	Designed to provide protection from the adverse health effects of air contamination; intended to protect and conserve the natural resources and environment.	*Relevant and Appropriate* In the event that a remedial alternative, such as soil excavation/grading, could impact ambient air quality for an extended period of time. The state regulation has 12-month average standards for dust levels from a specific source.

Notes:
CFR Code of Federal Regulations
NYCRR New York Codes, Rules and Regulations

Generally, ARARs pertain either to contaminant levels or to performance or design standards to ensure protection at all points of potential exposure. ARARs are divided into three general categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs.

ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the MRS.
- Chemical analysis performed or scheduled to be performed.
- Types of media (air, soil, groundwater, surface water, and sediment).
- Geology and other MRS characteristics.
- Use of MRS resources and media.
- Potential contaminant transport mechanisms.
- Purpose and application of potential ARARs and TBCs.

Remedial alternatives considered for MRS cleanup. 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 an MRS. The preliminary ARARs are summarized in **Table 3-14.** No MEC was found in the Siege Battery MRS during the RI field activities and no MC chemicals of concern were identified. It is anticipated that future remedial alternatives will not include on-site treatment, on-site storage (greater than 90 days), or on-site disposal of hazardous waste; therefore, potential action-specific ARARs related to these activities were not considered applicable at this time.

Location-specific ARARs were not identified for the Siege Battery MRS. Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. A portion of the Siege Battery MRS is located within the Constitution Island special natural area. Four wetlands, totaling 2.24 acres, are located in the portion of the Siege Battery MRS on Constitution Island. Based on the findings of the RI, it is anticipated that the remedial alternatives will not include activities that would impact these ecological resources; therefore, certain potential ARARs related to these activities were not considered applicable at this time.

Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Chemical-specific ARARs are used to provide benchmarks with which to compare environmental sampling results for metals and explosives. Residential SCO values published in NYSDEC regulations (NYSDEC, 2006) would be considered chemical-specific ARARs for MC concentrations at the MRS. However, MC was not found at levels of concern (i.e., not detected or detected below risk-based screening values and/or background levels) at the Siege Battery MRS. Therefore, chemical-specific ARARs did not need to be carried forward based on the information available at the time of the RI. TBCs were identified for the Siege Battery MRS (see Section 3.4.4).

NYSDEC participated in TPP 1 (General Project Introduction and Approach) and TPP 2 (Presentation of RI Field Work Approach). Discussions at TPP 1 and TPP 2 generally consisted of establishing which NYSDEC and EPA standards for MC would apply to the whole project (WESTON, 2011a). The RI reports will be presented at the TPP 3 meeting.

The ARARs will be further refined during future phases of work (e.g., the decision document) at the Siege Battery MRS as needed.

3.7 CONTAMINANT FATE AND TRANSPORT

The intent of this section is to describe the fate of contaminants in the environment and the potential transport mechanisms for MEC and MC identified at the Siege Battery MRS. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to the migration mechanisms away from the source area. MD items were found within the Siege Battery MRS, consistent with MD and MEC found in adjacent MRSs. UXO was found on Constitution Island during the SI. Fate and transport dynamics related to MEC at the Siege Battery MRS are discussed in Section 3.7.1.

The surface soil incremental samples did not contain MC concentrations greater than the screening levels or published background levels that would pose a potential human health risk; therefore, the pathways for human receptors to contact MC are considered incomplete. There is little to no potential for adverse ecological impacts from MC in surface soil at the Siege Battery MRS because explosives were not detected and the SQLs were less than the ESVs or alternative ESVs, and the metals detected were within the range of background concentrations published for the area. The risk of exposure to COPECs for ecological receptors at the Siege Battery MRS is considered to be minimal. Based on the analytical data evaluation and the subsequent risk assessment performed for the RI, an MC risk is not present within the Siege Battery MRS. Therefore, further analysis of MC fate and transport dynamics is not warranted.

3.7.1 MEC Fate and Transport

Potential routes of migration include those physical processes that might result in the movement or relocation of MEC from its original placement. If not removed, the MEC will have the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement and are active at the Siege Battery MRS:

- Potential MEC being picked up or moved by a person(s).
- Disturbance of potential MEC during construction, excavation, or other soil moving activities.
- Natural processes such as erosion/deposition or frost heave.

Consistent with the preliminary CSM, the RI identified the following potential human receptors for the Siege Battery MRS: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors. All of these potential receptors engage in activities at the ground surface and may contact and subsequently transport MEC. MRS residents or construction and installation personnel may perform soil-moving activities (e.g., gardening, fencing, construction) that may involve contact and transport of MEC at the ground surface or in the subsurface soil or allow transport of MEC to the Siege Battery MRS in construction fill material.

Over time, the natural erosion of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, this process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of the wash).

In addition to erosion, buried objects have been known to move or migrate toward the surface during freezing and thawing cycles. Movement occurs when cold penetrates the ground, and the water below the buried objects freezes and expands, gradually pushing the objects upward. The phenomenon is often referred to as “frost heave” and is most likely to affect items buried above the frost line. The soil type influences the occurrence of frost heave. Gravel, sand, and clay are not typically susceptible to frost heave, whereas silty soil is susceptible. The maximum frost penetration depth for the region is 1.00 to 1.25 meters (approximately 3.28 feet to 4 feet) bgs (National Oceanic and Atmospheric Administration [NOAA], 1978).

No MEC was identified in the Siege Battery MRS during the RI. MD was found between 0 and 16 inches bgs on the Main Post and between 1 and 8 inches bgs on Constitution Island.

The topography of the Main Post portion of the MRS varies from relatively flat developed areas surrounding a steep ridge that runs parallel to the Hudson River to a steeply sloped area near the northern boundary. The steeply sloped areas have a high potential for erosion because of the slope and soil type (Rock outcrop – Hollis Complex sloping and moderately steep). The soils in the flatter areas of the Main Post portion are moderately to excessively drained with a moderate erosion potential.

The Constitution Island portion of the Siege Battery MRS has moderately sloping hills with a shoreline that includes steep cliffs. The soils are well drained to excessively well drained with a moderate to high erosion potential.

No MEC was identified within either portion of the MRS during the RI; however, one UXO (a 3-inch Stokes mortar) was identified on Constitution Island during the SI. The one UXO and the MD items identified within the MRS are classified as small (less than 100 pounds) and capable of being moved by surface erosion. The one UXO and the MD were identified above the frost line.

The soils found in the Main Post portion of the Siege Battery MRS are low to moderately susceptible to frost heave because of their capacity to retain moisture (see Section 3.1.1.4) and because of the seasonally cold temperatures typical for the regional location of West Point.

The soils found in the Constitution Island portion of the Siege Battery MRS range from well drained to somewhat excessively well drained with a limited capacity to retain moisture and thus a low potential for frost heave.

Surface interactions such as wet/dry erosion are likely to impact source material across the entire MRS. Burrowing biota might come in contact with residual MD because of the shallow depth of the MD observed during the RI, which was identified within the zone of biological activity.

3.8 REVISED CONCEPTUAL SITE MODEL

This section presents the revised MEC and MC CSMs for the Siege Battery MRS based on the results of the data collected for the RI and the information provided in the SI report. The preliminary CSMs are discussed in Section 3.2.1.

3.8.1 Revised Munitions and Explosives of Concern Conceptual Model

The Siege Battery MRS was documented in the preliminary CSM as a 179.3-acre MRS (based on information collected during the RI, the acreage was adjusted to 167.1 acres) comprised of noncontiguous parcels. West of the Hudson River, the MRS includes a portion of the former range area and the firing point (115.1 acres) located on the Main Post area of West Point. East of the Hudson River, the MRS includes 52 acres of Constitution Island associated with the former range fan for the battery.

After completion of the RI field work, an increase in MEC and/or MD densities was observed laterally extending across several MRSs with overlapping ranges, including the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. Based on the observed density distribution, and the type of MEC and MD recovered, the source of the increased clustering and densities is related to the former target area on Crows Nest mountain in the northern extent of West Point. This impact area includes 66.3 acres of the Siege Battery MRS in its northwestern extent where the MRS intersects the Fort Clinton West MRS and abuts the Crows Nest area. Based on the data collected during the RI, the only other portion of the Siege Battery MRS that was observed to be impacted, indicating that a MEC source is present, is Constitution Island.

Separating the 66.3 acres in the northwestern portion of the MRS and the 52 acres on Constitution Island from the original boundary of the Siege Battery MRS would reduce the total acreage from 167.1 acres to 48.8 acres (see **Figure 3-11**) based on the data collected during the RI. Because UXO and/or MD was confirmed to be present in the northwestern 66.3 acres and in the 52 acres on Constitution Island, but not identified in the southeastern 48.8 acres of the range area located on the Main Post (including the firing point), the three portions of the Siege Battery MRS are addressed separately in three CSMs (see **Figure 3-12, Figure 3-13,** and **Figure 3-14**).

3.8.1.1 Revised Munitions and Explosives of Concern Exposure Pathway Analysis

As described in Section 3.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered potentially complete when a source (MEC) has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered incomplete if any one of the three components (source, interaction, or receptors) is not present at an MRS.

3.8.1.1.1 Source

A MEC source is the location where MEC is situated or is expected to be found. Potential MEC source areas in the Siege Battery MRS were considered to be UXO and MD in former range areas and DMM and/or MD at the firing point. High concentrations of MEC and MD were not anticipated within the Siege Battery MRS because the impact area for the former range was located on Crows Nest mountain and not included within the MRS boundary. Low concentrations of MEC, in particular UXO, may be found within the Siege Battery MRS as a result of misfires or undershots toward the former targets. It is possible that MEC and MD may have been transported in fill material and placed within the Siege Battery MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

During the SI survey activities, more than 50 MD items were identified at ground surface within the northwestern portion of the Siege Battery MRS in and around the Lee Housing Area. Additionally, one MEC item (3-inch Stokes mortar) and MD, including fragments of cannonballs and a portion of a Mark IV fuze from a 3-inch Stokes mortar, were identified on Constitution Island. Based on the findings and subsurface anomalies detected, it was concluded in the SI that the exposure pathway for MEC was complete for surface and subsurface soil within the MRS.

A statistical approach was developed to assess the potential MEC density within the Siege Battery MRS to satisfy the UXO Estimator parameters of 0.5 MEC/acre at a 95% confidence level. Following the field work, the results were assessed using UXO Estimator. Based on surveying 5.88 acres with no UXO items found, the actual range of MEC densities characterized in the Siege Battery MRS was calculated to be between 0 and 0.496 MEC/acre with an average of 0.164 MEC/acre. The extent of the MD observed during the RI and the MEC and MD observed previously during the SI were in the delineated impact area within the northwestern portion of the MRS and on Constitution Island on the east side of the Hudson River. During the spatial assessment of geophysical RI findings, it was noted that the SI reported area for the Siege Battery MRS (WSTPT-015-R-01) of 179.3 acres included portions of the Hudson River; therefore, the acreage was adjusted to 167.1 acres to align with the current land boundary. The 12.2 acres removed are assumed to be associated with the Siege Battery – TD – River MRS (WSTPT-016-R-01).

During the RI characterization coverage of 5.88 acres and the intrusive investigation, no MEC was identified. A total of 646 MD items were recovered. The MD was concentrated in two portions of the MRS—the northwestern extent (621 MD items) of the Siege Battery MRS and Constitution Island (24 MD items). Only one MD item was observed along the mag and dig transects performed in the southeastern portion of the MRS. All munitions-related materials were recovered between the surface and 12 inches bgs.

The increase in MEC and MD density observed within the northwestern 66.3-acre portion of the Siege Battery MRS was also observed laterally extending across several MRSs, including the

Fort Clinton West, Lusk Reservoir, and Artillery Firing Range MRSs. Based on the observed density distribution and the type of MEC and MD recovered, the source of the increased clustering and densities is related to the former target area on Crows Nest mountain in the northern extent of West Point. The consistent findings are indicative of a common CSM observed across the MRS boundaries. The MEC sources for the southeastern 48.8-acre portion, the northwestern 66.3-acre portion, and the Constitution Island portion of the Siege Battery MRS are discussed separately in the following subsections.

Southeastern Main Post Portion

During the RI, no MEC was found in the southeastern portion of the Siege Battery MRS. The lack of MEC, and only one subsurface MD item detected (2 inches bgs) in the 48.8 acres, suggests that no MEC source and thus no explosive hazard is anticipated to be present in the southeastern portion of the MRS on the Main Post.

Northwestern Main Post Portion

MD recovered during the RI within the northwestern portion of the Siege Battery MRS was consistent with MD and MEC found in the adjacent Fort Clinton West MRS, and portions of other MRSs (Lusk Reservoir MRS and Artillery Firing Range MRS) with abutting boundaries that terminate south of the Crows Nest. The delineated impact area associated with the Crow Nest includes the 66.3-acre northwestern portion of the Siege Battery MRS. Therefore, a MEC source and an explosive hazard are considered to be present in this portion of the MRS. The MEC and MD are attributed to historical firing toward targets on Crows Nest mountain. Based on the RI results from the adjacent MRSs (Fort Clinton West, Lusk Reservoir, and Artillery Firing Range MRSs) observed to be similarly impacted by MEC and/or MD, the southern boundary for the Crows Nest impact area was determined to traverse the Siege Battery MRS south of the Lee Housing Area and north of the Target Hill MRS.

Constitution Island

During the SI survey activities, one UXO (3-inch Stokes mortar) and MD, including fragments of cannonballs and a portion of a Mark IV fuze from a 3-inch Stokes mortar, were identified on Constitution Island. Although RI findings did not confirm the presence of additional MEC on

Constitution Island, the MD findings were similar in nature to the UXO found previously during the SI. Therefore, a MEC source and thus an explosive hazard are considered to be present for this portion of the MRS.

3.8.1.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes both access and activity considerations. Access describes the degree to which a MEC source or an environment containing MEC is available to potential receptors. Activity describes the action by which receptors come in contact with a source. Typically, a receptor may contact MEC, if present, on the ground surface simply by walking. A receptor may contact MEC in the subsurface, if present, by performing intrusive activities.

Southeastern Main Post Portion

The southeastern 48.8-acre portion of the Siege Battery MRS, where only one subsurface MD item was recovered during the RI, is located in two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. This portion of the MRS is largely undeveloped and densely forested. At the southeastern extent of the MRS, structures include a utility building and sewage treatment facility; and south of the North Athletic Field MRS, structures include the Gillis Field House, Eisenhower Hall (a theater), a utility building, the building that houses the Director of Intercollegiate Athletics, and an amphitheatre. A small portion of the West Point Cemetery is also located within the boundaries of the Siege Battery MRS. Developed portions of the Main Post lie to the south of the MRS.

There are no current plans to change the land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the MRS. Residential and maintenance activities in the southeastern portion of the Siege Battery MRS may disturb surface and subsurface soils (only one subsurface MD item was found). Recreational use is typically confined to surface soil interaction, where no MEC or MD was found. The undeveloped areas in the southeastern portion of the Siege Battery MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

Northwestern Main Post Portion

The northwestern 66.3-acre portion of the Siege Battery MRS, where 621 MD were recovered during the RI, is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. Part of the Lee Housing Area and undeveloped, heavily wooded terrain are located in this portion of the MRS (see **Figure 3-11**). The Crows Nest lies to the north of the MRS.

There are no current plans to change the land use. Once on the West Point installation, access to the northwestern portion of the Siege Battery MRS is unrestricted for human and ecological receptors. A receptor may contact UXO that is on the ground surface (unconfirmed) simply by walking. A receptor may contact UXO (unconfirmed) in the subsurface by performing intrusive activities. Residential and maintenance activities in the Siege Battery MRS may disturb surface and subsurface soils. Recreational use is typically confined to surface soil interaction. The undeveloped areas in the northwestern portion of the Siege Battery MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

Constitution Island

Constitution Island, where primarily MD has been observed except for the one UXO item reported during the SI, is located on the east side of the Hudson River, and is undeveloped. No structures or utilities are located on the Constitution Island portion of the Siege Battery MRS, and this portion of the Siege Battery MRS is located within the Constitution Island Special Natural Area. There are no current plans to change the land use. The portion of the Siege Battery MRS on Constitution Island is restricted by a road with a locked gate that must be accessed by contacting the caretaker. However, Constitution Island is accessible by boat from West Point and is open to the public for organized, scheduled tours. A receptor may contact UXO that is on the ground surface simply by walking. A receptor may contact UXO in the subsurface (unconfirmed) by performing intrusive activities. Recreational use, such as the public tours, is typically confined to surface soil interaction. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

3.8.1.1.3 Receptors

A receptor is an organism (human or ecological) that comes in physical contact with MEC. Human receptors identified for the Siege Battery MRS include West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors. On the Main Post, the area where the majority of MD has been recovered includes the Lee Housing Area in the northwestern extent of the MRS. The center of the MRS is undisturbed and consists of heavily forested, steep terrain, and the southeastern extent contains structures used by West Point personnel and residents. Constitution Island is undeveloped, but accessed by recreational users.

Potential ecological receptors are presented in Section 3.1.1.6.5. Because the northwestern and southeastern areas of the Siege Battery MRS are extensively developed, it is unlikely that the majority of the ecological receptors would rely on these areas for habitat. The central portion of the Siege Battery MRS (abutting the western and southern boundaries of the Target Hill MRS) and Constitution Island may provide habitat for some ecological receptors.

3.8.1.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Siege Battery MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS given current and anticipated future land users.

A statistical approach was taken for the characterization of the Siege Battery MRS, and a portion of the MRS was investigated by geophysical surveys and intrusive investigations. No MEC was identified within the 5.88 acres of investigation coverage and the investigation of 873 anomalies. MD was identified at ground surface and in subsurface soils to a depth of 12 inches bgs. Two portions of the Siege Battery MRS were observed to be impacted by MD—the northwestern extent in the vicinity of the Lee Housing Area and Constitution Island.

3.8.1.2.1 Southeastern Main Post Portion

No MEC and only one MD item was recovered in the 48.8 acres investigated in the southeastern portion of the Siege Battery MRS on the Main Post, including at the firing point. Based on the results of the SI and RI field investigations, it is not expected that a MEC source or explosive safety hazard related to historical range activities is present in this portion of the Siege Battery MRS. Because no MEC source or explosive safety hazard has been identified, there are no current receptor interactions or anticipated interactions under future land use. The revised CSM for MEC identified incomplete pathways for surface and subsurface soils for all receptors having access to the southeastern portion of the MRS (**Figure 3-12**).

3.8.1.2.2 Northwestern Main Post Portion

In the northwestern 66.3-acre portion of the Siege Battery MRS, 621 MD items were recovered during the RI consistent with the findings in adjacent MRSs. These items are believed to be associated with an impact area for former targets on Crows Nest mountain. Numerous MD fragments were also observed in the developed areas. These fragments are believed to have been transported in fill material used for construction activities.

Within the northwestern 66.3 acres of the Siege Battery MRS that are within the Crows Nest impact area, the pathways for MEC to potential receptors are complete based on the MD found within the MRS and on the UXO and MD found adjacent to the Siege Battery MRS. A CSM pathway diagram is provided in **Figure 3-13** for the 66.3 acres in the northwestern portion of the Siege Battery MRS.

3.8.1.2.3 Constitution Island

On Constitution Island, 24 MD items were recovered during the geophysical investigation. These MD items are believed to be a result of munitions fired from the Siege Battery during former range training.

Based on the historical discovery of UXO during the SI on Constitution Island and the MD recovered during the RI, the pathways for all receptors are complete. A CSM diagram for the 52 acres on Constitution Island is provided in **Figure 3-14**.

3.8.2 Revised Munitions Constituents Conceptual Site Exposure Model

MC sampling was conducted based on the need to supplement the historical MC data collected during the SI and based on the RI geophysical investigations at the Siege Battery MRS. Ten incremental samples (includes two field duplicates) were collected to assess MC at eight sampling locations within the Siege Battery MRS.

Seven 0.8-acre sampling units were strategically placed within the Siege Battery MRS in areas where the MD had been found within the Crows Nest impact area in the northwestern portion of the MRS. One of the sampling units was placed along the shared boundary with the Fort Clinton West MRS, where a primary and field duplicate sample were collected. Incremental samples collected from the Crows Nest impact area were comprised of 50 increments collected within each of the 0.8-acre sampling units. One 0.5-acre sampling unit was also placed at the firing point in the southeastern portion of the MRS, and was assessed by collecting both a primary and field duplicate incremental sample, comprised of 30 increments.

The MC sampling results are discussed in Section 3.5.2. The complete analytical results and data validation reports are provided in **Appendix 3-J**. The analytical results were used in the HHRA and SLERA (see Section 3.6), and to update the preliminary CSM as needed.

3.8.2.1 Revised Munitions Constituents Exposure Pathway Analysis

The MC exposure pathway analyses for the Siege Battery MRS are summarized in this section. As previously described in Section 3.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. An exposure pathway for MC requires a source exposure medium (i.e., MC in soil), interaction (release mechanism and exposure route), and receptors. A pathway is considered complete when all components exist and imply potential risk. A pathway is considered potentially complete when data are required to determine whether the pathway is complete or incomplete. An incomplete pathway presents no associated risk and no further data are required.

3.8.2.1.1 Source

Southeastern Main Post Portion

No potential MC sources are known to exist in the 48.8-acre southeastern portion of the Siege Battery MRS on the Main Post. Furthermore, there were no explosives detected in the incremental samples (primary and duplicate) collected from the firing point.

Northwestern Main Post Portion

A significant concentration of MD was identified in the northwestern 66.3 acres of the Siege Battery MRS, and delineated within the impact area associated with the former targets on Crows Nest mountain. Although no soil staining was observed, MC sampling was conducted based on the confirmed MD to investigate whether a MC release occurred and warranted further delineation. Data evaluation and HHRA activities did not identify any COPCs or potential risks to human receptors. No explosives were detected in any of the samples, and detections of lead and mercury were below the alternative screening levels and within the published background levels. The risk from the one COPEC identified during the SLERA, due to an SQL that did not meet the selected ESV, was determined to be minimal. The finding is consistent with analytical sampling performed to support the SI, and indicates that MD, when present, is not a significant source of MC within the Siege Battery MRS and the potential risk of encountering an MC hazard is not present within the northwestern 66.3 acres of the MRS.

Constitution Island

During the SI, two samples were collected from soil on Constitution Island. Based on the SI screening-level comparison, iron was detected in one sample collected from soil associated with MD (cannonball fragment) at a concentration of 47,700 mg/kg. This concentration was above the EPA Region 9 PRG screening value of 23,000 mg/kg, which was the current value at the time of the SI. Since the SI, EPA has replaced the Region 9 PRGs with the RSLs developed and updated biannually by ORNL. Based on the May 2012 RSLs available and selected for use during the RI, the residential soil direct contact screening level for iron is 55,000 mg/kg. Based on this updated screening level, the concentrations of MC observed during the SI would not warrant selection of iron as a COPC. Because the additional MD identified on Constitution Island during the RI was similar in nature to that observed during the SI, and no additional source material for MC was observed (i.e., UXO, soil staining, leaking munitions), no further assessment for MC was performed on Constitution Island. The data collected during the RI indicate that UXO and MD, when present, are not a significant source of MC within the Constitution Island portion of the Siege Battery MRS (52 acres), and the potential risk of encountering an MC hazard is not present.

3.8.2.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes an exposure route with a release mechanism for impacted media. The Siege Battery MRS is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. Once on the West Point installation, access to the portion of the Siege Battery MRS on Main Post is unrestricted for human and ecological receptors. The portion of the Siege Battery MRS on Constitution Island is restricted by a road with a locked gate that must be accessed by contacting the caretaker. However, Constitution Island is accessible by boat from West Point and is open to the public for organized, scheduled tours. A human or ecological receptor may encounter MC in soil through direct contact, including ingestion, inhalation, or dermal exposure routes.

Within the environment, fate and transport of MC in soil, if present, has the potential to be affected by secondary release processes such as wet/dry erosion, infiltration/leaching to groundwater, and food web interactions. These processes may result in the movement or transformation of MC within environmental media. Because an MC release has not been identified in any environmental media, no interactions are expected to exist at the Siege Battery MRS that would expose receptors to MC contamination.

3.8.2.1.3 Receptors

Potential receptors for MC at the Siege Battery MRS are the same as those presented in the revised MEC CSM in Section 3.8.1.1.3.

3.8.2.2 Munitions Constituents Exposure Pathway Conclusions

The analytical results of the eight primary incremental samples and of the two field duplicates were used to update the preliminary MC CSM for the Siege Battery MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users.

3.8.2.2.1 Southeastern Main Post Portion

Sampling for MC was conducted only at the firing point in the southeastern 48.8 acres of the Siege Battery MRS during the RI (no samples collected during the SI) because no MEC, significant amount of MD, soil staining, or visible evidence of a potential MC release have been identified in this southeastern portion of the MRS. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources, and thus no potential risk, are known to exist in the 48.8-acre southeastern portion of the Siege Battery MRS (see **Figure 3-15**).

3.8.2.2.2 Northwestern Main Post Portion

Sampling for MC during the RI was conducted within the northwestern 66.3-acre portion of the Siege Battery MRS (Crows Nest impact area) where the preponderance of MD was found during the SI and RI. Explosives were not detected in any of the soil samples, and the SQLs were determined to be protective of human health during the HHRA. The SQL for 2,6-DNT exceeded the project ESV, but not the NOAEL. Although detected, neither lead nor mercury was found in concentrations above alternative screening levels and/or the published background concentrations. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources, and thus no potential risk, are known to exist in the 66.3-acre northwestern portion of the Siege Battery MRS (see **Figure 3-16**).

3.8.2.2.3 Constitution Island

Although sampling for MC was not performed specifically on Constitution Island during the RI, the lack of MEC identified during the RI characterization of this portion of the MRS indicates that an MC source and thus an MC hazard are not present on Constitution Island. The pathways for MC exposure for this portion of the MRS are considered incomplete (see **Figure 3-17**).

3.9 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT AND MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL

3.9.1 Munitions and Explosives of Concern Hazard Assessment

The CERCLA process for responding to releases or potential releases of hazardous substances includes the development of site-specific risk assessments appropriate to the requirements of a site. The results of the risk assessments are used to help site managers decide whether a response action is required and to support the risk management decisions that are made through the remedy evaluation, selection, and implementation process.

The CERCLA methodology for human health chemical risk assessment was not designed to address explosive safety hazards at MEC sites. In October 2008, the Technical Working Group for Hazard Assessment, which included representatives from DoD, Department of the Interior, EPA, and others, made available the technical reference document *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). The document was designed to be used as the CERCLA hazard assessment methodology for MRSs where an explosive hazard exists from the known or suspected presence of MEC.

3.9.1.1 Southeastern Main Post Portion

No MEC was identified at the Siege Battery MRS during the RI field activities. As a result, the project team determined that the calculation of a MEC HA score was not warranted at the 48.8-acre portion of the Siege Battery MRS.

3.9.1.2 Northwestern Main Post Portion

No MEC was identified at the Siege Battery MRS during the RI field activities; however, a high density area of MD was identified. MD recovered during the RI within the northwestern Main Post portion of the Siege Battery MRS was consistent with the MD and MEC found in the adjacent Fort Clinton West MRS, and portions of other MRSs (Lusk Reservoir MRS and Artillery Firing Range MRS) with abutting boundaries that terminate south of the Crows Nest. The delineated impact area associated with the Crow Nest includes the 66.3-acre northwestern portion of the Siege Battery MRS. Therefore, although no MEC was identified within the 66.3-acre northwestern portion, MEC was identified in the surrounding Crows Nest impact area. Therefore, calculation of a MEC HA score was warranted (see Section 6.6).

3.9.1.3 Constitution Island

During the SI survey activities, one UXO (3-inch Stokes mortar) and MD, including fragments of cannonballs and a portion of a Mark IV fuze from a 3-inch Stokes mortar, were identified on Constitution Island. Although RI findings did not confirm the presence of additional MEC on Constitution Island, the MD findings were similar in nature to the UXO found previously during the SI. Therefore, a MEC HA score was calculated for the Constitution Island portion of the Siege Battery MRS.

The MEC HA is structured around three components of a potential explosive hazard incident:

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

Each of these components is assessed in the MEC HA by input factors for the Constitution Island portion of the Siege Battery MRS. The sum of the input factor scores falls within one of four defined ranges, called hazard levels. Each of the four levels reflects site attributes that describe groups of sites and site conditions ranging from the highest to the lowest hazards. The MEC HA hazard levels are as follows:

- Hazard Level 1 — Sites with the highest hazard potential. There might be instances where an imminent threat to human health exists from MEC.
- Hazard Level 2 — Sites with a high hazard potential. A site 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.
- Hazard Level 3 — Sites with a moderate hazard potential. A site that would be considered safe for the current land use without further munitions responses, although not necessarily suitable for reasonable, anticipated future use. Level 3 areas generally would have restricted access, a low number of contact hours, and, typically, MEC only in the subsurface.
- Hazard Level 4 — Sites with a low hazard potential. A site compatible with current and reasonably anticipated future use. Level 4 sites typically have had a MEC cleanup performed.

The MEC HA fits into MMRP activities and the regulatory structure of CERCLA by addressing the NCP requirements to conduct site-specific risk assessments for threats to human health and the environment. The MEC HA does not directly address environmental or ecological concerns that might be associated with MEC (EPA, 2008).

The MEC HA guidance document (EPA, 2008) includes an automated workbook that develops site scoring through standardized input and formulas. As part of the RI, the automated workbook was used to provide an HA score. The following is a summary of the MEC HA scoring for the Constitution Island portion of the Siege Battery MRS:

Site ID: Siege Battery Constitution Island	Hazard Level	Category Score
Current Use Activities	3	690

Source: EPA MEC HA Worksheet V.1.2,

The Constitution Island portion of the Siege Battery MRS has a Hazard Level Category of 3, which indicates the MRS has a moderate hazard potential. The presence of MEC at an MRS means that an explosive hazard may exist. Siege Battery Constitution Island MRS characteristics of a Hazard Level 3 MRS include the following:

- No features or facilities where people may congregate within the MRS or hazardous fragment distance arc.
- An MRS with moderate accessibility, and a low number of contact hours.
- A safety buffer area.

Supporting MEC HA input information is provided in **Appendix 3-K.**

3.9.2 Munitions Response Site Prioritization Protocol Scoring Update

The results from the RI were used to update the MRSPP scoring. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with CWM can be assigned to Priority 1 and no MRS with CWM can be assigned to Priority 8.

3.9.2.1 Southeastern Main Post Portion

MRSPP forms for the southeastern 48.8-acre portion of the Siege Battery MRS not within the impact area are provided in **Appendix 3-L**. The MRSPP for the southeastern 48.8 acres indicates that there is no known or suspected hazard.

3.9.2.2 Northwestern Main Post Portion

Data and information relative to the northwestern 66.31-acre portion of the Siege Battery MRS are included in application of the MRSPP to the Artillery Firing Range North MRS (see Section 6.6.2).

3.9.2.3 Constitution Island

MRSPP forms for the 52-acre Constitution Island portion of the Siege Battery MRS are provided in **Appendix 3-L**. A priority of 3 was assigned to the Constitution Island portion of the MRS based on characterization performed during the RI.

3.10 SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI activities conducted at the Siege Battery MRS. The RI was conducted to determine the nature and extent of MEC and MC and to determine the potential hazards and risks posed to human health and the environment by MEC and MC. The RI also provided additional data to assist in determining what remedial alternatives, if any, are necessary. As a result of the characterization activities conducted at the Siege Battery MRS, the objectives of the RI have been satisfied.

3.10.1 Summary of Remedial Investigation Activities

The preliminary CSM for the Siege Battery MRS aided in developing data needs and DQOs as documented in the Final RI Work Plan (WESTON, 2011a). In general, the data needs and DQOs focused on characterizing the nature and extent of the MEC and MC that may be present in the MRS because of activities at the former batteries and artillery ranges. The characterization activities to support the data needs and DQOs were used to gather information to evaluate whether there are unacceptable potential risks to human health and the environment associated with MEC and/or MC to determine whether further action is required under the CERCLA process.

UXO Estimator was used to develop a statistically based characterization strategy. Geophysical surveys were performed at the Siege Battery MRS between April and August 2011 to assess the nature and extent of MEC in the MRS. Both DGM (EM61-MK2) and mag and dig (White's all-metals detector) surveys were performed as part of the RI field work. A total of 5.88 acres and 873 anomalies were investigated as a result of the geophysical surveys.

No MEC was observed in the Siege Battery MRS. A total of 646 MD items were recovered at depths ranging between 0 inches and 12 inches bgs. The MD was recovered from two concentrated areas—the northwestern portion of the MRS where the boundary abuts the Crows

Nest and Constitution Island. One MD fragment was found along a mag and dig transect located on the Main Post outside the Crows Nest impact area and southwest of the Target Hill MRS (transect SB-T12). The MD recovered from within the Siege Battery MRS included the following items:

- Southeastern Main Post Portion
  - 1 fragment from unknown munitions
- Northwestern Main Post Portion (Crows Nest impact area)
  - 615 fragments from unknown munitions
  - One empty hand grenade (MKII)
  - One 3.5-inch cannonball (solid shot)
  - One 6-inch cannonball (solid shot)
  - One 8-inch Butler projectile
  - One 5.3-inch Parrott type II bottle top
  - One 10-inch Parrott type II bottle top
- Constitution Island
  - 24 fragments from unknown munitions.

The remaining non-MD related material included 217 items classified as cultural debris, 7 no contacts, and 3 quality control seeds. These items were recovered between the surface and 16 inches bgs.

Seven sampling locations were selected to assess potential MC contamination in soil through incremental sampling at the Siege Battery MRS based on the significant densities of MD. MEC observed in the adjacent Fort Clinton West MRS was also considered, and one of the sampling units was placed along the border of the two MRSs. No other signs of a MC release (e.g., soil staining, broken/leaking munition) were observed during the RI. Fifty increments were collected within 0.8-acre sampling units located in the MD-impacted area observed in the northwestern 66.3-acre portion of the Siege Battery MRS delineated within the Crows Nest impact area. One 0.5-acre sampling unit was also placed at the firing point located in the southeastern portion of the MRS.

The samples were collected and analyzed to identify the presence of MC (if any) and to fully characterize the nature and extent of MC. No explosives were detected in the samples; however, elevated SQLs for several compounds were further evaluated during the HHRA and SLERA. Lead and mercury concentrations were also considered in the HHRA and SLERA.

3.10.2 Risk Assessment

The results of the HHRA showed that no MC was present that constituted a potential risk to human health. All explosives analytical results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs, and were observed below the project screening levels ultimately used to assess human health effects. Although the SQL reported for nitroglycerin was above the project screening level initially selected to assess a target HQ of 0.1, the lack of identified noncarcinogens allowed the screening level to be adjusted upwards to a target HQ of 1.0. In the HHRA, it was determined that the nondetect SQLs reported by the laboratory were protective of human health. Both lead and mercury were positively detected, but based on results of the HHRA, the incremental samples did not contain concentrations of either analyte in excess of background levels that would pose a potential risk to current or future West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

There is little to no potential for adverse ecological impacts from explosives MC in surface soil at the Siege Battery MRS because only the SQL for 2,6-DNT slightly exceeded the EPA conservative screening value. However, SQLs for 2,6-DNT were below the less conservative alternative screening value obtained to assess the NOAEL. Additionally, 2,6-DNT was not detected in any samples collected at the program-level at other West Point MRSs, and toxicological information indicates that this compound would not be likely to persist in surface soil. Although both mercury and lead were positively detected at concentrations above the conservative project ESVs initially used for the point-by-point comparison, the concentrations were found to be both below alternative ESVs that were available and within published background levels. Therefore, the risk of exposure to COPECs for ecological receptors at the Siege Battery MRS is considered to be minimal.

3.10.3 Revised Conceptual Site Model

A discussion of the preliminary CSM, based on the data available at the time and the historical information compiled prior to the RI activities, is presented in Section 3.2.1. The information collected during the RI was used to update the CSM. The purpose of the CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and reasonably anticipated future land use activities at the MRS. An exposure pathway is the course a

MEC item or MC takes from a source to a receptor. Each pathway includes a source, interaction (activity and access), and receptor.

The Siege Battery MRS includes the Siege Battery and Seacoast Battery firing points, the Siege Battery range fan, and portions of overlapping artillery range fans from adjacent MRSs. High concentrations of MEC and MD were not anticipated within the MRS. The impact area for the former range is on Crows Nest, and not included within the Siege Battery MRS boundaries. The firing point has been reworked significantly as a result of infrastructure development since active use for training. Low concentrations of MEC, in particular UXO, might be located within the MRS because of misfires or undershots toward the impact area. It is possible that MEC and MD may have been transported in fill material and placed within the Siege Battery MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

A statistical approach was developed to assess the potential MEC density within the Siege Battery MRS. UXO Estimator was used to develop the appropriate coverage necessary to make high confidence assessments. No MEC was found within the 5.88 acres where geophysical surveys and subsequent intrusive investigation of 873 anomalies were conducted. These results were then re-assessed in UXO Estimator. The statistical upper bound density of MEC was determined to be 0.496 MEC per acre based on the percentage of area surveyed at the Siege Battery MRS and the actual intrusive investigation results. This value was within the DQO target density of 0.5 MEC per acre, which means that the investigation was adequate to be 95% confident that there is less than 0.496 MEC per acre within the MRS. The UXO Estimator results indicate that a statistical potential for MEC may remain at the MRS.

Based on the spatial distribution of MD findings and the lack of MEC detected during the RI, it is anticipated that no MEC source or explosive safety hazard is present in the 48.8 acres of the southeastern portion of the Siege Battery MRS on the Main Post.

During the RI, two areas with concentrations of MD were characterized—the northwestern extent of the Siege Battery MRS on the Main Post where the MRS abuts the Crows Nest and the 52 acres located on Constitution Island.

On the Main Post portion of the Siege Battery MRS, 622 MD items were recovered, with all but one item found in the northwestern portion of the MRS. Concentrations of UXO and/or MD were also observed in the MRSs adjacent to the Siege Battery MRS. The UXO and MD are attributed to the MEC impact area associated with Crows Nest mountain. The southeastern boundary for the Crows Nest impact area was determined to extend south of the Lee Housing Area and to follow the northern extent of the Target Hill MRS boundary within the Siege Battery MRS. Thus the 66.3-acre northwestern portion of the Siege Battery MRS is within the Crows Nest impact area.

On Constitution Island, 24 MD items were identified during the RI geophysical investigation in addition to the MD and one UXO item (3-inch Stokes mortar) found in this portion of the MRS during the SI.

Removing the 66.3-acre northwestern portion and the 52 acres located on Constitution Island from the MRS would reduce the total area for the Siege Battery MRS from 167.1 acres to 48.8 acres.

The revised CSM for the Siege Battery MRS addresses the three areas separately—the southeastern 48.8 acres on the Main Post, the northwestern 66.3 acres delineated within the Crows Nest impact area, and the 52 acres on Constitution Island.

3.10.3.1 Southeastern Main Post Portion

The UXO Estimator results indicate that a statistical potential for MEC may remain at the MRS; however, no MEC source was identified and only one MD item was recovered during the RI in the 48.8-acre southeastern Main Post portion of the Siege Battery MRS. Therefore, it is unlikely that an explosive safety hazard exists in this portion of the MRS. The revised CSM for MEC identified incomplete pathways for all receptors having access to the 48.8-acre southeastern Main Post portion of the Siege Battery MRS.

3.10.3.2 Northwestern Main Post Portion

Based on the statistical potential for UXO to remain within the Siege Battery MRS, and the confirmed UXO recovered during the RI in the adjacent Fort Clinton West MRS and Artillery Firing Range MRS, the pathways for MEC exposure for all receptors were determined to be complete in the 66.3-acre northwest Main Post portion of the Siege Battery MRS included in the Crows Nest impact area delineation.

3.10.3.3 Constitution Island

Based on the discovery of 24 MD items during the RI on Constitution Island believed to be associated with former range activities, and the historical UXO found during the SI, it was concluded that the pathways for MEC exposure are complete for the 52 acres of the Siege Battery MRS located east of the Hudson River.

3.10.3.4 MC Sampling

Media sampling was performed at the Siege Battery MRS at the firing point and in the area where a potential MC release could occur based on the presence of MD identified during the RI. No MC was detected within the Crows Nest impact area or at the firing point that would pose significant risks to human or ecological receptors. The RI findings indicate that the MC exposure pathway is incomplete for human and ecological receptors in all three portions of the MRS.

3.10.4 Munitions and Explosives of Concern Hazard Assessment

An evaluation of the explosive hazard at the Siege Battery MRS was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). No MEC was identified at the MRS during the RI field activities. However, during the SI survey activities, one UXO (3-inch Stokes mortar) was identified on Constitution Island. A MEC HA score of 690 with a corresponding hazard level of 3 was calculated for the Siege Battery Constitution Island MRS. The confirmed UXO found on Constitution Island is included in the MEC HA provided in **Appendix 3-K**.

Despite the lack of MEC found during the RI surveys and anomaly investigations, qualitative assessment regarding a MEC source for the Siege Battery Constitution Island MRS indicates that there is likely a source and an explosive hazard present. Therefore, fate and transport dynamics pertaining to MEC are discussed as applicable to the Siege Battery Constitution Island MRS.

3.10.4.1 MEC Fate and Transport

Potential routes of migration include those physical processes that might result in the movement or relocation of MEC from its original placement. If not removed, the MEC will have the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement and are active at the Siege Battery MRS:

- Potential MEC being picked up or moved by a person(s).
- Disturbance of potential MEC during construction, excavation, or other soil moving activities.
- Natural processes such as erosion/deposition or frost heave.

All human receptors with access to the MRS may engage in activities at the ground surface and may contact and subsequently transport MEC.

Over time, the natural erosion of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, this process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of the wash).

The soils found in the Main Post portion of the Siege Battery MRS are low to moderately susceptible to frost heave because of their capacity to retain moisture (see Section 3.1.1.4) and because of the seasonally cold temperatures typical for the regional location of West Point. The soils found in the Constitution Island portion of the Siege Battery MRS range from well drained to somewhat excessively well drained with a limited capacity to retain moisture and thus a low potential for frost heave. Surface interactions such as wet/dry erosion are likely to impact source material across the entire MRS.

Burrowing biota might come in contact with residual MD because of the shallow depth of the MD observed during the RI, which was identified within the zone of biological activity. The maximum frost penetration depth for the region is 1.00 to 1.25 meters (approximately 3.28 feet to 4 feet) bgs (National Oceanic and Atmospheric Administration [NOAA], 1978).

3.10.5 Uncertainties

The primary uncertainty for this RI is based on the statistical calculations performed using UXO Estimator. The survey coverage for the Siege Battery MRS was determined by UXO Estimator so that at a 95% confidence level, a minimum MEC density of 0.5 MEC/acre was expected to be found at the survey area. Following the investigation, UXO Estimator was used to calculate the statistical upper bound density of MEC to be 0.496 MEC/acre at a 95% confidence level. The statistical lower bound density of MEC within the Siege Battery MRS was calculated to be 0.164 MEC/acre. Therefore, it is statistically possible that MEC may be present at the Siege Battery MRS, especially within the 66.3 acres delineated within the Crows Nest impact area in the northwestern extent of the MRS and on Constitution Island where UXO was found during the SI. MEC may be present either as a result of misfires or undershots during former range use or within fill material transferred to the Siege Battery MRS from other portions of West Point. However, because the DQOs were met and no MEC was found during the RI field activities, the anticipated MEC density is low.

3.10.6 Conclusions and Recommendations

Based on the results of the RI field activities, the following conclusions were determined for the Siege Battery MRS:

- A total of 5.88 acres were investigated at the MRS during the RI, exceeding the required spatial coverage needed to achieve a high statistical confidence to determine MEC density.
- MD was found in surface and subsurface soil to 12 inches bgs in the 66.3-acre northwestern portion of the MRS delineated within the Crows Nest impact area, and within the 52 acres of the MRS located on Constitution Island. Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for these portions of the MRS.

- Because no MEC and only one MD was found and the DQOs for the project were met, an explosive safety hazard is not anticipated to exist in the remaining 48.8 acres of the Siege Battery MRS located on the Main Post. Incomplete MEC pathways were identified for surface and subsurface soils for all receptors having access to this portion of the MRS.
- MC pathways to potential receptors were determined to be incomplete for the southeastern Main Post portion, the northwestern Main Post portion, and Constitution Island.

The DQOs for the Siege Battery MRS have been satisfied and the nature and extent of MEC and MC adequately characterized. It is recommended that the 66.3-acre northwestern portion of the Siege Battery MRS located on the Main Post and associated with the Crows Nest impact area be transferred to the Artillery Firing Range North MRS (WSTPT-001-R-02). The Artillery Firing Range North MRS consolidates the areas of the Main Post that have increased concentrations of MEC and MD associated with the Crows Nest impact area. The recommendations, which are further documented in **Table 3-15** and **Figure 3-11**, are as follows:

- Revise the Siege Battery MRS to 48.8 acres within the Main Post.
- Transfer the northwestern 66.3-acre portion of the Siege Battery MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS.
- Delineate the 52 acres of the Siege Battery MRS located east of the Hudson River on Constitution Island as a separate MRS.

Table 3-15 Siege Battery MRS Recommendations

Original Configuration		Configuration Following Recommendations	
MRS Name	**Area**	**MRS Name**	**Area**
Siege Battery (WSTPT-015-R 01)	167.1 acres	Siege Battery (WSTPT-015-R-01)	48.8 acres
		Artillery Firing Range North (WSTPT-001-R-02)	143.3 acres (includes 66.3 acres from within the original boundaries of the Siege Battery MRS)*
		Siege Battery Constitution Island (WSTPT-015-R-02)	52 acres

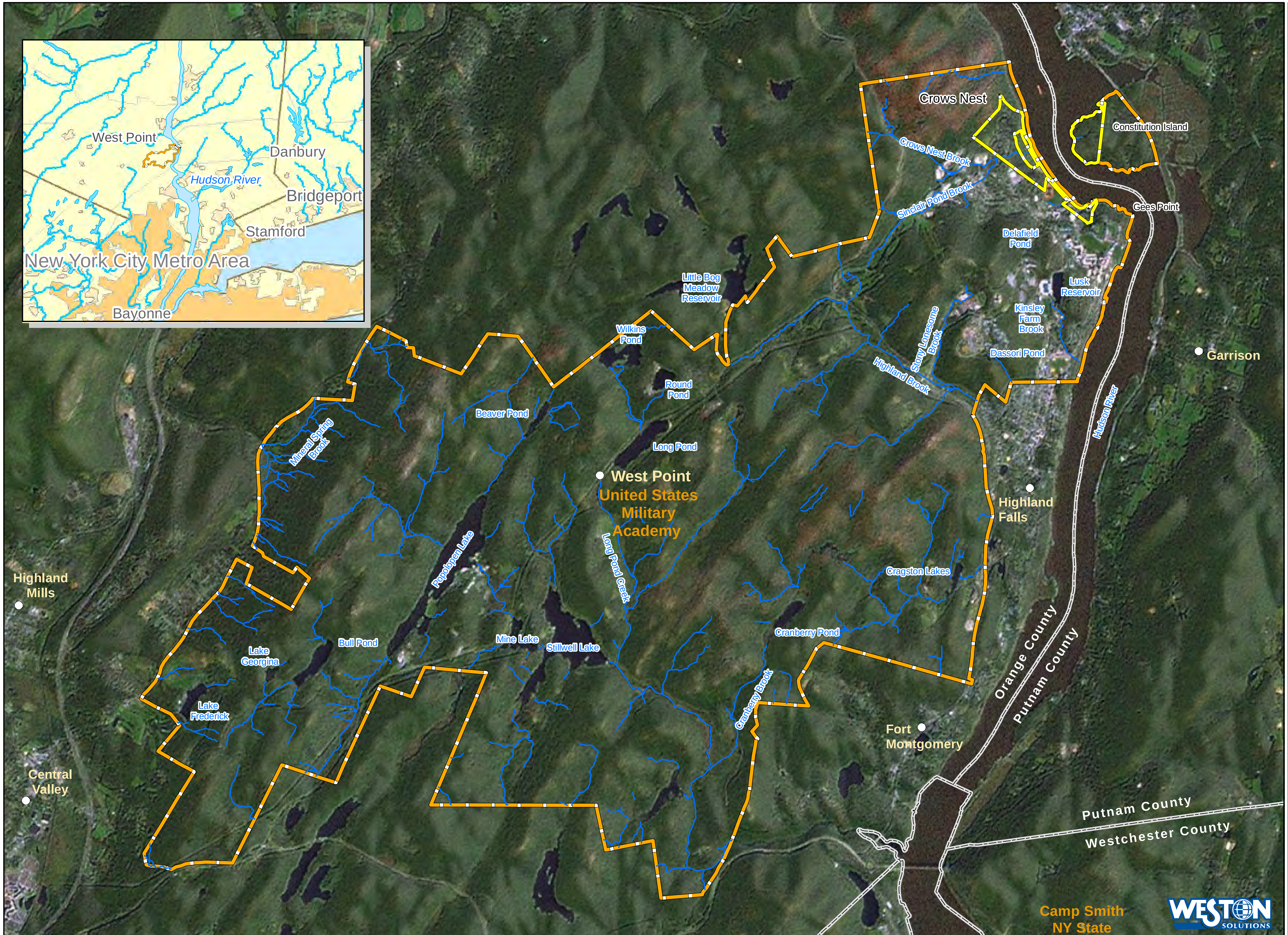
* The Artillery Firing Range North MRS acreage is a combination of areas from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, and the Artillery Firing Range MRS that have increased concentrations of MEC and MD associated with the Crows Nest impact area (see Section 6).

Adjusted Siege Battery MRS (WSTPT-015-R-01)—Based on the conclusions, no further action under the MMRP is recommended for the adjusted Siege Battery MRS (WSTPT-015-R-01). Future actions for the Siege Battery MRS may include the preparation of a No Further Action Proposed Plan for public review followed by the issuance of a Decision Document.

Artillery Firing Range North MRS (WSTPT-001-R-02)—The Artillery Firing Range North MRS is discussed in Section 6. It is recommended that the Crows Nest impact area be further evaluated for potential action in an FS to address hazards related to the presence of MEC. Sections 2 through 5 present details about the Crows Nest impact area that was identified within the original boundaries of the Lusk Reservoir, Fort Clinton West, Siege Battery, and Artillery Firing Range MRSs.

Siege Battery Constitution Island MRS (WSTPT-015-R-02)—Based on the MD found on Constitution Island during the RI and the UXO found previously during the SI, an FS is recommended to further evaluate future action at the Siege Battery Constitution Island MRS.

SECTION 3
FIGURES



Legend

Installation Boundary

Siege Battery MRS - 167.1 Acres

Streams

Imagery Source: ESRI, World Imagery USAD FSA, NAIP 2009

N W E S

0 1 2

Miles

WESTON SOLUTIONS

Figure 3-1
Regional Location Map
Showing the Location of
Siege Battery MRS
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Location Map.mxd, 2/27/2014 3:30:46 PM, johna

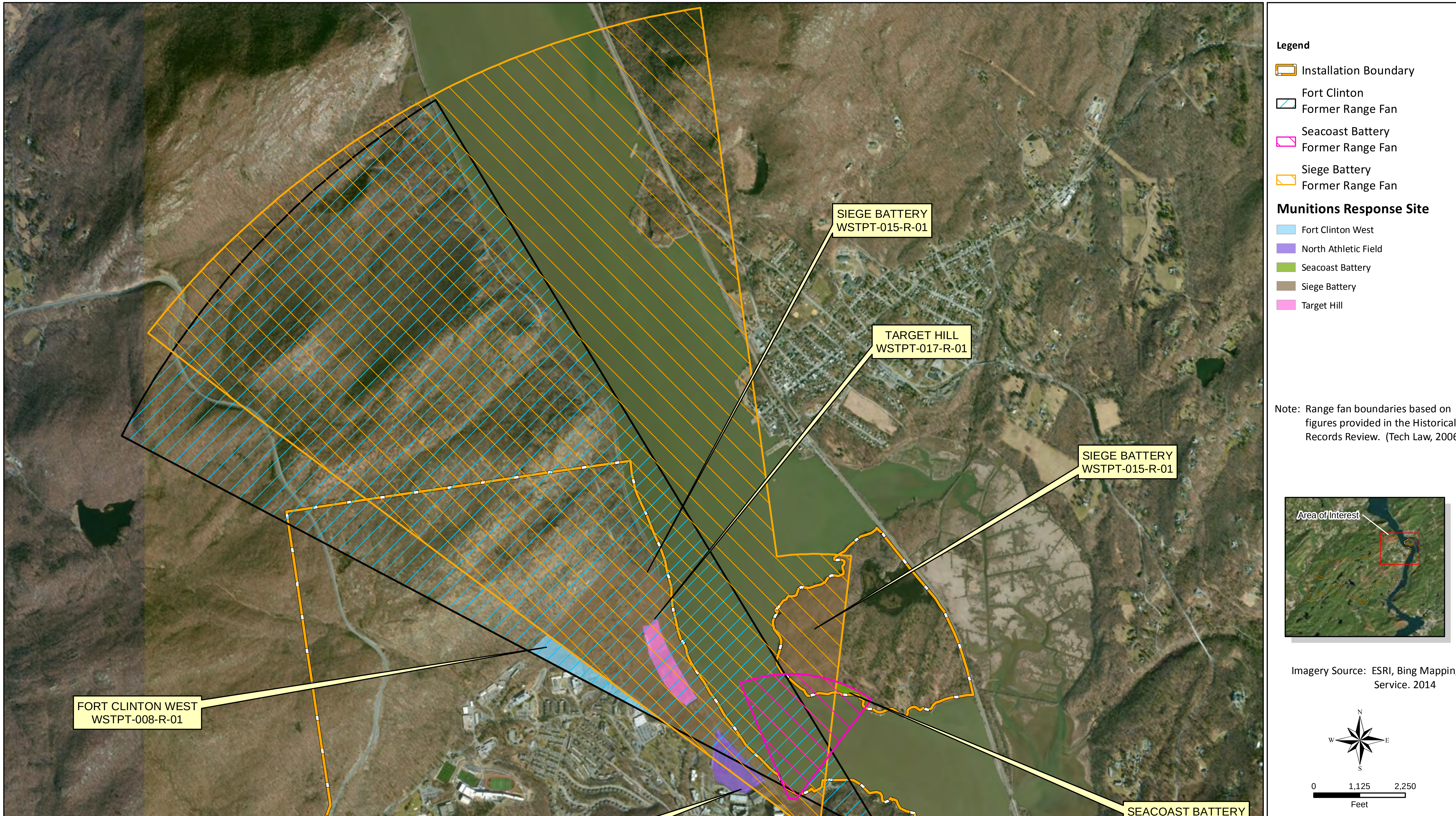


Figure 3-2
Historical Range Fans
U.S. Army Garrison - West Point

File: Y:\West_Point\mxd\RI\Historic_Rangefans.mxd, 2/6/2015 10:45:56 AM, ricksc

Legend

Siege Battery MRS - 167.1 Acres

Cultural Resources

Imagery Source: ESRI, Bing Mapping Service. 2013

N S W E

0 375 750 Feet

Figure 3-3
Siege Battery MRS
(WSTPT-015-R-01)
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Siege_Battery.mxd, 2/21/2014 2:30:31 PM, ricksc

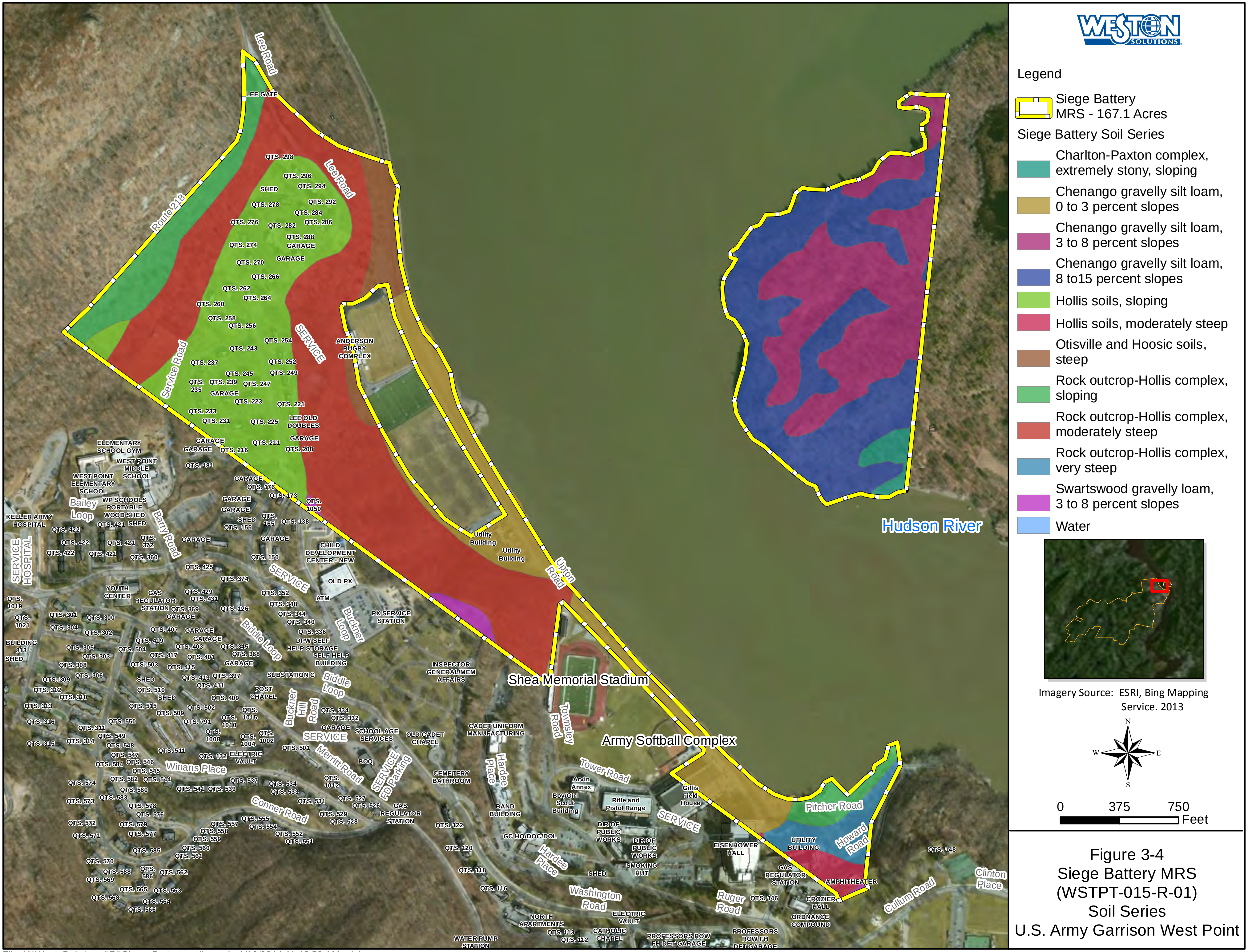
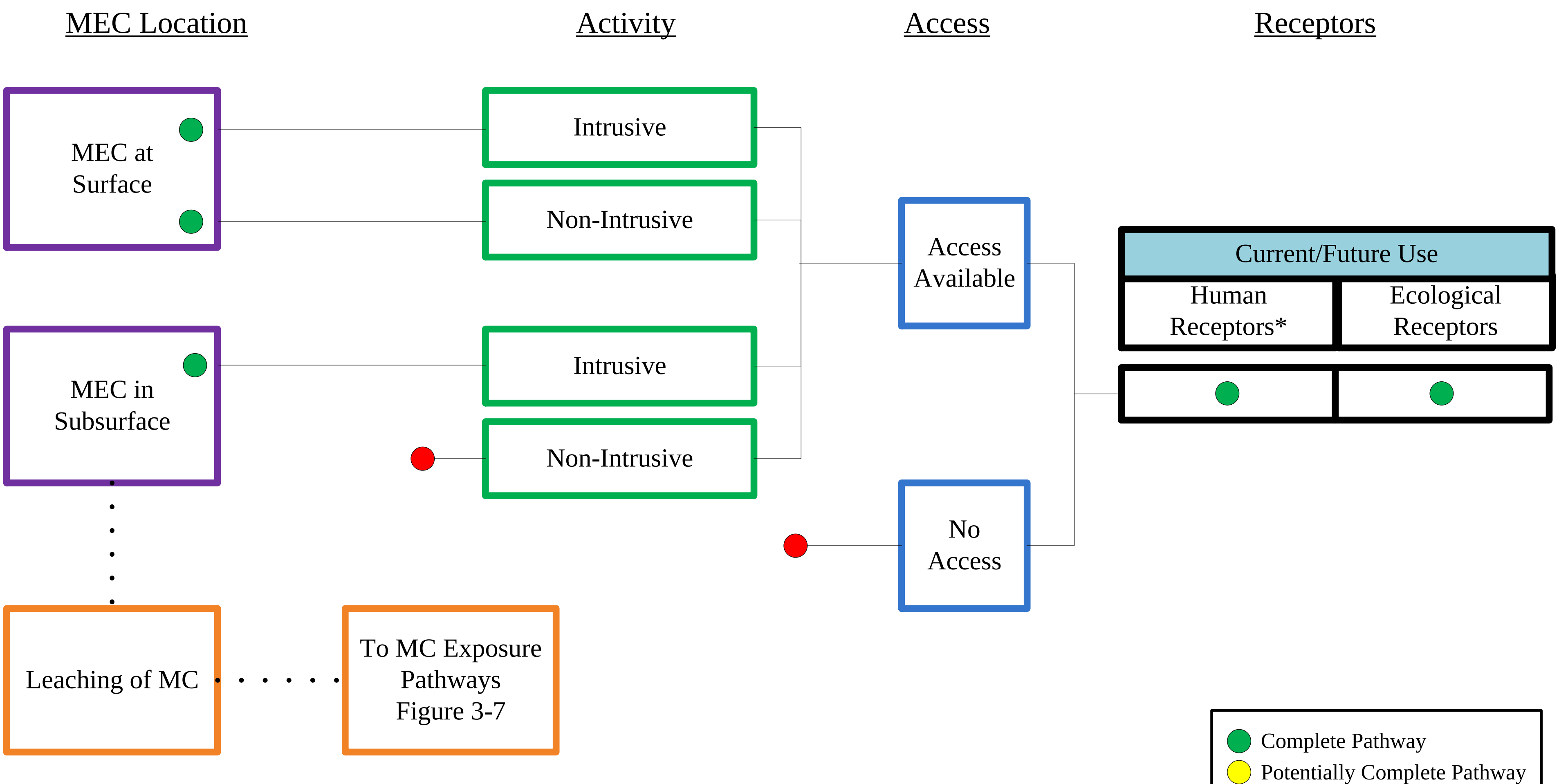


Figure 3-4
Siege Battery MRS
(WSTPT-015-R-01)
Soil Series
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Siege_Battery_soils.mxd, 1/10/2014 11:42:50 AM, ricksc

Figure 3-5
Siege Battery MRS
(WSTPT-015-R-01)
SI Results
U.S. Army Garrison West Point

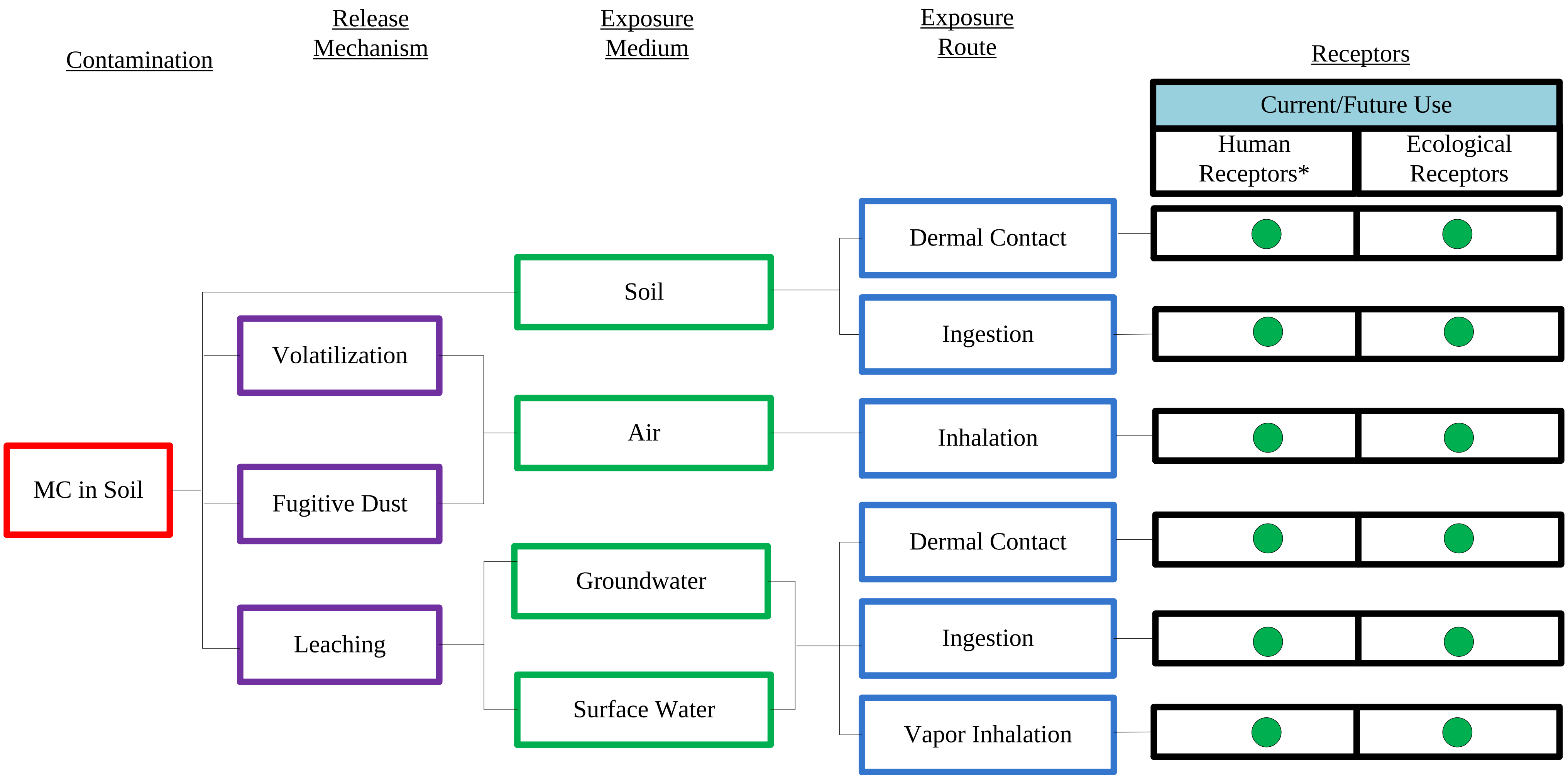
File: Y:\West_Point\mxd\RI\Siege_Battery_SI.mxd, 1/10/2014 11:42:38 AM, ricksc



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

Source: TLI Solutions, Inc., 2007.

Figure 3-6
SI Exposure Pathways for
Receptors to MEC, Siege Battery MRS



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

Source: TLI Solutions, Inc., 2007.

- Complete Pathway
- Potentially Complete Pathway
- Incomplete Pathway

Figure 3-7
SI Exposure Pathways for Receptors to MC, Siege Battery MRS

Path: Y:\West_Point\mxd\RI\Siege_Battery_Grid_Transect_locs.mxd Author: ricksc 1/10/2014 11:48:10 AM

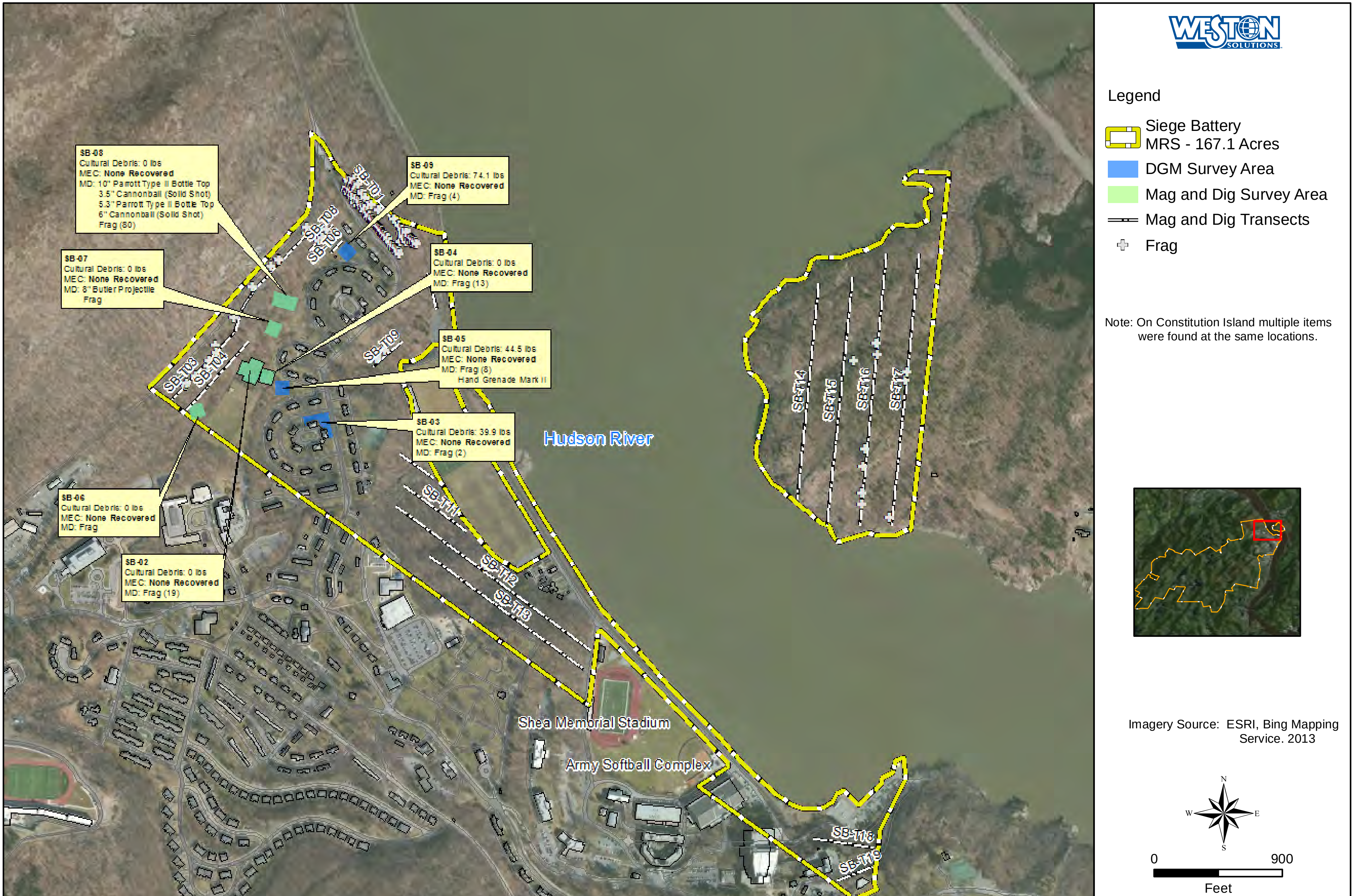


Figure 3-9
Siege Battery MRS
(WSTPT-015-R-01)
Dig Results
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Siege_Battery_Dig_Result_Cultural_Debris.mxd, 1/13/2014 12:46:23 PM, ricksc

Figure 3-10
Siege Battery MRS
(WSTPT-015-R-01)
Dig Results: Higher Density Area
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Siege_Battery_Dig_Result_Cultural_Debris_zoom.mxd, 12/19/2013 3:58:14 PM, ricksc

Legend

Siege Battery (WSTPT-015-R-01) - 48.8 Acres

Portion of Siege Battery (66.3 acres) Transferred to Artillery Firing Range North MRS (WSTPT-001-R-02)

Siege Battery - Constitution Island (WSTPT-015-R-02) - 52.0 Acres

Crows Nest Impact Area

Imagery Source: ESRI, Bing Mapping Service. 2013

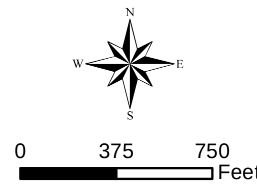
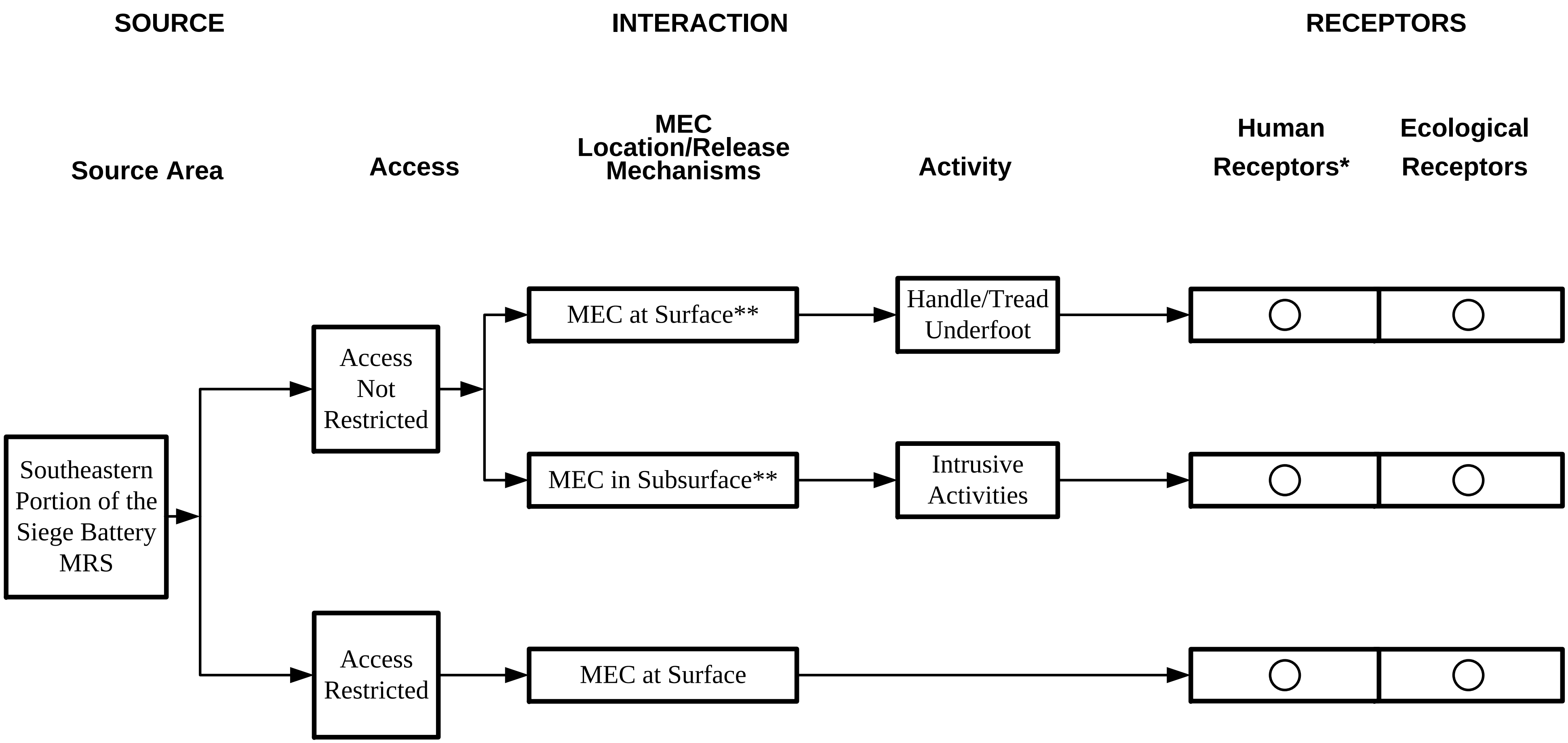


Figure 3-11
Siege Battery MRS
Revised Boundaries
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Siege_Battery_Revised_MRS.mxd, 11/3/2014 2:04:31 PM, ricksc



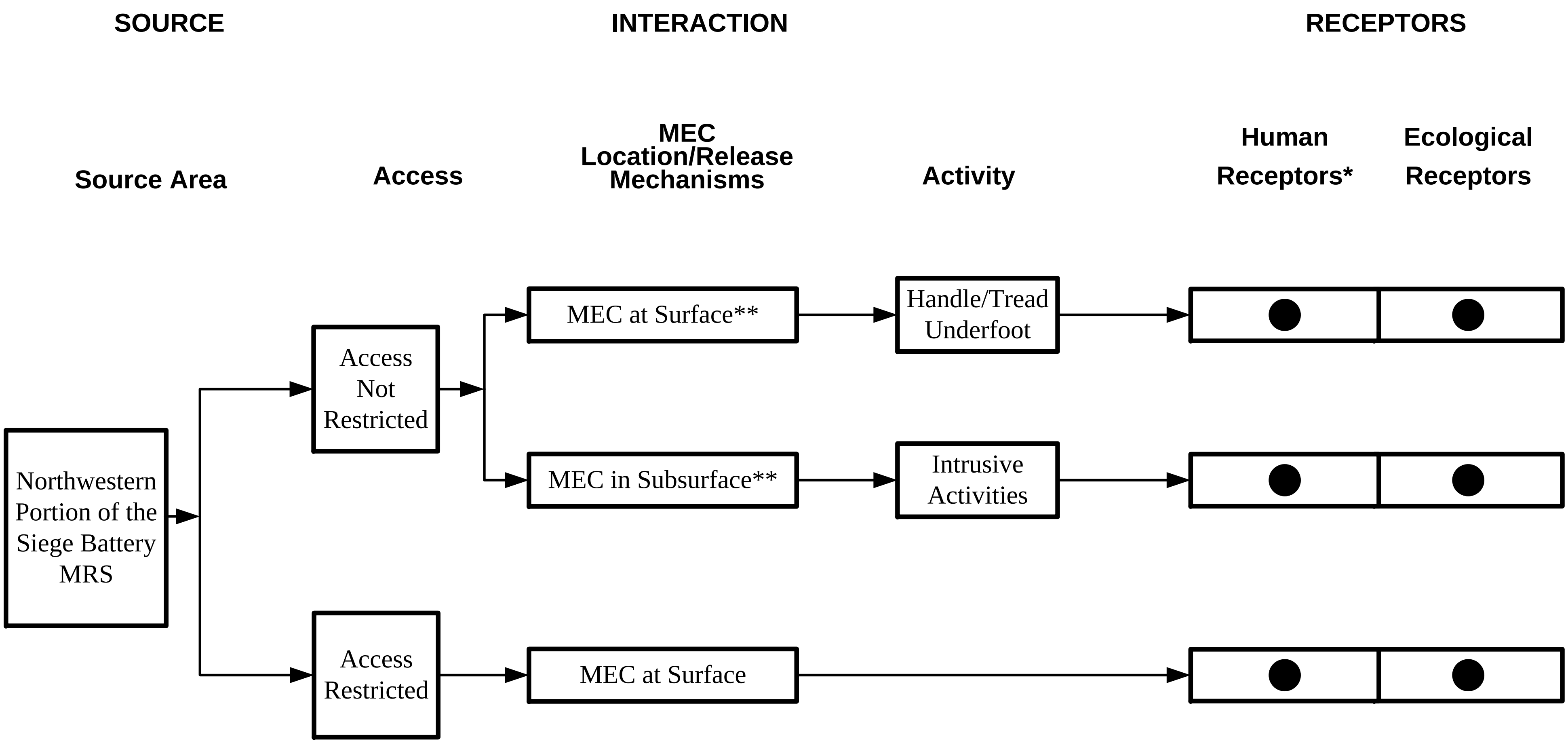
* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** No MEC recovered during the RI; one MD item found at 2 inches bgs.

Complete Pathway
Potentially Complete Pathway
Incomplete Pathway

Figure 3-12
RI Exposure Pathways for Receptors to MEC in the Southeastern Main Post 48.8-Acre Portion of the Siege Battery MRS

Fig 3-12_3-13_3-14_3-15_3-16_3-17_Siege Battery_Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** No UXO recovered during the RI in this MRS, MD recovered at ground surface and to 12 inches bgs. UXO recovered in adjacent Fort Clinton West MRS also within the Crows Nest impact area.

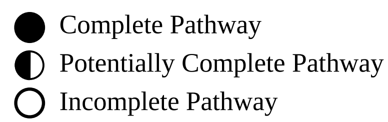
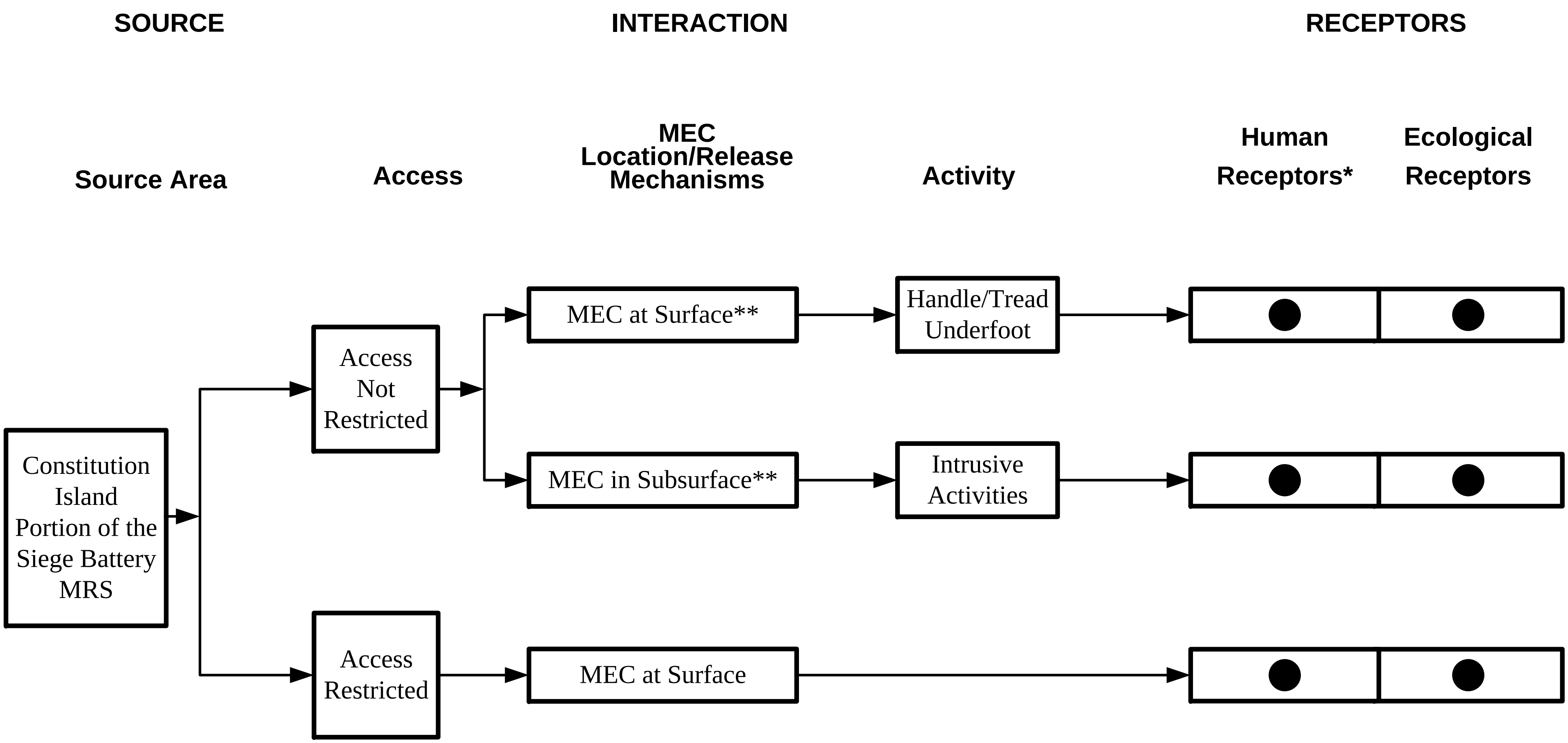


Figure 3-13
RI Exposure Pathways for Receptors to MEC in the Northwestern Main Post 66.3-Acre Portion (Crows Nest Impact Area) of the Siege Battery MRS

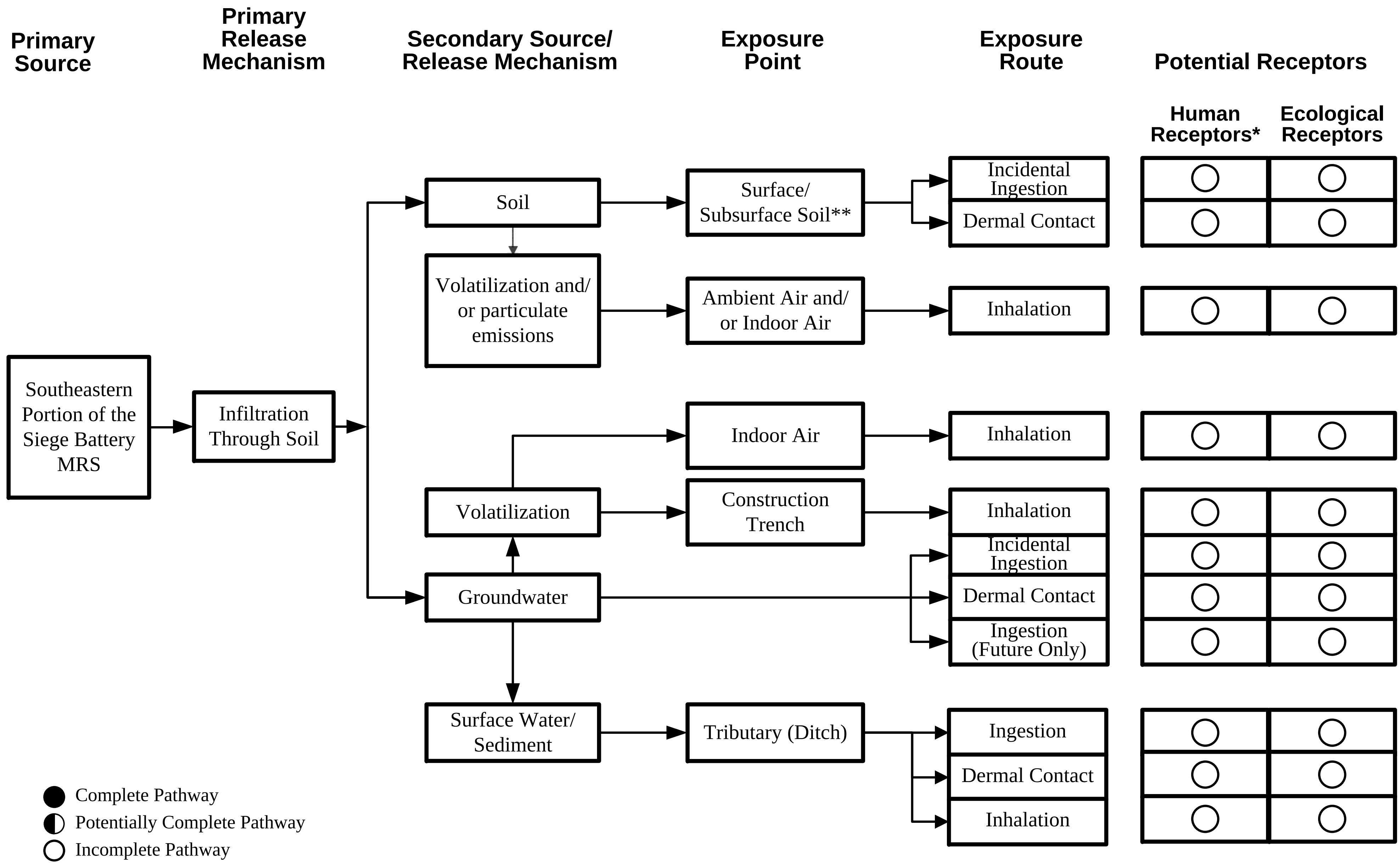


* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** No UXO recovered during the RI in this MRS. MD recovered at ground surface and to 12 inches bgs. UXO found at ground surface during the SI.

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

Figure 3-14
RI Exposure Pathways for Receptors to MEC in the Constitution Island 52-Acre Portion of the Siege Battery MRS



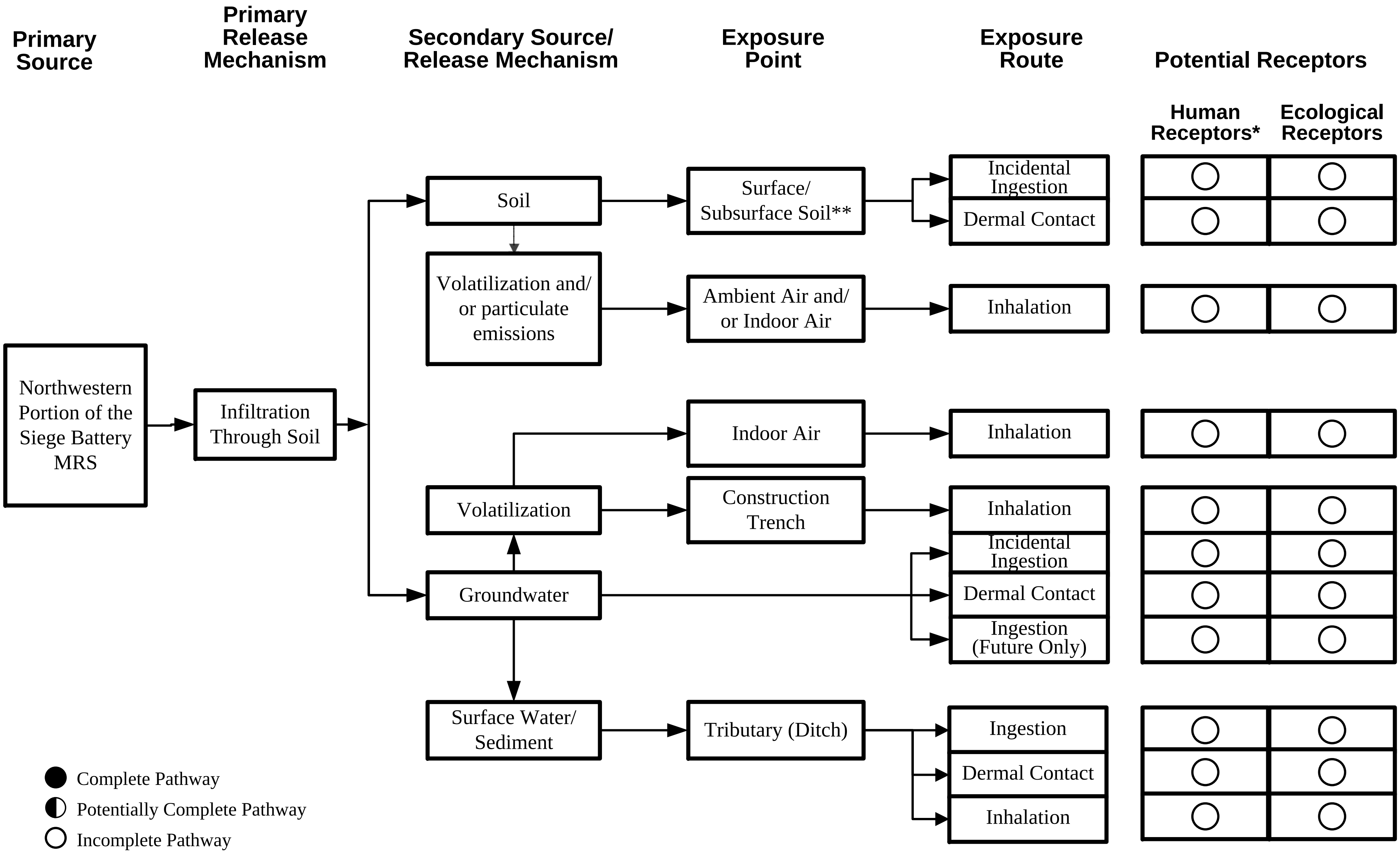
* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** No MEC was recovered during the RI; one MD item found at 2 inches bgs.

Figure 3-15

RI Exposure Pathways for Receptors to MC in the Southeastern Main Post 48.8-Acre Portion of the Siege Battery MRS

Fig 3-12_3-13_3-14_3-15_3-16_3-17_Siege Battery_Exposure Pathways for MEC and MC.vsd

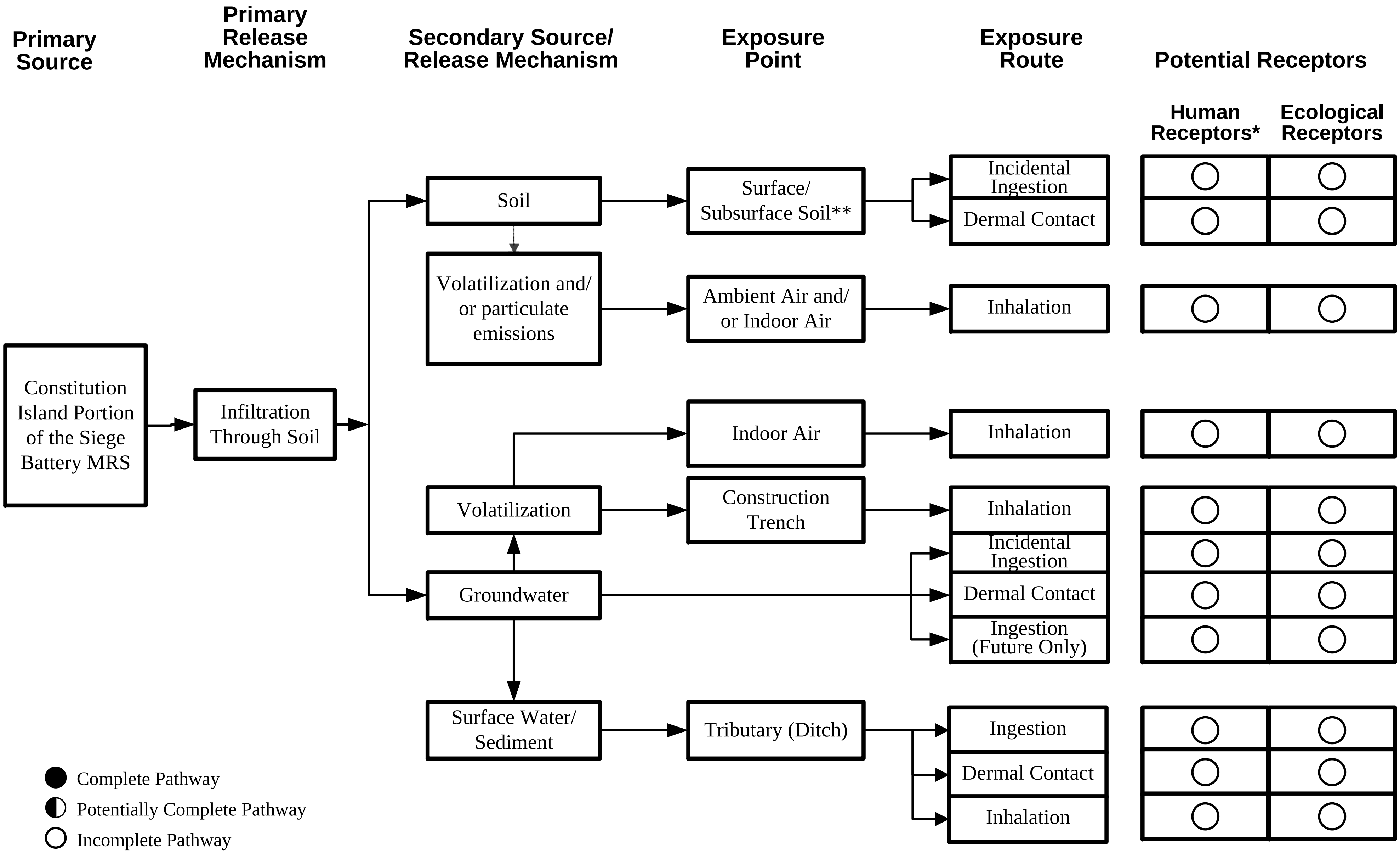


* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** No UXO recovered during the RI in this MRS, MD recovered at ground surface and to 12 inches bgs. UXO recovered in adjacent Fort Clinton West MRS also within the Crows Nest impact area.

Figure 3-16

RI Exposure Pathways for Receptors to MC in the Northwestern Main Post 66.3-Acre Portion (Crows Nest Impact Area) of the Siege Battery MRS



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and site visitors.

** No UXO recovered during the RI in this MRS, MD recovered at ground surface and to 12 inches bgs. UXO found at ground surface during the SI.

Figure 3-17

RI Exposure Pathways for Receptors to MC in the Constitution Island 52-Acre Portion of the Siege Battery MRS

Fig 3-12_3-13_3-14_3-15_3-16_3-17_Siege Battery_Exposure Pathways for MEC and MC.vsd

4. LUSK RESERVOIR MRS

4.1 INTRODUCTION

Section 4 presents the activities, results, and conclusions from the Military Munitions Response Program (MMRP) remedial investigation (RI) performed to characterize the Lusk Reservoir munitions response site (MRS) tracked under WSTPT-019-R-01 in the Army Environmental Database – Restoration Module.

4.1.1 Site Description

The Lusk Reservoir MRS (WSTPT-019-R-01), which encompasses 83.2 acres, is located in the area of a former artillery firing range on the Main Post of West Point (see **Figure 4-1**). The firing point for the range is located east of the Lusk Reservoir and Stewart Road (**Figure 4-2**). The Lusk Reservoir range fan extends to the northwest through the Main Post and terminates at the Crows Nest in the northern extent of West Point. Approximately 150 structures are located within the boundaries of the Lusk Reservoir MRS. These structures include a residential housing area, schools (West Point Middle School and a portion of the Elementary School), youth center, water pump station, post chapel, gas regulator station, transformer vault, and Substation C (an electrical substation).

4.1.1.1 Climate

The climate of the region that includes West Point is characterized as a humid, continental climate. Summers are warm and have periods of high humidity. The semi-permanent Bermuda High brings south to southwest warm and humid air to the area. July is the hottest month, with a mean temperature of 86 degrees Fahrenheit (ºF); and the coldest month of the year is January, which has a mean temperature of 27 ºF. Winters are cold with extended periods of snow cover and are influenced by the cold Hudson Bay air masses. Most winters are characterized by one or more warm periods when soils nearly or completely thaw (Tetra Tech, Inc., 2011).

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 (Tetra Tech, Inc., 2011).

Thunderstorms occur approximately 20 times per year. Tornadoes occur at a frequency of 3 to 4 times a 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 the least amount (approximately 3.5 inches each month) occurring in January and February, and the most precipitation occurring in May (approximately 4.9 inches) (Tetra Tech, Inc., 2011).

4.1.1.2 Geology

West Point lies in the Hudson Highlands, a low, rugged mountain range, that forms a zone of folded and faulted metamorphic and igneous rocks subjected to extensive weathering and erosion. Precambrian-age granite, diorite, gneiss, and schist compose the majority of the crystalline bedrock underlying West Point. Granite, the most prevalent rock type in the bedrock, is typically medium-grained and composed of quartz, feldspar, and mica. Granite and pegmatite are igneous rocks that occur as dikes and sills within the gneiss. Igneous rocks on the West Point installation consist of plagioclase feldspar, hornblende, pyroxene, and biotite mica and quartz (Tetra Tech, Inc., 2011).

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 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 (Tetra Tech, Inc., 2011).

The faults mapped at the surface near and within the habitation area at West Point include the Long Pond, the Crown Ridge, and the Highland Brook faults. 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 (NY 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 between the Long Pond and Crown Ridge faults (Tetra Tech, Inc., 2011).

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 features are 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 (Tetra Tech, Inc., 2011).

Site-specific geologic investigations were not conducted for the Lusk Reservoir MRS, and information regarding site-specific geology is not available for the MRS**.** Regional geologic maps (Cadwell, 1989; Fisher et al., 1970) indicate that the bedrock geology of the Lusk Reservoir MRS is leucogranitic gneiss, rusty and gray biotite-quartz-feldspar gneisses, amphibolite, and hornblende granite and granitic gneiss.

4.1.1.3 Topography

The topography of West Point is described as having moderately steep hills and numerous escarpments. Slopes from 10 to 60% are common on the West Point 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 (Tetra Tech, Inc., 2011). The Lusk Reservoir MRS crosses through the Main Post area, and the elevation ranges between 210 feet (64 meters) and 430 feet (131 meters) above mean sea level (amsl).

4.1.1.4 Soils

Six soil types exist within the Lusk Reservoir MRS (**Figure 4-3**). Smoothed Udorthents exist at the far northern reach of the MRS, in the vicinity of the West Point Middle School. Sloping Hollis soils comprise approximately half of the MRS, and are located in the Grey Ghost Housing Area. From north to south, below the Grey Ghost Housing Area, the soils are primarily moderately steep Hollis soils and moderately steep Rock outcrop-Hollis soils, which are separated by a band of very steep Rock outcrop-Hollis complex soils. The Lusk Reservoir MRS also contains three small areas of sloping Rock outcrop-Hollis complex soils.

The six soil types located within the Lusk Reservoir MRS range from well drained to somewhat excessively well drained. With the exception of the smoothed Udorthents, the soils are typically shallow. The smoothed Udorthents are characteristic of man-made cut-and-fill areas, which are generally near industrial sites, urban developments, or other construction sites. The Hollis soils (sloping and moderately steep) formed in glacial till deposits derived from crystalline rock that is dominantly schist, gneiss, and granite. The Rock outcrop-Hollis complex soils (sloping, moderately steep, and very steep) exist on hillcrests, hilltops, and ridges of the mountainous uplands. This complex is approximately 45% Rock outcrop; 45% Hollis loam, sandy loam, gravelly sandy loam, or gravelly loam; and 10% other soils.

4.1.1.5 Hydrology

4.1.1.5.1 Surface Water

Small portions of Lusk Reservoir and Delafield Pond are located within the Lusk Reservoir MRS. The reservoir is east of the firing point at the southern end of the MRS. In addition to Lusk Reservoir and Delafield Pond, the following surface water bodies are located within a 3.0-mile radius of the MRS: Crows Nest Brook, Sinclair Pond Brook, Kinsley Farm Brook, Stony Lonesome Brook, Highland Brook, Dassori Pond, Round Pond, Wilkins Pond, and Cragston Lakes (see **Figure 4-1**).

4.1.1.5.2 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 West Point installation, but the deposits are thin and generally have fairly small well yields that average about 40 gallons per minute (gpm). 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 (Tetra Tech, Inc., 2011; TLI Solutions, Inc. [TLI], 2007). Based on the geology, an unconsolidated aquifer does not exist within the Lusk Reservoir MRS. Site-specific groundwater investigations were not conducted for the Lusk Reservoir MRS.

4.1.1.6 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 in that five physiographic provinces—the Appalachian Plateaus, Folded Appalachians (Valley and Ridge), New England, Piedmont, and Coastal Plain—converge within a 35-mile radius of the West Point installation. West Point is located in the New England Province in an area known as the Hudson Highlands (Tetra Tech, Inc., 2011).

4.1.1.6.1 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 West Point installation. The Lusk Reservoir MRS is not located within or adjacent to any of the 12 identified sites (Tetra Tech, Inc., 2011).

4.1.1.6.2 Wetlands

Approximately 1,010 acres of wetlands are located throughout West Point in association with streams, ponds, depressions, and seeps (Tetra Tech, Inc., 2011); however, there are no wetlands located within the Lusk Reservoir MRS (TLI, 2007; WESTON, 2011a).

4.1.1.6.3 Flora

Vegetation within the northern half of the Lusk Reservoir MRS is limited to mowed lawn and trees that are characteristic of developed, landscaped areas. The southern half of the MRS is largely undeveloped and contains stands of mature hardwood forest and or dense vegetation consisting of small saplings, mountain laurel, blueberry, briers, and vines.

4.1.1.6.4 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 species of fish and invertebrate species (Tetra Tech, Inc., 2011). It is unlikely that the majority of these species are present in the developed areas of the Lusk Reservoir MRS. The southern half of the MRS may provide habitat for some of these species.

4.1.1.6.5 Ecological Receptors

Potential ecological receptors were provided by West Point and are presented in the overall conceptual site model (CSM) for West Point. The following list of ecological receptors was modified from the list of receptors in the overall CSM for West Point to include only those species that have the potential to exist within the Lusk Reservoir 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.
- 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 (5 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.

An MRS-specific inventory of floral and faunal species was not conducted in the Lusk Reservoir MRS. However, the *Integrated Natural Resources Management Plan for the United States Army Garrison – West Point* (Tetra Tech, Inc., 2011) contains an extensive list of species that have been documented at West Point.

4.1.1.7 Sensitive Environmental Resources in the MRS

Weston Solutions, Inc. (WESTON®) submitted a request for review by the New York Natural Heritage Program (NYNHP) to determine whether there are records of any known rare, threatened, and endangered species or species of special concern located within or near the West Point MRSs. In response, the 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 the 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*]). The three fish species are typically salt-water species residing in brackish water, which does not exist in either water body (Delafield Pond or Lusk Reservoir) within the Lusk Reservoir MRS. The remaining species listed above have the potential to occur in the Lusk Reservoir MRS. Because the northern half of the Lusk Reservoir MRS is extensively developed, it is unlikely that these species would rely on the northern portion of the MRS for habitat. The southern half of the MRS may provide potential habitat for these species; however, the NYNHP did not identify any federally threatened or endangered plant species within any of the West Point MRSs.

4.1.1.8 Cultural and Archaeological Resources

Because West Point is one of the older training grounds in the United States that is still intact, it contains numerous cultural, archaeological, and historical sites. Several Revolutionary War sites are located in the vicinity of the firing point, but outside the MRS boundaries. Additionally, Fort Putnam, a Revolutionary War fort, is located along the southern edge of the Lusk Reservoir MRS outside the MRS boundaries (see **Figure 4-2**) (TLI, 2007; WESTON, 2011a).

4.1.1.9 Current and Projected Land Use

Most of the land area on the Main Post is highly developed or is considered undevelopable because of steep slopes. West Point is divided into four land use zones based on the functional categories that reflect the West Point missions (Tetra Tech, Inc., 2011):

- Cadet Use: Academic, intramural athletic, billeting, and parading.
- Cadet Support: Intercollegiate athletic fields and some cadet support facilities.
- Post Support: Housing, commercial, and service support to staff and faculty, non-West Point military personnel, and military retirees.
- Recreational, Industrial, Field Training: Building and storage area support for industrial operation, field training areas, recreation areas, and open space.

The Lusk Reservoir MRS is located primarily in two land use zones, Post Support and Recreational, Industrial, Field Training. Residential homes and the West Point Middle School are located in the northern half of the MRS. The majority of the southern half of the MRS consists of open space. Delafield Pond, which is located in the southern half of the MRS, is used for swimming. Lusk Reservoir is used for recreational purposes consisting of fishing and non-motorized boating (e.g., canoes and kayaks). No changes to the current land uses are anticipated.

4.1.2 Previous Investigations

4.1.2.1 Historical Information

The project area map in the Archives Search Report developed by USACE-Rock Island District for the West Point/Cold Spring Foundry (USACE, Rock Island District, 2001) indicates an artillery firing point was located to the east of Lusk Reservoir near the current site of a radio tower. In 1908, siege guns were fired from the east side of Lusk Reservoir toward Crows Nest mountain; however, the exact positions of the targets are unknown. Firing from the east side of Lusk Reservoir occurred in 1909, 1914, 1915, and 1916. The firing in 1915 and 1916 was described as sub-caliber and service target practice. Weapons that might have been used at Lusk Reservoir include 2.95-inch Mountain Howitzers, 75 millimeter (mm) gun M1897, 75mm gun M1907, 6-inch high capacity gun, 15-inch mortar, and 16-inch mortar (TLI, 2006).

Several unexploded ordnance (UXO) investigations and removals have been conducted in relation to the Storm King site, located due north of West Point within what is currently Storm King State Park. The recovered UXO is believed to be associated with testing activities from the West Point Foundry (located upstream of West Point along the Hudson River in Cold Spring, New York, and sometimes referred to as the Putnam County or Cold Spring Foundry). UXO identified at the Storm King site could also have been fired from several locations in West Point at targets on Crows Nest mountain, resulting in overshots that landed in the Storm King area (ATI, 2006). Historical documentation indicates that former munitions training at West Point included firing in the direction of Crows Nest from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and the Redoubt No. 2 MRS (TLI, 2006 and 2007). UXO similar to the type of UXO identified at the Storm King site and the Crows Nest during historical surveys and removals may be present in these MRSs (see Section 6.1.2 for details regarding historical investigations related to Crows Nest).

4.1.2.2 Site Inspection Report and Results

The site inspection (SI) field activities at the Lusk Reservoir MRS, which were conducted in spring 2006, included visual surveys along approximately 14.5 linear miles and the collection of one surface soil sample and one sediment sample for munitions constituents (MC) analysis. A digital geophysical survey was not conducted at that time. No munitions and explosives of concern (MEC) or munitions debris (MD) was observed during the visual surveys. The area of the Lusk Reservoir MRS from Mill Road to the northwest includes a portion of Delafield Pond where the terrain is steep, rocky, and heavily wooded; therefore, this area could not be safely accessed for the surveys. In the Lusk Reservoir MRS, two metal items were found approximately 100 yards north of the Airman’s Memorial. One of the items was possibly a metallic mold of some type. It is uncertain whether the fragments were related to military munitions (TLI, 2007).

During the visual survey, each team member walked individual transects, nominally spaced at 10- to 50-foot intervals (based on terrain, ground cover, and vegetation) to identify and record all MEC, MD, and munitions-related materials. Hand-held Global Positioning System (GPS) units were used to track the visual survey transects, and a waypoint was logged if items were observed. GPS units were accurate to within 15 to 40 feet, depending on satellite availability and the tree canopy. In addition, Schonstedt magnetic locators and hand-held electromagnetic metal detectors were used during the visual survey to aid in the identification of metallic items at the ground surface. At times it was necessary to extend the visual surveys beyond the boundaries of the MRS. Work outside the MRS boundaries was required for several reasons, including attempts to accurately locate the firing point, the need to circumvent unsafe terrain or dense vegetation, and the need to access sites from outside locations (TLI, 2007). The visual survey coverage and sample locations are presented in **Figure 4-4**.

One surface soil sample and one sediment sample were collected to assess MC for the Lusk Reservoir MRS. The soil sample was collected near the estimated location of the firing point for the range. The sediment sample was collected from a drainage along the northeast boundary of the MRS. The samples was analyzed for Target Compound List (TCL) explosives by Method 8330 and a subset of the Target Analyte List (TAL) metals by Methods SW846 6010B and 7471A. Metals were selected for analysis based on the metals known to be associated with the munitions historically used at West Point. The samples were analyzed for antimony, copper, iron, lead, mercury, potassium, and zinc. The analytical results for seven TAL metals and TCL explosives were compared, for evaluation purposes only, against U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for residential soils (current screening levels at that time), where available.

Copper, iron, lead, mercury, potassium, and zinc were detected in the samples collected for the Lusk Reservoir MRS. In addition, a trace amount of antimony was identified in the soil sample, at a concentration below the applicable screening value. Trace amounts of 1,3,5-trinitrobenzene (0.023 milligrams per kilogram [mg/kg]) and 4-amino-2,6-dinitrotoluene (0.25 mg/kg) were detected in the sediment sample but at concentrations well below the respective EPA Region 9 PRG. Explosives were not detected in the soil sample (TLI, 2007).

The SI Report provided the following recommendations for the Lusk Reservoir MRS:

- No MEC was identified within the MRS during the visual survey. However, during a previous anomaly investigation and removal conducted in 2001, three ordnance or ordnance-related items were identified within the northwest corner of the MRS. It was recommended that the MRS be further investigated for MEC.
- The analytical results of the SI indicated that MC does not require further investigation at the Lusk Reservoir MRS. However, if the further investigation of MEC at the MRS identifies areas of concern or if MEC is identified during construction activities, additional sampling may be warranted.

4.1.2.3 Munitions Response Site Prioritization Protocol Scoring

The Munitions Response Site Prioritization Protocol (MRSPP) reflects the statement in 10 United States Code (U.S.C.) §2710(b)(2) that the priority assigned should be based on the overall conditions at each location, taking into consideration various factors relating to safety and environmental hazard potential. As required under 10 U.S.C. §2710(b)(1), the priority assigned to each MRS will be included with the inventory information made publicly available. The requirement for an inventory of MRSs known or suspected of containing unexploded ordnance (UXO), discarded military munitions (DMM), or MC is found at 10 U.S.C. §2710(a). The assigned priority will be reviewed annually and updated to reflect new information that becomes available.

The MRSPP for the Lusk Reservoir MRS was applied after the SI. The Lusk Reservoir MRS was assigned a Priority 5 (out of 8) based on the potential explosive hazard identified during construction activities. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with chemical warfare materiel (CWM) can be assigned to Priority 1, and no MRS with CWM can be assigned to Priority 8. The MRSPP was reapplied based on the RI results, and is presented in Section 4.9.2.

4.1.3 Remedial Investigation Report Organization

Section 4 for the Lusk Reservoir MRS is organized as follows:

- Section 4.1 provides the purpose and scope of the project, a description and history of the MRS, and a summary of the previous investigations.
- Section 4.2 includes a discussion of the preliminary CSM, preliminary remediation goals, data needs, and data quality objectives (DQOs) used to develop the RI.
- Section 4.3 provides details on the approach, methods, and procedures used to characterize MEC.
- Section 4.4 provides the details of the MC sampling.
- Section 4.5 provides the results of the RI characterization activities.
- Section 4.6 presents the results of human health and ecological baseline risk assessment activities for MC and also presents the preliminary identification of potential applicable or relevant and appropriate requirements (ARARs).

- Section 4.7 addresses MEC and MC fate and transport processes.
- Section 4.8 presents the revised CSM developed for the MRS based on the RI findings.
- Section 4.9 addresses the MEC hazard assessment and the reapplication of the MRSPP to the Lusk Reservoir MRS based on the data collected during the RI.
- Section 4.10 presents the RI summary and conclusions.

The references cited in Section 4 are provided in Section 8.

4.2 PROJECT REMEDIAL RESPONSE OBJECTIVES

The goal of the RI was to conduct an investigation at the Lusk Reservoir MRS to characterize the nature and extent of potential MEC and MC, and to assess the hazards and the baseline risks to human health or the environment from MEC and MC. The overall RI approach included the following:

- Developing DQOs and data needs through the Technical Project Planning (TPP) process.
- Performing mag and dig and digital geophysical mapping (DGM) surveys.
- Intrusively investigating anomalies detected during the mag and dig and DGM surveys.
- Removing and disposing of recovered MEC and material documented as safe (MDAS).
- Conducting MC sampling at the Lusk Reservoir MRS based on the presence of a known artillery firing range firing point, and recovery of MEC and MD.
- Reporting results through the TPP process throughout the RI to gain stakeholder concurrence.
- Revising the CSM and reapplying the MRSPP based on the RI data collected.
- Submitting the RI Report.

The specific processes and procedures used to conduct the investigation are detailed in the *Final Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (Final RI Work Plan) (WESTON, 2011a). The characterization approach followed the methods presented and approved in the TPP 1 and TPP 2 meetings (see Section 4.2.2). The investigation methods are summarized in Sections 4.3 and 4.4, and the RI results are presented in Section 4.5.

4.2.1 Preliminary Conceptual Site Model

The CSM is used as a planning tool to integrate MRS information from a variety of sources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process of further data collection or action. The CSM development should be viewed as a process that reflects the progress of activities at an MRS from initial assessment through closeout. The CSM is divided into three primary components: potential sources, interactions, and receptors for MEC and/or MC, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. Each component is described as follows:

- Sources — Sources are those areas where MEC or MC has entered (or may enter) the physical system. An objective of the RI is to detect and delineate sources using geophysical surveys and intrusive investigations.
- Interactions — The hazard from MEC and the risk from MC are a result of direct human contact through an activity. Interactions describe ways that receptors come into contact with a MEC and/or MC source. For MC, interactions can include physical transport of the contaminant and transfer from one media to another through various processes so that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. For MEC, movement is not typically significant, and interaction will occur only at the source area, limited by access and activity. There can be movement of MEC through natural processes such as frost heave and soil erosion.
- Receptors — A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use because receptors are determined on that basis. Receptors include human receptors, such as West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children, and ecological receptors.

The preliminary CSM for the Lusk Reservoir MRS was based on information collected during the SI (TLI, 2007). Based on the SI results, MEC exposure pathways are complete because MD was observed at the Lusk Reservoir MRS. The primary exposure mechanism for human and ecological receptors to surface MEC is through handle/tread underfoot. In addition, a subsurface pathway may occur because biota may nest or burrow at the Lusk Reservoir MRS (TLI, 2007).

Figure 4-5 depicts the MEC exposure pathways for the Lusk Reservoir MRS based on the results of the SI.

Based on the results of SI soil sampling, no MC was identified above the EPA Region 9 PRGs (screening levels current at the time) at the Lusk Reservoir MRS; therefore, the pathways of MC to all human and ecological receptors were considered incomplete (TLI, 2007). **Figure 4-6** depicts the SI exposure pathways for receptors to MC at the Lusk Reservoir MRS.

The CSM is updated as new data and information become available. The data collected during the RI were used to revise the preliminary CSM developed following the SI, and the revised CSM is presented in Section 4.8.

4.2.2 Technical Project Planning

Prior to the initiation of RI field activities, representatives and stakeholders from the United States Army Corps of Engineers (USACE), West Point, EPA, New York State Department of Environmental Conservation (NYSDEC), WESTON, and TLI participated in two TPP meetings. TPP 1 was conducted on July 29, 2010. At this meeting, the MRS summary and the RI approach, objectives, planning documentation, and field investigation and reporting requirements were discussed.

TPP 2 was conducted on February 3, 2011. The project stakeholders reviewed the Draft Final RI Work Plan and identified and discussed project goals and DQOs. Details regarding the implementation of the MMRP RI were presented and discussed among the group. Based on the results of the second meeting, specific details of the investigation approach for the Lusk Reservoir MRS, including coverage area, survey type (grid versus transect), and quantities, were determined. The results from the TPP 2 meeting were integrated into the Lusk Reservoir MRS DQOs and presented in the Final RI Work Plan (WESTON, 2011a).

4.2.3 Data Quality Objectives

The data needs and DQOs were determined at the planning stage and are discussed in more detail in the Final RI Work Plan (WESTON, 2011a). The data needs include characterization of the nature and extent of MEC and MC at the Lusk Reservoir MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of the data generated for its intended use; and the ability to infer valid assessments from the data. The DQO process includes the following seven steps:

1. **State the problem:** Provide a concise description of the problem.
2. **Identify the decisions:** Develop decision statements to solve the problem.
3. **Identify inputs to the decision**: Identify information and measurements needed to make the decisions.
4. **Define study boundaries:** Identify conditions such as spatial and temporal boundaries.
5. **Develop a decision rule:** Qualify the decisions to understand data needs.
6. **Specify tolerable limits on decision errors:** Develop performance criteria.
7. **Optimize the design:** Design an effective data collection strategy based on the previous steps.

4.2.3.1 Lusk Reservoir MRS Data Quality Objectives

The following DQOs were developed specifically for the Lusk Reservoir MRS and were agreed upon by the stakeholders during the TPP sessions:

1. **State the problem:** This MRS is associated with the former Lusk Reservoir artillery range. The target area for this range was located north of West Point and not in this MRS. MEC and MD have been observed in the MRS; however, the approximate MEC density has not been verified. MC may also be present if a MEC release is detected within the MRS.

   A former firing point is located within the MRS. There is a potential for MC to be present because of former training activities. Burial of unused munitions was sometimes practiced during training. Buried MEC may be present at the firing point.

2. **Identify the decisions:** The primary decisions for this MRS include:

   - Determine the approximate MEC density in the MRS based on UXO Estimator coverage requirements.

   - If a MEC release is observed in the MRS, characterize the nature and extent of MEC and evaluate MC.

   - Characterize the nature and extent of MC if it is detected at the firing point.

   - Detect and investigate the potential burial features associated with munitions disposal at the firing point.

3. **Identify inputs to the decision:** Several inputs will be acquired during the course of the RI to support the decision. UXO Estimator requires that 5.75 acres be investigated to determine at a 95% confidence level that less than 0.5 MEC/acre is present within the MRS. DGM and mag and dig surveys will be performed along transects and in grids to accomplish the UXO Estimator requirements. All anomalies will be investigated. Intrusive results for MEC, MD, and non-MD will be evaluated in the project Geographic Information System (GIS). If a MEC release is detected, discrete or incremental soil and sediment sampling will be performed to determine whether MC is present. Incremental sampling will be performed at the firing point to determine the nature and extent of potential MC. DGM and intrusive investigations as necessary will be used to detect burial features at the firing point.

4. **Define study boundaries:** This MRS is 83.2 acres and intersects the Artillery Firing Range, Grey Ghost Housing Area, and Fort Clinton West MRSs. Part of the MRS is adjacent to the operational range area. The extent of potential MEC and MC observed during the RI will be delineated using DGM, mag and dig, discrete MC sampling, and incremental MC sampling; however, the operational range area will not be accessed.

5. **Develop a decision rule:** The results of the RI at the Lusk Reservoir MRS will be used to:

   - Assess, based on intrusive anomaly investigations, whether MEC density is less than 0.5 MEC/acre across the MRS.
   - Reassess the characterization approach if MEC density is found to be greater than 0.5 MEC/acre or if the CSM is not valid.
   - Determine whether MC is present at the firing point and fully characterize the nature and extent of MC.
   - Determine whether MEC burial features are present at the firing point and determine the nature and extent of MEC at burial sites.

6. **Specify tolerable limits on decision error:** It is anticipated that a low density of MEC exists at this MRS because of its location near the firing point of the overall range fan. The characterization approach will confirm that less than 0.5 MEC/acre is present at the MRS. If there is less than 0.5 MEC/acre within the MRS, no additional MEC investigations will be required to validate MEC density. If MEC is identified during intrusive work within the MRS, additional sampling may be warranted to achieve the desired confidence level. Additional sampling will be performed only if the MRS is still assumed to have a low density of MEC consistent with the CSM for the MRS. Additional coverage requirements will be determined by UXO Estimator.

7. **Optimize the design:** DGM surveys using a Geonics EM61-MK2 and mag and dig surveys using White's XLT all-metals detectors will be performed across the required 5.75 acres consistent with UXO Estimator assumptions. This includes nine 100-foot by 100-foot grids and approximately 3 miles of transects. Mag and dig surveys will be used in areas inaccessible to the DGM instrumentation. All anomalies will be investigated to determine the approximate MEC density.

4.3 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN

This section provides the comprehensive approach, methods, and operational procedures used for the MEC characterization performed at the Lusk Reservoir MRS. The RI field activities were conducted between April 19 and August 10, 2011 (see **Table 4-1**).

Table 4-1 Lusk Reservoir RI Field Activities

RI Field Activity	Dates
Location Surveying and Mapping	04/19/11 to 04/20/11
DGM Survey	04/20/11 to 04/28/11
Mag and Dig Survey	06/07/11 to 08/10/11
Anomaly Reacquisition and Intrusive Investigation	06/30/11 to 08/04/11
MC Sampling	6/22/11

4.3.1 Investigation Coverage Requirements

UXO Estimator (Version 2.2) is a software package developed by USACE to assist in designing field sampling plans to determine the MEC density for MRSs and to analyze field data after the data have been collected. UXO Estimator calculates the amount of acreage within an MRS that needs to be investigated to determine that a specific MEC density is present across the MRS to a preselected confidence level. The software inputs include the size of the MRS, the anticipated MEC density, and the confidence level to which the anticipated MEC density is to be tested.

A 0.5 MEC/acre density and a 95% statistical confidence at which to test the MEC density hypothesis were selected for the Lusk Reservoir MRS. The 0.5 MEC/acre density was chosen by the project team during the project planning phase based on the historical use of the former Lusk Reservoir Artillery Firing Range, recovery of MD within and surrounding the Lusk Reservoir MRS, and the guidelines provided in the help menu of the UXO Estimator software. Based on these factors, at least 5.75 acres would require investigation to be 95% confident that there are less than 0.5 MEC/acre at the Lusk Reservoir MRS.

UXO Estimator provides a quantitative assessment of the upper bound MEC density. In the case of the Lusk Reservoir MRS, the upper bound density is 0.5 MEC/acre, which means that the MEC density can range from 0 MEC/acre to 0.5 MEC/acre if no MEC is recovered in the MRS.

As part of the post-results analysis, qualitative assessments using the information from the revised CSM should be conducted to determine the actual MEC density within this range.

4.3.1.1 Data Collection and Site Coverage

To achieve the investigation coverage calculated by UXO Estimator, geophysical surveys were performed at pre-planned transect and grid locations across the Lusk Reservoir MRS based on the Final RI Work Plan (WESTON, 2011a). Both DGM and analog surveys were performed to locate surface and subsurface anomalies for further investigation along transects and grids within the MRS. Both methods of anomaly detection were employed to maximize coverage based on MRS accessibility and terrain. A total of 6.06 acres of coverage was performed at the Lusk Reservoir MRS, which exceeded the amount of coverage required based on the initial UXO Estimator calculation. One grid was specifically placed and investigated in the closest accessible area to the firing point (slightly northeast of the firing point and outside the Lusk Reservoir MRS boundary) to detect locations where MEC may have been buried or discarded (i.e., DMM). The following sections detail the geophysical investigations performed as part of the RI.

4.3.1.1.1 Location Surveys and Mapping

Location surveys and mapping activities were conducted within the Lusk Reservoir MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Surveying was performed by Beatty & Watson, a New York-licensed surveyor. The location surveys and the mapping task included the following:

- Establish site control relative to North American Datum 1983 (NAD 83), Universal Transverse Mercator (UTM) coordinate system, in units of U.S. Survey Feet.
- Install DGM survey control and mark out with survey nails.

The survey control locations used during the DGM surveys are listed in **Appendix 4-A.**

4.3.1.1.2 Mag and Dig Surveys

UXO Technicians traversed 3.1 miles of pre-planned transects using GPS as a navigational aid. Each transect was 10 feet wide, equating to a total of 3.76 acres. UXO Technicians used analog instrumentation (White’s XLT all-metals detectors) to detect anomalies. Mag and dig transects were selected for the areas where the terrain and vegetation would have limited the ability to perform DGM surveys. **Figure 4-7** and **Appendix 4-B** present the survey locations within the Lusk Reservoir MRS.

4.3.1.1.3 Digital Geophysical Mapping Surveys

Ten grids, each measuring 100 feet by 100 feet, were placed in accessible locations of the Lusk Reservoir MRS. Grid locations were adjusted in the field to avoid obstructions that might affect data quality or coverage. One grid was placed near the Lusk Reservoir artillery range firing point to specifically identify burial features where DMM may be present. Because of the vegetation and the steep topography at the apex of the range depicted on **Figure 4-7**, DGM grid LR-01 was placed in the closest accessible area (slightly northeast) of the firing point for the Lusk Reservoir MRS.

Once the general locations of the DGM grids were established, the surveyor set survey control at regular intervals to be used for digital data positioning. DGM surveys were then performed using a Geonics EM61-MK2 with line and fiducial navigation and positioning. DGM surveys were conducted within the Lusk Reservoir MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Any obstructions, such as trees or large boulders, were documented in field notes.

Approximately 2.3 acres of DGM surveys were completed at the Lusk Reservoir MRS. **Appendix 4-B** presents the survey locations within the MRS. Tests for instrumentation detection capabilities and functionality were conducted for the Lusk Reservoir MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a).

Geophysical System Verification

The Geophysical System Verification (GSV) approach was used to monitor and verify the geophysical equipment functionality during the DGM surveys. The GSV approach includes an Instrument Verification Strip (IVS) and a blind seeding program to monitor the sensor detection performance throughout the duration of the DGM survey effort. IVS-specific data and results are provided in **Appendix 4-C**.

Instrument Verification Strip

The IVS was installed near current H-Block Field and linearly seeded with five items—one small industry standard object (ISO), two medium ISOs, one inert 37mm projectile, and one inert 75mm projectile. Item types were confirmed with the USACE Quality Assurance (QA) Geophysicist prior to construction. **Table 4-2** lists the IVS seed items and descriptions.

Table 4-2 Instrument Verification Strip Seed Items and Descriptions

IVS Seed Item Type	Northing	Easting	Orientation	Depth	Description
Small ISO[a] (1 inch by 4 inches)	15033479.01	1921684.05	Horizontal	4.2 inches	Part Number[b]: 44615K466 ASTM Specification: A53/A773.
Medium ISO[a] (2 inches by 8 inches)	15033473.57	1921675.82	Horizontal	7.7 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.
37mm projectile	15033467.92	1921667.50	Horizontal	4.3 inches	Inert projectile.
75mm projectile	15033462.55	1921659.03	Horizontal	10.7 inches	Inert shrapnel projectile.
Medium ISO[a] (2 inches by 8 inches)	15033457.11	1921650.70	Horizontal	6.8 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.

Notes:
[a] ISOs are schedule 40 pipe nipples, threaded on both ends, made from black welded steel and manufactured to an American Society for Testing and Materials (ASTM) specification.
[b] Part number from the McMaster-Carr catalog.

The items were seeded linearly over 70 feet and were spaced 10 feet apart horizontally (least favorable orientation) with the long axis aligned parallel to the ground surface. Item types were confirmed with the USACE QA Geophysicist prior to construction. After IVS construction, a DGM survey was performed to demonstrate the instrument functionality and to verify that the seed item responses were consistent with the instrument response curves calculated for the EM61-MK2. All responses matched the appropriate response curves based on the seed item type and depth. IVS-specific data and results are provided in **Appendix 4-C**.

The IVS and unseeded test strip were visited daily before and after the DGM surveys and intrusive investigations. Both the EM6-MK2 and White's XLT were tested at the IVS. The results were then compared to the seed item response baseline and sensor response curves to determine that the geophysical equipment was operating properly.

The pre- and post-survey IVS result, for the days that DGM data were collected at the Lusk Reservoir MRS are presented in **Table 4-3**. The results collected for each day of DGM at the

IVS show agreement and repeatable results for the series of seeds. The seed items placed within the IVS were observed in the geophysical data with signals consistent with the sensor response curves developed for the EM61-MK2.

Table 4-3 Instrument Verification Strip Results

Item Description	Small ISO	Medium ISO	37mm Projectile	75mm Projectile	Medium ISO
Item Depth (inches)	4.2	7.7	4.3	10.7	6.8
Least favorable orientation response (mV)	10.8	64.2	14.8	60.6	73.4
IVS Date	**Response (mV)**				
19 April 2011 Pre-Survey	26.62	101.73	45.27	83.7	89.4
19 April 2011 Post-Survey	20.96	88.21	38.04	71.41	83.63
20 April 2011 Pre-Survey	26	110.9	44.09	85.13	85.11
20 April 2011 Post-Survey	25.97	107.89	43.06	82.82	85.62
22 April 2011 Pre-Survey	25.29	109.05	44.03	84.55	83.82
22 April 2011 Post-Survey	24.69	109.34	43	83.44	84.41
25 April 2011 Pre-Survey	25.99	106.15	40.98	82.15	82.08
25 April 2011 Post-Survey	26.55	109.88	44.19	85.55	87.77
26 April 2011 Pre-Survey	24.07	105.72	42.17	84.99	81.84
26 April 2011 Post-Survey	25.09	111.8	44.82	83.75	86.29
28 April 2011 Pre-Survey	27.03	111.46	44.17	84.67	84.68
28 April 2011 Post-Survey	25.36	111.43	44.53	83.19	82.66

All peak responses from the seed items were observed to be greater than the least favorable orientation response and to have consistent responses between the surveys. These results demonstrate that the digital geophysical equipment was functioning within a tolerable range to achieve detection performance metrics. Photographs of the equipment are provided in **Appendix 4-D**.

Blind Seeding

A seeding program was instituted in the geophysical survey grids to provide ongoing monitoring of the geophysical instrumentation detection performance. Seeds were blind to the geophysical data collection teams. After the medium ISO seed items were initially placed within the DGM grids, the locations and depths of the items were surveyed. All blind seed items were observed in the geophysical data with a signal consistent with the sensor response curves developed for the

EM61-MK2, and within the 3.25-feet offset metric established in the project-specific measurement quality objectives (MQOs).

The seeds were recovered by the UXO teams during intrusive investigations. **Table 4-4** lists the depth, type, geophysical response, and offset of the seed items placed within the DGM grids. The location and depth of the seeds items were surveyed by Beatty & Watson.

Table 4-4 Blind Seeding Results

Grid	Item	Depth (inches)	Orientation	Target ID	Status	Peak Response (mV)	Offset (inches)
LR-01	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-01-095	Recovered	92.00	2
LR-02	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-02-41	Recovered	75.60	2
LR-03	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-03-62	Recovered	84.34	4
LR-04	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-04-09	Recovered	97.26	2
LR-05	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-05-110	Recovered	81.30	4
LR-06	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-06-113	Recovered	366.12	4
LR-07	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-07-085	Recovered	106.60	3
LR-08	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-08-48	Recovered	57.57	1
LR-09	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-09-29	Recovered	86.92	6
LR-10	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	LR-10-76	Recovered	70.74	6

4.3.2 Data Processing and Quality Control

The EM61-MK2 data were imported into the Geonics® DAT61MK2 software for pre-processing. DAT61MK2 is used to convert the raw binary sensor data into a Geosoft®-compatible XYZ data file. Each XYZ file contains data for each of the four time gates recorded, the position, and the time stamp associated with each reading. Digital data were processed by the Site Geophysicist using Geosoft's Oasis montaj software. The IVS and quality parameters that were monitored and assessed daily during data processing included:

- Coverage.
- Velocity.
- Sample separation.
- Noise.
- Function tests: static, static response, and cable connection tests.

Instrument functionality tests were conducted before and after DGM surveying adjacent to the IVS located at H-Block Field. The Static Test and Static Response Test involved collecting non-dynamic data for a period of 1 minute without and with a small ISO item, respectively. Tests for the EM61-MK2 show background noise levels ranging from 0.5 to 2.2 standard deviations, with minimum and maximum readings between -6 millivolt (mV) and 2 mV. The Static Spike Test measurements range from a minimum value of 38 mV to a maximum value of 46 mV with a standard deviation between 0.66 and 1.86. Static Response Test data for the EM61-MK2 show consistent response values within the ±20% metric over the test object in pre- and post-survey tests. The project metric for test data was established at a standard deviation of less than 2.5. No anomalous data spikes or outside interference was observed during the static instrument tests.

Background noise was evaluated for each dataset by windowing a section of the data and generating statistics using the UX-Process QC module. Statistics calculated for Lusk Reservoir DGM data are presented in **Table 4-5**. Channel 2 was then gridded using a grid cell size of 0.25 feet with a search radius of 2 feet and blanking distance of 2.25 feet.

Table 4-5 DGM Data Parameters

Data Metric		Mean Sample Separation (ft)	Mean Velocity (mph)	Background Noise (mean)	Background Noise (standard deviation)
	DQO	**< 0.5 ft**	**< 3 mph**	**MRS Specific**	**< 2.5**
Grid ID	LR-01	0.28	1.89	0.48	2.02
	LR-02	0.27	1.81	0.78	2.04
	LR-03	0.25	1.66	0.72	1.18
	LR-04	0.21	1.44	0.68	1.46
	LR-05	0.33	2.23	0.46	1.7
	LR-06	0.3	2.04	0.39	1.37
	LR-07	0.32	2.18	1.11	1.87
	LR-08	0.33	2.23	0.58	2.33
	LR-09	0.29	1.93	0.58	1.22
	LR-10	0.29	1.93	0.25	1.5

Anomalies were selected from the Channel 2 gridded data using the Blakely Test target selection algorithm. A target threshold value of 7.2 mV on Channel 2, as approved by the USACE QA Geophysicist, was used to select the initial target list. This threshold was based on the sensor response curve for a 75mm projectile at a depth of 3 feet in the least favorable (horizontal) orientation. Target review consisted of manually evaluating all selected targets and removing or merging multiple targets associated with large anomalies. Processing parameters are listed in **Table 4-6**.

Table 4-6 EM61-MK2 Data Processing Parameters

Process	Parameter
Drift – Non-Linear Drift Correction Filter (UCEDRIFT.GX)	Window Length: 100 % lowest values ignored: 10% % highest values ignored: 70% All data channels were processed using the same parameters.
Statistical Evaluation of Background Noise	Windowed section of background/using UX-Process QA/QC module to evaluate standard deviation and mean noise values.
Grid	Cell Size: 0.25 ft Blanking Distance: 2.25 ft Search Radius: 2 ft
Blakely Peak Picking Algorithm	Smooth Filter: 3 Normal Peak Detection Grid Value Threshold: EM 7.2 mV
Target Decay Analysis	Performed based on each data channel.
Target Review	Performed.

A target decay analysis was run to remove targets that had an atypical decay between the four time gate channels. An atypical decay is observed when an anomaly signal does not decrease through time, but instead shows an increase in any of the subsequent time gate channels. The most common causes of atypical decay are due to external radio frequency interferences or rough terrain encountered during data collection. **Appendix 4-B** presents the DGM data results with target locations.

All data related to DGM surveys were managed using Geosoft® Oasis montaj software. All spatial data were managed using a GIS and stored in Environmental Systems Research Institute® (ESRI)-compatible GIS formats, primarily ArcInfo coverage and ArcView shape files. All DGM data were provided electronically to the USACE QA Geophysicist for QA.

4.3.2.1 Anomaly Investigation Activities

A total of 795 anomalies were selected as part of the DGM data analysis. The anomalies were compiled into a dig list. The dig list data were logged into a hand-held computer and managed using WESTON's RespondFast® UXO Investigation software. Each of the anomalies was reacquired and intrusively investigated. Anomaly reacquisition was performed using a Trimble S8® Robotic Total Station (RTS) for navigation to the precise location of each target. A reacquisition team navigated to the location and marked it with a non-metallic pin flag designated by the unique anomaly ID. Eight anomalies were detected during the mag and dig surveys. Dig lists developed following digital data analysis are presented in **Appendix 4-E**.

4.3.2.2 Anomaly Investigation Procedures

Intrusive investigations were conducted at the locations of the 803 anomalies detected as part of the DGM and mag and dig surveys in accordance with the Final RI Work Plan (WESTON, 2011a), including the approved Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) and the Explosives Site Plan (ESP). Intrusive investigations at selected anomaly locations were performed to positively identify and recover MEC, material potentially presenting an explosive hazard (MPPEH), and MD. All recovered items were treated as MPPEH and were subject to field inspection to determine the nature of recovered anomalies. All items were verified free of explosives hazards prior to being relocated for future disposal.

The Senior UXO Supervisor (SUXOS) conducted oversight of all intrusive investigations, and the UXO Quality Control Specialist (UXOQCS) conducted daily quality control (QC) following target reacquisition and intrusive investigation as documented in the Daily Reports for the RI (see **Appendix 4-F)**.

UXO Technicians began the anomaly investigations by sweeping a 3-foot radius around the pin flag with a White's XLT all-metals detector to focus the excavation at the peak response. The offset and northing and easting position of the peak response were recorded for each anomaly. Intrusive operations at each anomaly location were performed using hand tools. The UXO Technicians excavated at the location of the highest detector response until the source of the anomaly was found. The target location was considered clear when a signal source was no longer detected after the removal of the conductive item, or the source of the signal was identified to be associated with a cultural feature such as a fence or building.

Exclusion zones during intrusive operations were based on the project munition with the greatest fragmentation distance, which is a 75mm high explosive (HE) projectile. The minimum separation distance for nonessential personnel was 238 feet.

The dig teams used the personal hand-held computers with RespondFast UXO Investigation software to electronically log the target characteristics real-time in the field. Characteristics logged in RespondFast include item category, item type, depth, dig data, and final disposition.

The results of the intrusive investigation are provided in the expanded dig lists in **Appendix 4-E.** Photographs of the anomaly reacquisition process are provided in **Appendix 4-D.**

4.3.2.2.1 Inspection of Munitions-Related Items

Munitions-related items underwent a three-step inspection process during the intrusive investigations. Munitions-related items were inspected in the grid by a UXO Technician II and then a Technician III and classified as MPPEH or MD. After the Technician III inspected the item, the item underwent a third inspection by the SUXOS, with verification by the UXOQCS, to determine the final disposition. The item was then determined to be MD or material documented as an explosive hazard (MDEH). The items classified as MDEH were to be disposed of by detonation. At the Lusk Reservoir MRS, no items were classified as MDEH.

MD was recovered from the grids, certified and verified as free from explosives, and stored in a locked container as MDAS. The items classified as MDAS pose no explosive hazard and were transported to a collection point for final disposal. A final inspection was conducted immediately prior to the transfer of MDAS to the West Point Recycle Center. Certified MDAS was transferred to the West Point Recycle Center with the completed DoD Form 1348-1A, signed by the SUXOS to certify that the material listed had been thoroughly inspected and, to the best of the SUXOS's knowledge and belief, was inert and/or free of explosives or related materials.

After the DoD Form 1348-1A was verified and signed by the UXOQCS, a copy was maintained and the original accompanied the MDAS to its final disposition at the West Point Recycle Center. Copies of the forms are provided in **Appendix 4-G**.

4.3.2.2.2 Intrusive Investigation Quality Control

In accordance with the Final RI Work Plan, the UXOQCS inspected at least 10% of the dig locations using a White's XLT all-metals detector to determine whether the removal was effective. The UXOQCS joined the intrusive team and inspected all digs made during one day. The results of the QC inspections for the intrusive investigation are provided in the UXOQCS reports (**Appendix 4-F**). The USACE Ordnance and Explosive Safety Specialist (OESS) also performed two QA inspections at the Lusk Reservoir MRS grids. The Form 948 documents accepting the QC results are provided in **Appendix 4-H**.

On July 15, 2012, a QC check in grid LR-01 by the UXOQCS recovered three additional 3.5-inch cannonballs (solid shot) at target 119 where only one had been initially identified. As a conservative measure, the entire grid was resurveyed using the EM-61 on the original targets, and the data were verified to ensure that no other anomalies were present. Corrective action was initiated by the SUXOS and UXOQCS, who provided additional instruction and direction to the UXO technicians to be more stringent while clearing targets. The QC failure did not affect the overall data quality as no other QC failures were noted in the Lusk Reservoir MRS, or in any of the other MRSs included in the West Point MMRP RI.

4.4 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS CONSTITUENTS

4.4.1 Purpose of Munitions Constituent Sampling

Characterization activities for MC were conducted in accordance with the Final RI Work Plan, specifically the UFP-QAPP and the MC Sampling Memorandum (Appendix G of the Final RI Work Plan). Based on the MC Sampling Memorandum, sampling activities would be performed at locations based on information obtained during the MEC investigation activities. MC investigations would be initiated in the following instances:

- Further investigation of MC at currently unknown but potential MEC releases (i.e., concentrated munitions use areas) identified during the geophysical surveys conducted as part of the West Point RI.
- Further investigation of MC at known former artillery range firing points that potentially contain MC.
- MC sampling at individual MEC item locations where soil staining or visible evidence of a potential MC release is observed.

Incremental sampling for MC in surface soil was performed only at the Lusk Reservoir artillery range firing point where MC may have been released from firing activities even though MEC was not found at the firing point. The results of the MC characterization are reported in Section 4.5.2.

4.4.2 Remedial Investigation Munitions Constituent Sampling

In accordance with the Final RI Work Plan (WESTON, 2011a), one 0.5-acre incremental sampling unit with 30 increment locations was designated to encompass the artillery firing point. The number of increments is based on the USACE Interim Guidance Document 09-02, *Implementation of Incremental Sampling of Soil for Military Munitions Response Program* (USACE, 2009).

Once the location of the sampling unit had been identified, as depicted in **Figure 4-7**, the increment locations were identified within the sampling unit using a random number generator. The increment coordinates for each incremental sample were then loaded into the GPS units as waypoints for the field team and were also printed on aerial maps that were used in the field. The field maps showing the locations of the planned incremental samples within the sampling units are included in **Appendix 4-I**.

One field team, consisting of two environmental scientists and one UXO Technician II, performed incremental sampling at the Lusk Reservoir MRS. The field team located each increment in accordance with the waypoint data that were loaded into the GPS unit prior to field activity. The sample team used a hand-held GPS unit to navigate to each increment location, or used a measuring tape to locate a specific offset, and placed numbered pin flags at each increment location. Sample increments were then collected by field personnel travelling a meandering path. Field personnel confirmed the collection of each increment in the field logbook according to the numbered flags in the sampling unit. The sample team did not record the specific path travelled to collect increments.

Once a surface soil increment area was located, the UXO Technician II performed anomaly clearance using a metal detector. After the area was deemed safe, the environmental scientists collected a soil sample using a Multi-Incremental Sampling Tool (MIST) and placed it in a plastic resealable bag. If an area could not be cleared by the UXO Technician II, or if rocks or other debris were in the way, the field team sampled an area 1 meter away. There were no cases in which the location had to be eliminated because of UXO clearance issues.

For some locations, surface features, such as tree roots, rocky areas, standing water, or steep drop-offs, were found at an increment location that was selected by the random number generator prior to mobilization. In these cases, the incremental sample was collected as close as possible to the original location. The direction and the distance the incremental sample was moved were noted in the field logbooks included in **Appendix 4-I**. All incremental samples were surface samples and were collected from a depth of 0 to 3 inches. Sufficient sample mass, approximately 1 kilogram, was obtained for each sampling unit. Once all the increments were placed in the plastic resealable bag, the soil contents were labeled, homogenized, sealed, placed on ice, and shipped to the laboratory for analysis. The incremental sample was collected using new, clean, dedicated, and disposable equipment; therefore, no investigation-derived waste (IDW) (solid or liquid) was generated.

All increments were collected from surface soil; there was no subsurface soil sampling at the Lusk Reservoir MRS. The incremental sample was analyzed for explosives (see **Table 4-7**).

Table 4-7 Incremental Sample Summary at the Lusk Reservoir MRS

MRS	No. of Incremental Samples (Sample Numbers)	Size of Incremental Sampling Unit (acres)	No. of Increments	Analysis
Lusk Reservoir	1 sample: WPR09-SS04	0.5	30	Explosives

4.4.3 Analytical Laboratory and Analyses

Explosives were analyzed in surface soil for the Lusk Reservoir MRS. Compounds potentially associated with the MRS were evaluated for MC sampling. Because of the time period during which munitions were used at the Lusk Reservoir MRS, specific nomenclature for the munitions was not available in the historical records; therefore, generic MC information was compiled for these items. The explosives used in the greatest quantity at the Lusk Reservoir MRS were trinitrotoluene (TNT), nitroglycerin, pentaerythritol tetranitrate (PETN), and hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX). These explosives are insoluble in water and do not hydrolyze, volatilize, or bioconcentrate under normal environmental conditions. They also have average adsorption coefficients, suggesting that they will reasonably adsorb to soil and sediments and maintain low soil mobility. In addition, the volatilization rate from soil is extremely low. TNT and its breakdown products, and nitroglycerin, PETN, and RDX are anticipated to remain in the environment and are good indicators of explosives at the MRS. **Table 4-8** lists the specific explosives compounds included in the analyses of the soil samples.

Table 4-8 Explosives Analyzed in Surface Soil Samples from Lusk Reservoir MRS

Analyte*	Notes
Nitroglycerin	Known MC associated with munitions
Pentaerythritol tetranitrate (PETN)	Known MC associated with munitions
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Known MC associated with munitions
2,4,6-Trinitrotoluene (TNT)	Known MC associated with munitions
2,4-Dinitrotoluene (2,4-DNT)	Breakdown product of TNT
2,6-Dintrotoluene (2,6-DNT)	Breakdown product of TNT
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	Breakdown product of TNT
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	Breakdown product of TNT

*Explosives were analyzed using EPA Method SW-846 3535A/8330B.

Soil samples were submitted for analysis to a DoD Environmental Laboratory Accreditation Program (ELAP)-certified and National Environmental Laboratory Accreditation Conference (NELAC)-accredited laboratory, TestAmerica, Inc., located in South Burlington, VT. The laboratory provided a Level IV data package for validation that met the reporting requirements of *DoD Quality System Manual for Environmental Laboratories Version 4.2* (QSM 4.2) (DoD, 2010). The Level IV data package included all elements required to perform a full data validation, such as sample and QC data, chromatograms, raw data, instrument printouts, chain of custody records, log pages, and instrument calibration data. Samples were analyzed in accordance with the requirements of the analytical method, method-specific requirements of DoD QSM 4.2, and the project's Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) to ensure that sample results met project requirements for quality and technical competency. The analytical laboratory results are provided in **Appendix 4-J**.

Data validation was performed by an independent third party, MEC^{x}, LP. The following standard operating procedures and validation guidelines were used to manually validate explosives data:

- Method 8330B, Nitroaromatics, Nitroamines, and Nitrate Esters by High Performance Liquid Chromatography (HPLC) (EPA, 2006).
- Validation of Data, Nitroaromatics and Nitroamines by HPLC, SW-846 Method 8330A (SOP HW-16, Rev. 2) (EPA Region 2, 2006).
- Data Validation Procedure for Explosives, Nitroaromatics, and Nitroamines (DVP-16, Rev. 0) (MEC^{x}, LP, 2009).
- Standard Operating Procedure for Routine Validation of High Explosive (HE) Analytical Data (SOP-5164, Rev. 0) (Los Alamos National Laboratory [LANL], 2008).
- *Final Uniform Federal Policy Quality Assurance Project Plan, Remedial Investigation for Military Munitions Response Program Sites, U.S. Army Garrison West Point, West Point, NY (UFP-QAPP)* (WESTON, 2011b), as presented in Appendix J of the *Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (WESTON, 2011a).
- *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

4.4.4 Screening Levels

The MC sample analysis results were compared against two sets of screening levels, human health soil screening values and soil ecological screening values (ESVs), which were defined in the Final Work Plan prior to the RI field work for the Lusk Reservoir MRS. To facilitate RI data evaluation and comparisons, the Final Work Plan list of selected ESVs was expanded to include all potential ESVs available from various sources.

For human health soil screening values, Oak Ridge National Laboratory (ORNL) regional screening levels (RSLs) for residential soils and NYSDEC residential and unrestricted use soil cleanup objectives (SCOs) were compared for each analyte. The ORNL RSLs, which are updated by ORNL (EPA, 2012) semi-annually, are now used by EPA as risk-based screening benchmarks (in place of the EPA Region 9 PRGs that were used in the SI).

For ESVs, NYSDEC, EPA ecological soil screening level (Eco-SSL), EPA Region 5 ecological screening level (ESL), ORNL Benchmark 1, and ORNL Benchmark 2 were compared for each analyte. For analytes for which there was no benchmark available (NBA) in the screening values listed in the Work Plan, additional research was conducted to identify ESVs. Publications, including U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) and scientific reports written by Efroymson et al. (1997a and 1997b) and Kuperman et al. (2006), were evaluated.

The screening values referenced in this section are deemed to-be-considered information (TBCs), except for NYSDEC SCOs, which are considered ARARs, as discussed in more detail in Section 4.6.3. **Table 4-9** lists the analytes and the lowest of the human health and ecological screening values used for sample comparison. MC sampling and analytical results are reported in Section 4.5.2.

Table 4-9 Screening Levels for Explosives

Analyte	Human Health Soil Screening Value	Human Health Soil Screening Value Method Used	Ecological Soil Screening Value	Ecological Soil Screening Value Method Used[4]
Explosives (µg/kg)				
Nitroglycerin	610	ORNL Residential RSL[1]	3,000	USACHPPM[5]
Pentaerythritol tetranitrate (PETN)	NBA	NBA	170,000	USACHPPM[6]
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	5,500	ORNL Residential RSL	21,000	Kuperman et al., 2006[7]
2,4,6-Trinitrotoluene (TNT)	3,600	ORNL Residential RSL	70	USACHPPM[8]
2,4-Dinitrotoluene (2,4-DNT)	1,600	ORNL Residential RSL	1,280	EPA Region 5 RSL[3]
2,6-Dintrotoluene (2,6-DNT)	1,030	NYSDEC Unrestricted Use SCO[2]	32.8	EPA Region 5 ESL
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[9]
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[9]

Notes:
[1] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (April, 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.
[2] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html
[3] EPA. 2003. Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels - http://www.epa.gov/reg5rcra/ca/ESL.pdf
[4] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the following hierarchy was used to select the screening value: EPA Eco-SSL, EPA Region 5 ESL, ORNL Benchmark 1, ORNL Benchmark 2.
[5] USACHPPM, 2000.
[6] USACHPPM, 2001a.
[7] Kuperman et al., 2006.
[8] USACHPPM, 2001b.
[9] USACHPPM, 2005.
NBA=no benchmark available.
µg/kg=milligram/kilogram.

4.5 REMEDIAL INVESTIGATION RESULTS

This section presents the results of the RI MEC characterization (Section 4.5.1) and of the MC characterization (Section 4.5.2).

4.5.1 Results for Munitions and Explosives of Concern Characterization

As described in Section 4.3, the characterization performed at the Lusk Reservoir MRS during the RI involved the following tasks:

- Mag and dig transect surveys.
- DGM data collection.
- Digital data processing, analysis, and anomaly selection.
- Anomaly reacquisition.
- Intrusive investigation of detected anomalies.

The following subsections detail the results of these activities.

4.5.1.1 Geophysical Survey Results

A total of 3.1 miles, or 3.76 acres, were investigated using mag and dig transect surveys performed using a White's XLT all-metals detector. All anomalies (a total of 8) detected were investigated by UXO Technicians to determine the anomaly source. A total of ten 100-foot x 100-foot grids or 2.30 acres of DGM surveys were performed using a man-portable EM61-MK2 sensor in cart mode. A total of 795 anomalies were selected from the DGM data for intrusive investigation. The intrusive investigation results of all 803 anomalies are discussed in Section 4.5.1.2.

4.5.1.2 Intrusive Investigation Results

No MEC was observed in the Lusk Reservoir MRS. A total of 13 MD items were recovered at depths ranging between 2 inches and 6 inches below ground surface (bgs). The MD items included four 3.5-inch cannonballs (solid shot), one MKII hand grenade (empty), and eight unidentifiable fragments from unknown munitions (see **Figure 4-8**).

The four 3.5-inch cannonballs (solid shot from the Revolutionary War era) were recovered within grid LR-01, which was placed near the Lusk Reservoir firing point location, but outside the MRS boundary. Because these cannonballs were described as solid shot, they are not considered DMM and are MD. The cannonballs were stacked on top of one another; therefore, it is likely they were intentionally buried during firing point use.

The remaining non-MD-related material included 765 items classified as cultural debris, 15 no contacts, and 10 quality control seeds. These items were recovered between the surface and 21 inches bgs. **Figure 4-8** and **Appendix 4-B** show the locations of the items recovered from the Lusk Reservoir MRS. **Table 4-10** summarizes the MD recovered from the MRS. The complete dig list is provided in **Appendix 4-E**.

Table 4-10 MD Summary at the Lusk Reservoir MRS

Target ID No.	Item Type	Item Description	Dig Date	Depth (inches)	Weight (lb)
LR-01-119	MD	Four 3.5-inch cannonballs (solid shot)	6/30/11	2	6 (each)
LR-05-33	MD	Fragment	7/22/11	3	2
LR-05-38	MD	Fragment	7/22/11	3	2
LR-05-49	MD	Fragment	7/22/11	3	0.5
LR-05-59	MD	Fragment	7/22/11	3	0.1
LR-05-91	MD	Fragment	7/22/11	3	2
LR-05-101	MD	Fragment	7/22/11	2	3
LR-05-119	MD	Fragment	7/22/11	6	7
LR-08-114	MD	Fragment	7/22/11	3	2
LR-10-79	MD	MKII Hand Grenade (empty)	8/4/11	3	1.5

4.5.1.3 Geophysical Survey and Intrusive Investigation Analysis

The Lusk Reservoir MRS is part of a surface danger zone for a former range. Geophysical transect and grid surveys performed within the MRS were used to assess the nature and extent of MEC and MD. A majority of the MD items recovered within the Lusk Reservoir MRS are fragments from former munitions use. MD recovered during the RI field activities were concentrated in the northern portion of the MRS. No MEC and limited MD was observed in the southern portion of the MRS, consisting of four 3.5-inch solid shot cannonballs identified at a grid near the firing point. The northern portion of the MRS is closer to the range impact area where MEC and MD are most likely to be encountered. The southern portion of the MRS is located closer to the range firing point where it is less likely to encounter MEC and MD. The northern portion of the MRS has been developed with buildings, parking areas, and roadways more than the southern portion of the MRS. MEC and MD could have been covered or moved during construction activities. The nature and extent of the MD observed in the northern portion of Lusk Reservoir MRS is consistent with the survey results in adjacent MRSs. Although an increase in MEC and MD density was not observed in the northern portion of the Lusk Reservoir MRS, an elevated MEC and MD density was observed laterally extending across the adjacent Siege Battery, Fort Clinton West, and Artillery Firing Range MRSs. A reduced amount of MEC and MD was found in the portions of the Lusk Reservoir MRS and of the adjacent MRSs closer to the range firing point.

Based on the observed density, distribution, and the type of MEC and MD within the adjacent MRSs, the source of these items is attributed to the historical firing at targets on Crows Nest mountain. The collective RI characterization strategy using geophysical transects and grids allowed the successful delineation of the southern boundary of the Crows Nest impact area.

In accordance with the DQOs, the RI field results were also evaluated using the UXO Estimator *Analyze Field Data Module*. The following inputs were assessed in UXO Estimator:

- **Total number of acres in MRS**: 83.2 acres
- **Number of acres investigated**: 6.06 acres
- **Number of MEC recovered in the investigated area**: 0 MEC recovered
- **Specify the MEC target density per acre** (same value used to develop DQOs): 0.5 MEC/acre
- **Specify the desired upper confidence level** (same value used to develop DQOs): 95% confidence

The UXO Estimator calculations were initially designed to evaluate the 83.2-acre Lusk Reservoir MRS. UXO Estimator calculated a statistical upper bound MEC density of 0.469 MEC/acre at a 95% confidence level based on the RI field results. The calculated average MEC density across the MRS based on the UXO Estimator results is 0.153 MEC/acre.

It is statistically possible that MEC may be present across the entire MRS. However, based on the results of the geophysical transect and grid characterization and because only limited MD was recovered in the southern portion of the MRS, there are no MEC anticipated in this portion of the MRS. The southern portion of the MRS is closer to the range firing point where MEC and MD are less likely to be encountered.

MD recovered in the MRS was concentrated in the northern portion of the MRS where it is more likely additional MD and potential MEC are present because of the proximity to the range impact area. These results are consistent with the RI findings in adjacent MRSs. The CSM for the Lusk Reservoir MRS is discussed further in Section 4.8.

4.5.1.4 Additional Findings

After completion of the RI field investigations, one munition was found within the Lusk Reservoir MRS boundaries and responded to by West Point Explosive Ordnance Disposal (EOD). This finding, which was included in the overall qualitative assessment of the MRS, is reported below:

- On January 3, 2012, a construction crew working behind the West Point Middle School encountered a 90mm armor-piercing capped tracer (APC-T) projectile in a load of fill material. The West Point EOD responded to the UXO discovery and detonated the item in a disposal area. The 90mm projectile is from the World War II or Korean era and does not fit with past munitions items found within the MRSs. The item appeared to be found in fill material that was most likely imported from areas where 90mm munitions were used.

4.5.2 Results for Munitions Constituents Characterization

During the RI field investigations, no MEC indicating the presence of a confirmed source for MC was identified. In accordance with the Work Plan and the UFP-QAPP, sampling to investigate MC was conducted only at the firing point (**Figure 4-7)**. One incremental sample, comprised of 30 increments distributed over a 0.5-acre sampling unit area, was collected at the firing point (WPR09-SS04). The incremental sample was collected and analyzed to identify the presence of MC (if any) and to characterize the nature and extent of MC. The incremental sample was collected using new, clean, dedicated, and disposable equipment; therefore, no IDW (solid or liquid) was generated. Analytical results for the Lusk Reservoir MRS are provided in **Table 4-11**.

4.5.2.1 Explosives

No detections of explosives were reported for the sample collected from the Lusk Reservoir firing point area. Analytical results for nitroglycerin, 2,6-DNT, and PETN were reported with UJ qualifiers, which indicates that the analytes were not detected above the reported sample quantitation limits (SQLs). The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analytes in the sample. The analytical results for the remainder of the explosives included U qualifiers for each reported value, indicating that the explosive was analyzed for, but was not detected, above the reported SQL (**Table 4-11**). Data qualifiers are discussed in more detail in Section 4.5.2.2.2.

Table 4-11 Analytical Results for Soil Sampling for MC

Sample ID:	**WPR09-SS04**	
Lab Sample ID:	**200-5727-4**	
Sample Type:	**Soil**	
Date Sampled:	**6/22/2011**	
Comments:		
Explosives (µg/kg)	**Result**	**Qualifier**
RDX	23	U
Nitroglycerin	5,700	UJ
2,4,6-Trinitrotoluene	14	U
4-Amino-2,6-dinitrotoluene	23	U
2-Amino-4,6-dinitrotoluene	23	U
2,6-Dinitrotoluene	770	UJ
2,4-Dinitrotoluene	29	U
PETN	20,000	UJ

Notes:
U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

Section 4.6 presents the analytical results in comparison to the human health and ecological screening values (**Table 4-9**), used to establish baseline risks to potential human and ecological receptors.

4.5.2.2 MC Data Quality

An assessment of data quality for MC sampling was conducted in accordance with the Final Work Plan (WESTON, 2011a) and UFP-QAPP (WESTON, 2011b). Field QC samples were collected and analyzed to assess the quality of the data resulting from the field sampling program at a program-wide level for the MMRP RI at West Point. Additionally, as discussed in Section 4.4.3, 100% of the MC data results were validated by an independent third party, MEC^{x}, LP.

4.5.2.2.1 Field QC Samples and Sampling QC

Field QC samples were collected and assessed during the MMRP RI at West Point at a program-level based on the sample delivery groups submitted to the laboratory for analysis. Some MRSs had one or very few soil samples, and samples were batched together where possible. No field QC samples were collected specifically within the Lusk Reservoir MRS. The one routine MC sample collected at the Lusk Reservoir MRS was included in a sample delivery group with samples from other MRSs for the purposes of laboratory QC and field QC.

High-quality MC data were collected at the Lusk Reservoir MRS as evidenced by the following parameters employed to assess data usability:

- Precision is represented as the RPD between measurements of an analyte in duplicate samples. Sample WPR07-SS02 was collected as a field duplicate of sample WPR07SS01 from the Siege Battery MRS firing point area, which was analyzed in the sample delivery group with the Lusk Reservoir MRS sample. The pair of samples did not have reportable detects of explosive chemicals; therefore, the RPDs were not calculated. These data do not indicate a concern about the sampling or laboratory precision. This data usability parameter, however, could not be quantitatively evaluated.
- Accuracy was ensured by selecting appropriate data collection instruments, having clearly delineated instructions for their correct use, and following the sampling plan discussed in Section 3.13 and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No deviations from the sampling plan were documented during the RI field activities **(Appendix 4-F)**. Collection of incremental replicates allows the comparison of incremental sample results for the same sampling unit to evaluate whether the sampling procedure was accurate. Incremental replicates collected during the RI included three individual samples from within the sampling unit (field sample, duplicate, and triplicate). No field duplicate/triplicate incremental samples were collected from the Lusk Reservoir MRS. Incremental duplicate/triplicate samples in the same sample delivery group representing field QC at the program-level were collected at the Artillery Firing Range MRS (WPR01-SS06, WPR01-SS07, and WPR01-SS08) (see Section 5.5.2). None of the three samples had reportable detects of explosive chemicals; therefore, the RSD could not be calculated. This information is discussed in the data validation reports provided in **Appendix 4-J**. Rinsate and field blanks were not obtained during the soil investigation because of the use of new, clean, dedicated disposable equipment (i.e., scoops, aluminum pans, and sterile gloves).
- Data representativeness at the Lusk Reservoir MRS was accomplished by implementing the approved sampling procedures discussed in Section 3.13 and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No significant deviations from the sampling procedures were documented during the RI field activities (**Appendix 4-F and Appendix 4-I)**. Incremental sampling reduces data variability and increases sample representativeness. Increment placement within the sampling

unit and collection along a random meandering path was inconsistent with the approach detailed in the Final RI Work Plan that stated, “Increments will be collected using a systematic random approach.” However, the simple random approach for sampling unit design that was employed is an equivalent approach supported by industry and USACE guidance, and all increment locations were sampled. Therefore, the impact to data usability relative to representativeness is considered minimal.

- Completeness was achieved because the number of locations (**Figure 4-7**) sampled equaled the number of planned sample locations as discussed in the Final RI Work Plan.

- Comparability of data sets generated for the project was obtained through the implementation of, and adherence to, the standard sampling procedures discussed in Section 3.13 and the UFP-QAPP (Appendix J) of the Final RI Work Plan. A review of the field daily reports (**Appendix 4-F**) indicated no deviations from standard sample management procedures.

The high-quality data meet the data quality objectives of the RI established in the Final Work Plan for the Lusk Reservoir MRS and provided in Section 4.2.4 of the RI Report. These data are sufficient to support the risk assessment and the evaluation of alternatives.

4.5.2.2.2 Data Validation Results

The data validation guidelines are listed in Section 4.4.3. The data validation package for the Lusk Reservoir MRS, including the validation report narratives for the MRS analytical results and a glossary of QA/QC terms and data qualifier codes, is provided in **Appendix 4-J**. The data validation guidelines ensure that all data meet uniform requirements for accuracy and determine the validity of the data. If the data quality parameters for the MRS-specific analyses did not meet the criteria of the EPA and DoD Quality Systems Manual (QSM) Version 4.2 or the laboratory standard operating procedure (SOP), a discussion of the implications regarding the guidelines was included in the data validation narrative.

No major issues were identified during data validation. The results for the incremental sample for the Lusk Reservoir MRS showed some nondetects with elevated SQLs. These values were qualified as UJ due to poor photodiode array spectral match, which is a method routinely used for further identification of any detection above the limit of quantitation. A validation note consisting of an “H8” code was added to the UJ qualifier, verifying that the analyte was not confirmed on a second dissimilar column or that the diode array spectrums did not match the library. These UJ values are considered estimated, but still usable, data, which met all remaining acceptance criteria. Some sample results were below the detection limit and had an elevated intercolumn RPD; as a result, they were qualified with a nondetect, U.

Overall, the data validation showed that the data received from the laboratory were valid. The preceding data usability assessment (see Section 4.5.2.2.1) determined the data are usable for assessing the environmental conditions related to MC. Sufficient usable data were available for the Lusk Reservoir MRS to meet the objectives of the RI and to complete the risk assessment.

4.6 RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS

4.6.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was performed for Lusk Reservoir MRS. Based on the revised CSM in Section 4.8, the potential human receptors include West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

4.6.1.1 Data Evaluation

Sampling at the Lusk Reservoir MRS consisted of one incremental sample collected from an area historically defined as an artillery firing point. This sample consisted of a 0.5-acre sampling unit from which 30 increments were collected and analyzed for explosives (**Figure 4-7**). **Table 4-11** presents the validated analytical results for the Lusk Reservoir MRS surface soil incremental sample. No explosives were detected above the SQLs; however, because elevated SQLs were reported for several chemicals, a screening level human health risk evaluation was initiated as a conservative measure.

4.6.1.2 Selection of Chemicals of Potential Concern

Typically, soil chemicals of potential concern (COPCs) are identified by comparing the maximum detected concentration of each chemical with the recommended human health screening value. The analytical results for the surface soil incremental sample at Lusk Reservoir showed U and UJ values, indicating the analytes were not detected above their reported SQLs. The laboratory would have reported detects below the screening level, even if they were estimated values (J), and none were reported. However, to be conservative, a screening was performed to ensure the protectiveness of the SQLs.

As presented in **Table 4-12**, the recommended human health screening value is the lowest human health NYSDEC value (NYSDEC, 2006). If a NYSDEC value was not available, the ORNL residential RSL (EPA, 2012) was used. For COPC screening purposes, noncarcinogenic RSLs were adjusted to correspond to a target hazard quotient (THQ) of 0.1 rather than 1. Thus, these chemicals with additive effects were not prematurely eliminated during screening. If RSLs were available for carcinogenic and noncarcinogenic endpoints and both ingestion and inhalation exposure routes, the lower (i.e., more stringent) value was used for the screening comparison.

The results presented in **Table 4-12** indicate that no analytes had SQLs above the recommended screening level used to assess baseline risk to human health. The nitroglycerin SQL exceeded its benchmark when using the risk-based screening level at a THQ of 0.1 (610 µg/kg). However, because no other chemicals were detected (i.e., no additive effects from multiple chemicals), the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg, which is above the nitroglycerin SQL of 5,700 µg/kg.

4.6.1.3 Human Health Risk Assessment Summary and Conclusions

No evidence of military munitions was observed within the sampling grid. The sample results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs. Based on results of the HHRA, the surface soil incremental sample did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), contractor personnel, installation personnel, recreational users, and school children.

Table 4-12 Human Health Soil Screening for MC

Analyte	WPR09-SS04 200-5727-4 6/22/2011		EPA Residential RSL[a]		NYSDEC Residential SCO[b]	NYSDEC Unrestricted Use SCO[b]	Recommended Human Health Screening Value[c]		HH COPC?
Explosives (µg/kg)									
2,4,6-Trinitrotoluene	14	U	3,600	n	NBA	NBA	3,600	n	No
2,4-Dinitrotoluene	29	U	1,600	c	NBA	NBA	1,600	c	No
2,6-Dinitrotoluene	770	UJ	6,100	n	NBA	1,030	1,030		No
2-Amino-4,6-Dinitrotoluene	23	U	15,000	n	NBA	NBA	15,000	n	No
4-Amino-2,6-Dinitrotoluene	23	U	15,000	n	NBA	NBA	15,000	n	No
Nitroglycerin	5,700	UJ	610	n	NBA	NBA	610	n	No [d]
Cyclotrimethylenetrinitramine (RDX)	23	U	5,600	c	NBA	NBA	5,600	c	No
Pentaerythritol tetranitrate (PETN)	20,000	UJ	12,000	n	NBA	NBA	12,000	n	No

[a] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (April 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.
[b] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html
[c] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the ORNL Benchmark was used.
[d] When using the ORNL RSL values, noncarcinogens were reduced by an order of magnitude to yield a risk-based screening level with a THQ of 0.1 to address the additivity of noncancer effects when there is exposure to multiple chemicals. However, because no other chemicals were detected, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg.
c = cancer effects at a target risk of 1.0E-06.
µg/kg = micrograms per kilogram.
n = noncancer effects, at a target hazard quotient of 0.1.
NBA = no benchmark available.
RSL = regional screening level.
SCO = soil cleanup objectives.
U = The analyte was analyzed for, but was not detected above the reported sample limit of detection.
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

4.6.2 Ecological Risk Assessment

A focused Screening Level Ecological Risk Assessment (SLERA) was completed to assess the potential adverse impacts on the current and future ecological receptors exposed to MC in surface soil at the Lusk Reservoir MRS. The assessment endpoint for the SLERA is the protection of local populations and communities of biota from exposure to explosive chemicals of potential ecological concern (COPECs) in soil. The CSM for the Lusk Reservoir MRS is presented in Section 4.8.

4.6.2.1 Ecological Screening Values

Average concentrations of chemicals detected in soil at the Lusk Reservoir MRS (based on incremental sampling) were compared to conservative ESVs selected to assess baseline risks during the RI. All chemicals detected in soil at concentrations greater than the ESV were considered to potentially adversely impact ecological receptors and were identified as COPECs. The ecological screening values are presented in **Table 4-9** and **Table 4-13**.

The ESVs used for comparison to chemicals detected in soil samples were obtained from the NYSDEC Remedial Program SCOs, EPA Eco-SSLs, EPA Region 5 Resource Conservation and Recovery Act (RCRA) ESLs, information obtained from select ORNL guidance, and additional appropriate guidance, as necessary. The primary source for the recommended screening value was the NYSDEC value. If a NYSDEC value was not available, ESVs were selected in accordance with the hierarchy listed above.

If no value was established within the hierarchy presented in the RI Work Plan, additional research was conducted to identify ESVs during the development of the SLERA. ESVs were obtained for the following analytes: nitroglycerin, PETN, 2,4,6-trinitrotoluene, 4-amino-2,6-dinitrotoluene, and 2-amino-4,6-dinitrotoluene (**Table 4-13**).

Table 4-13 Screening Level Ecological Risk Assessment Results for Soil

Analyte	Sample Number	Recommended Ecological Screening Value (µg/kg)	Maximum Detected IS Value (µg/kg)*	COPEC?
2-Amino-4,6-Dinitrotoluene	WPR09-SS04	9,000[a,b]	23 U	N
4-Amino-2,6-Dinitrotoluene	WPR09-SS04	9000[a,b]	23 U	N
2,4-Dinitrotoluene	WPR09-SS04	1,280[c]	29 U	N
2,6-Dinitrotoluene	WPR09-SS04	32.8[c]	770 (385) UJ	Y
Nitroglycerin	WPR09-SS04	3,000[a,d]	5,700 (2,850) UJ	N
PETN	WPR09-SS04	170,000[a,e]	20,000 UJ	N
RDX	WPR09-SS04	21,000[f]	23 U	N
2,4,6-Trinitrotoluene	WPR09-SS04	70[a,g]	14 U	N

Notes:
[a] µg/kg/d = microgram per kilogram per day, no observed adverse effect level (NOAEL).
[b] USACHPPM, 2005.
[c] EPA, 2003.
[d] USACHPPM, 2000.
[e] USACHPPM, 2001a.
[f] Kuperman et al., 2006.
[g] USACHPPM, 2001b.
* Second value is ½ the estimated sample quantitation limit.
U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2)
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photo diode array confirmed that the analyte was not present.

4.6.2.2 Habitat and Receptors

The Lusk Reservoir MRS extends northwest from the firing point located to the east of the Lusk Reservoir and crosses through the central portion of West Point. Once on post, access to the former range is unrestricted. There are approximately 150 structures located within the boundaries of the Lusk Reservoir MRS.

About 50% of the Lusk Reservoir MRS has been disturbed by the development of the Grey Ghost Housing Area and the Old Brick Housing Area in the northern portion of the MRS. The middle portion is undisturbed and consists of heavily forested, steep terrain. The eastern portion, which is where the former firing point was located, consists of gentle hills with forested and grassy areas.

Ecological receptors that could potentially be exposed to MC at the Lusk Reservoir MRS include terrestrial plants; terrestrial invertebrates; and terrestrial avian and mammalian species, including herbivores, omnivores, and carnivores. A list of the potential ecological receptors for West Point is presented in Section 4.1.1.6.5.

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Lusk Reservoir MRS. Although habitat is present at West Point that could support threatened and endangered species, no threatened or endangered species are known to reside or breed within the areas sampled at the Lusk Reservoir MRS (Tetra Tech, 2011).

4.6.2.3 Screening of Chemicals of Potential Ecological Concern

The maximum detected values for the incremental soil sample at the Lusk Reservoir MRS were compared to appropriate ESVs. One sample (WPR09-SS04) was collected at the historical firing point of the MRS.

The analytical results for the surface soil incremental sample at the Lusk Reservoir MRS showed U and UJ values, indicating the analytes were not detected above their reported SQLs. The laboratory would have reported positive detections below the quantitation levels, even if they were estimated values (J), and none were reported. However, because of the elevated SQLs, to be conservative, a screening was performed to ensure the protectiveness of the SQLs. The explosive compound 2,6-dinitrotoluene (2,6-DNT) was reported as a nondetect with an SQL of 770 µg/kg in soil sample WPR09-SS04; the SQL is greater than the ESV (**Table 4-13**). Because all samples collected from West Point MRSs where RIs were conducted had results for 2,6-DNT that were reported as qualified nondetects, half of the reported sample result (385 µg/kg) was used for comparison to the ESV of 32.8 µg/kg (Region 5 RCRA Ecological Screening Levels [EPA, 2003]). Although a value of half the sample quantitation still exceeds the ESV, it is less than the alternative no observed adverse effect level (NOAEL) value for 2,6-DNT of 700 µg/kg for ingestion exposure for mammals (USACHPPM, 2006).

No munitions that would constitute a source of 2,6-DNT were observed at the firing point where the incremental sample was collected and 2,6-DNT was not positively detected in any of the MC samples collected from the MRSs included in the MMRP RI at West Point. It is highly unlikely that 2,6-DNT is present related to historical activities at the Lusk Reservoir MRS. Furthermore, even if a release to surface soil at the MRS had occurred, 2,6-DNT is unlikely to persist in the environment because this compound readily breaks down in the presence of oxygen and sunlight, and is highly water soluble (Agency for Toxic Substances and Disease Registry [ATSDR], 1998).

The explosive compound nitroglycerin was reported in soil sample WPR09-SS04 as a nondetect with an SQL of 5,700 µg/kg; the SQL is greater than the ESV. Because all samples collected from West Point MRSs where RIs were conducted yielded results for nitroglycerin that were qualified as nondetects, half of the SQL (2,850 µg/kg) was used for comparison to the ESV (3,000 µg/kg). Because half of the SQL is below the RI-selected ESV, nitroglycerin is not considered a COPEC.

4.6.2.4 Uncertainty Assessment

The 2,6-DNT concentration is listed as a nondetect/estimated value (UJ), but the SQL exceeds the established conservative ESV. It is unclear whether 2,6-DNT is present and poses a quantifiable risk of exposure to ecological receptors within the Lusk Reservoir MRS. Based on the secondary spectral analysis performed by the laboratory, which confirmed that no explosives were present, and on the screening-level evaluation results presented above, the uncertainty associated with the elevated SQLs is considered minimal.

4.6.2.5 Summary of Ecological Risk

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Lusk Reservoir MRS. No threatened or endangered species are known to be present within the area sampled at the Lusk Reservoir MRS. The ecological habitat at the firing point within the MRS is not considered to be of high quality because of the urbanization in the area, and it is expected that potential ecological receptors would use other habitats within the surrounding area.

There is little to no potential for adverse ecological impacts from MC in surface soil at the Lusk Reservoir MRS because the results of the chemical analyses indicated that no explosives were detected in the soil sample. The SQL for 2,6-DNT was greater than the conservative ESVs; however, the SQL value is less than the alternative NOAEL value (**Table 4-9** and **Table 4-13)**. An elevated SQL for 2,6-DNT is not considered a potential risk to ecological receptors because there was no evidence of military munitions within the incremental sampling unit at the firing point. In addition, 2,6-DNT was not positively detected in any of the program-level MC samples collected at West Point to support the ongoing RIs, and the toxicological information indicates that this compound would not be likely to persist in surface soil. The uncertainty associated with the estimated SQLs observed using Method 8330B analysis was minimized by obtaining secondary confirmation by spectral analysis that 2,6-DNT was not present. The risk of exposure to COPECs for ecological receptors at the Lusk Reservoir MRS is considered to be minimal.

4.6.3 Preliminary Identification of Applicable or Relevant and Appropriate Requirements

A preliminary identification of potential ARARs is conducted during RI characterization. The ARARs are used as a “starting point” in determining remedial action objectives and the protectiveness of a remedy to be assessed in a feasibility study (FS).

As the RI/FS process continues, the list of ARARs is further refined. The ARARs are used to establish the appropriate extent of cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative.

Pursuant to Section 300.400(g) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a list of ARARs and other to-be-considered advisories, criteria, and guidance (TBCs) is developed for a site or sites to identify the requirements that may apply to response actions. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the NCP provide that the development and evaluation of remedial actions must include remedial alternatives to attain ARARs and to ensure protection of public health and the environment.

ARARs are defined as follows:

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

First, it is determined whether a requirement is applicable to the site. If a requirement is not applicable, then it is determined whether the requirement is relevant and appropriate. The procedure for determining whether a requirement is relevant and appropriate is a two-step process. First, to determine relevance, it is evaluated whether the requirement addresses problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made about whether the requirement would also be well-suited to the conditions of the site. In some cases, only a portion of a requirement would be both relevant and appropriate. Once a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR. The results of the selection process for the Lusk Reservoir MRS are provided in **Table 4-14**.

“Applicable requirements” and “relevant and appropriate requirements” are considered to have the same weight under CERCLA. Section 121(d) of CERCLA requires the attainment of federal ARARs and of state ARARs if the state environmental or facility siting laws are promulgated, are more stringent than federal laws, and are identified by the state in a timely manner.

CERCLA and the NCP also identify the TBC category, which includes nonpromulgated (not enforceable) federal and state criteria, advisories, and guidance documents, which are also considered. TBCs do not have the same status as ARARs; however, if no ARAR exists for a substance or particular situation, TBCs may be used to ensure that a remedy is protective.

Generally, ARARs pertain either to contaminant levels or to performance or design standards to ensure protection at all points of potential exposure. ARARs are divided into three general categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs.

Table 4-14 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments (Applicable or Relevant and Appropriate)
Action-Specific			
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	*Applicable* Identify when military munitions become a solid waste; and, if these wastes are also hazardous under this subpart or 40 CFR Part 261, identify the management standards that apply to these wastes.
NY Division of Water - Classes and Standards of Quality and Purity and EPA National Pollutant Discharge Elimination System	6 NYCRR §750-1.5 and 40 CFR Part 122.26	Establishes water quality standards, including classifications of New York waters and water quality criteria to protect the ground and surface water resources; and controls stormwater and effluent discharges, including toxic substances, into state waters.	*Relevant and Appropriate* For remedial alternatives where soil excavation activities are performed and require stormwater management. Construction activities disturbing one or more acres of soil must be authorized under the NY General Permit for Stormwater Discharges from Construction Activities.
Hazardous Waste Manifest System and Related Standards For Generators, Transporters and Facilities	6 NYCRR Part 372	Establishes standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its record keeping requirements.	*Applicable* in the event that hazardous waste is generated as part of a remedial alternative; for example, if MEC were removed and would need to be shipped (by a party other than the Army) as hazardous waste.
Waste Transporter Permits	6 NYCRR Part 364	Protects the environment from mishandling and mismanagement of regulated waste transported from the site of generation to the site of ultimate treatment, storage or disposal.	*Applicable* to any off-site transport and disposal of classified hazardous wastes, if generated as part of remedial alternative.
Air Quality Classifications and Standards	6 NYCRR Part 257-1.3 and 257-1.4	Designed to provide protection from the adverse health effects of air contamination; intended to protect and conserve the natural resources and environment.	*Relevant and Appropriate* in the event that a remedial alternative, such as soil excavation/grading, could impact ambient air quality for an extended period of time. The state regulation has 12-month average standards for dust levels from a specific source.

Notes:
CFR Code of Federal Regulations
NYCRR New York Codes, Rules and Regulations

ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the MRS.
- Chemical analysis performed or scheduled to be performed.
- Types of media (air, soil, groundwater, surface water, and sediment).
- Geology and other MRS characteristics.
- Use of MRS resources and media.
- Potential contaminant transport mechanisms.
- Purpose and application of potential ARARs and TBCs.
- Remedial alternatives considered for MRS cleanup.

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 an MRS. The preliminary ARARs are summarized in **Table 4-14.** No MEC was found in the Lusk Reservoir MRS during the RI field activities and no MC chemicals were detected. It is anticipated that future remedial alternatives will not include on-site treatment, on-site storage (greater than 90 days), or on-site disposal of hazardous waste; therefore, potential action-specific ARARs related to these activities were not considered applicable at this time.

Location-specific ARARs were not identified for the Lusk Reservoir MRS. Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. The Lusk Reservoir MRS does not contain any ecologically sensitive or unique areas. Several Revolutionary War sites are located near the firing point, but outside the MRS boundaries. Fort Putnam, a Revolutionary War fort, is located along the southern edge of the Lusk Reservoir MRS outside the MRS boundaries. Based on the findings of the RI, it is anticipated that the remedial alternatives will not include activities that would impact these historic resources; therefore, potential action-specific ARARs related to these activities were not considered applicable at this time.

Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Chemical-specific ARARs are used to provide benchmarks with which to compare environmental sampling results for metals and explosives. Residential SCO values published in NYSDEC regulations (NYSDEC, 2006) would be considered chemical-specific

ARARs for MC concentrations at the MRS. However, because MC was not detected at the Lusk Reservoir MRS, chemical-specific ARARs do not need to be carried forward based on the information available at the time of the RI. TBCs were identified for the Lusk Reservoir MRS and are discussed in Section 4.4.4.

NYSDEC participated in TPP 1 (General Project Introduction and Approach) and TPP 2 (Presentation of RI Field Work Approach). Discussions at TPP 1 and TPP 2 generally consisted of establishing which NYSDEC and EPA standards for MC would apply to the whole project (WESTON, 2011a). The RI reports will be presented at the TPP 3 meeting.

The ARARs will be further refined during future phases of work (e.g., the decision document) at the Lusk Reservoir MRS as needed.

4.7 CONTAMINANT FATE AND TRANSPORT

The intent of this section is to describe the fate of contaminants in the environment and the potential transport mechanisms for MEC and MC identified at the Lusk Reservoir MRS. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to the migration mechanisms away from the source area. Because no MEC was found at the Lusk Reservoir MRS during the SI and RI field activities, an explosive hazard has not been identified to provide the basis for a discussion of MEC fate and transport.

Sampling was conducted to evaluate the potential MC impacts at the firing point. Based on the analytical data evaluation and the subsequent risk assessment performed for the RI, an MC risk is not present within the Lusk Reservoir MRS.

No MEC was identified during the RI. MD was found between 2 and 6 inches bgs. One UXO item, a 90mm APC-T projectile, was identified during construction activities at the West Point Middle School. The exact depth of the UXO is unknown; however, the item is considered to have been found in the subsurface.

The northern portion of the Lusk Reservoir MRS is developed and relatively flat with a low potential for erosion. The southern portion of the MRS is undeveloped with two water bodies (Delafield Pond and Lusk Reservoir) with rolling hills and a greater potential for erosion.

The UXO item identified within the northern portion of the MRS is classified as small (less than 100 pounds) and capable of being moved by surface erosion. The soil types in the Lusk Reservoir MRS range from well drained to somewhat excessively well drained with a limited capacity to retain moisture and thus a low potential for frost heave. The UXO was identified above the frost line. The soils within the area are not readily susceptible to frost heave. Therefore, surface interactions such as wet/dry erosion have the potential to impact source material; however, frost heave is unlikely in the northern portion. There is the potential for erosion in the northern portion; however, because of the development (buildings, roads, parking lots), erosion is unlikely. Burrowing biota might come in contact with residual MEC and MD because of the shallow depth of MEC observed during the RI, which was identified within the zone of biological activity.

No MEC or MD was identified in the southern undeveloped portion of the MRS where surface interactions such as wet/dry erosion and frost heave are likely.

4.8 REVISED CONCEPTUAL SITE MODEL

This section presents the revised MEC and MC CSMs for the Lusk Reservoir MRS based on the results of the data collected for the RI and the previous information provided in the SI report. The preliminary CSMs are discussed in Section 4.2.1.

4.8.1 Revised Munitions and Explosives of Concern Conceptual Site Model

The Lusk Reservoir MRS was documented in the preliminary CSM as being a portion of the Lusk Reservoir artillery range fan nearest to the firing point. After completion of RI field work across all MRSs at West Point, an increase in MEC and/or MD densities was observed laterally extending across several MRS with overlapping ranges, including the Lusk Reservoir MRS, the Artillery Firing Range MRS, the Fort Clinton West MRSs, and the Siege Battery MRS. Based on the observed distribution of densities and the types of MEC and MD recovered, the source of the increased clustering and densities is related to the former target area on Crows Nest in the northern extent of West Point. This impact area includes 8.8 acres of the Lusk Reservoir MRS in its northern extent where the MRS intersects the Artillery Firing Range and Fort Clinton West MRSs.

Based on the data collected during the RI, separating the 8.8 acres in the northern portion of the MRS from the original boundary of the Lusk Reservoir MRS would reduce the total acreage from 83.2 acres to 74.4 acres (see **Figure 4-9**). Although no MEC was found in the Lusk Reservoir MRS during the RI, UXO found near the northern boundary of the MRS in the adjacent Fort Clinton West MRS warrants consideration in the revised CSM. The southern 74.4-acre portion and the northern 8.8-acre portion of the Lusk Reservoir MRS are assessed separately in **Figure 4-10** and **Figure 4-11**.

The southeastern boundary area of the Lusk Reservoir MRS was also assessed because of the investigation findings at a grid placed in the closest accessible area to the firing point (slightly northeast of the firing point and outside the Lusk Reservoir MRS boundary). Limited MD was found in the focused grid survey and the intrusive investigations, and no risks from MC were identified. Therefore, a revision of the boundary to incorporate the physical location of the MD found near the firing point but outside the MRS boundary is not necessary.

4.8.1.1 Revised Munitions and Explosives of Concern Exposure Pathway Analysis

The MEC exposure pathway analysis for the Lusk Reservoir MRS is summarized in the following subsections. As described in Section 4.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered potentially complete when a source (MEC) has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered incomplete if any one of the three components (source, interaction, or receptors) is not present at an MRS.

4.8.1.1.1 Source

A MEC source is the location where MEC is situated or is expected to be found. The Lusk Reservoir MRS is a portion of the Lusk Reservoir artillery range fan nearest to the firing point. Concentrations of MEC and MD indicative of an impact area were not anticipated within the MRS because the impact area for the former artillery range was located on Crows Nest and not included within the Lusk Reservoir MRS boundary. Low concentrations of MEC, in particular UXO, may be found within the MRS as a result of misfires or undershots toward the former targets. DMM was determined to be a potential MEC source at the firing point.

It is possible that MEC and MD may have been transported in fill material and placed within the Lusk Reservoir MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

During the SI survey activities, no MEC or MD was identified. However, the exposure pathway for MEC was determined to be complete for surface and subsurface soils based on the evidence of MEC documented as part of the previous investigations in the Lusk Reservoir MRS.

During the RI field activities, 6.06 acres of survey coverage was performed at the Lusk Reservoir MRS and a total of 13 MD items were recovered at depths ranging between 2 inches and 6 inches bgs. No MEC was recovered. The characterization coverage was determined to be adequate to satisfy the UXO Estimator parameters of 0.5 MEC/acre at a 95% confidence level. Because the MD was recovered only in the developed portions of the MRS, it is believed that most, if not all, of the MD was transported to the Lusk Reservoir MRS in fill material used for prior construction activities. Four 3.5-inch solid shot cannonballs were recovered in a grid near the firing point. Because these cannonballs were described as solid shot, they are not considered DMM. The cannonballs were likely intentionally buried by range users.

MD was recovered within the northern 8.8-acre portion of the Lusk Reservoir MRS and in the southern 74.4 acres of the MRS. After the RI field activities were completed, UXO consisting of a 90mm APC-T projectile was identified in the northern 8.8-acre portion of the MRS behind the

West Point Middle School. Although an increase in MEC and MD density was not observed within the northern 8.8-acre portion of the Lusk Reservoir MRS, an increased density was observed laterally extending across several MRSs, including the Fort Clinton West, Siege Battery, and Artillery Firing Range MRSs. Based on the observed density distribution and the type of MEC and MD recovered, the source of increased clustering and densities is related to the former target area on Crows Nest mountain in the northern extent of West Point. The consistent findings are indicative of a common CSM observed across the MRS boundaries. The MEC sources for the northern 8.8-acre portion and the southern 74.4-acre portion of the Lusk Reservoir MRS are discussed separately in the following subsections.

Southern 74.4-Acre Portion

Although only a statistical portion of the MRS was investigated, the intrusive investigation of 803 anomalies without evidence of MEC suggests that no MEC source and thus no explosive hazard is anticipated to be present in the southern portion of the Lusk Reservoir MRS.

Northern 8.8-Acre Portion

Concentrations of MEC and MD were observed in the MRSs adjacent to the Lusk Reservoir MRS and are attributed to the historical firing at targets on Crows Nest mountain. These concentrations of MEC and MD were located close to the northern boundary of the Lusk Reservoir MRS. Based on the RI results from the adjacent MRSs, the southern boundary for the Crows Nest impact area was determined to be Washington Road, which crosses through the Lusk Reservoir MRS. An 8.8-acre portion of the Lusk Reservoir MRS is included in the Crows Nest impact area. The 90mm APC-T projectile is not consistent with the historic munitions use the MRS and was identified within fill; therefore, the projectile was most likely transported to the MRS from an outside source.

4.8.1.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes both access and activity considerations. Access describes the degree to which a MEC source or an environment containing MEC is available to potential receptors. Activity describes the action by which receptors come in contact with a source. Typically, a receptor may contact MEC, if present, on the ground surface simply by walking. A receptor may contact MEC in the subsurface, if present, by performing intrusive activities.

The Lusk Reservoir MRS is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. Once on the West Point installation, access to the MRS is unrestricted. Residential homes and the West Point Middle School are located in the northern half of the MRS. The majority of the southern half of the Lusk Reservoir MRS consists of open space. Delafield Pond, a portion of which is located in the southern half of the MRS, is used for swimming. Approximately 150 structures are located within the boundaries of the Lusk Reservoir MRS. These structures include a residential housing area, the middle school, youth center, water pump station, post chapel, gas regulator station, transformer vault, and Substation C. Residential and maintenance activities in the Lusk Reservoir MRS may disturb surface and subsurface soils. No changes to the current land uses are anticipated.

4.8.1.1.3 Receptors

A receptor is an organism (human or ecological) that comes in physical contact with MEC. Human receptors identified for the Lusk Reservoir MRS include West Point residents (adults and children), school children (associated with the northern portion only), contractor personnel, installation personnel, recreational users, and site visitors.

Approximately half of the Lusk Reservoir MRS has been disturbed by the development of the Grey Ghost Housing Area and Old Brick Housing Area. The center of the MRS is undisturbed and consists of heavily forested, steep terrain. Potential ecological receptors are presented in Section 4.1.1.6.5. Because the northern half of the Lusk Reservoir MRS is extensively developed, it is unlikely that the majority of the ecological receptors would rely on the northern portion of the MRS for habitat. It is likely, however, that the southern half of the MRS provides habitat for some ecological receptors.

4.8.1.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Lusk Reservoir MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS given current and anticipated future land users.

A statistical approach was taken for the characterization at the Lusk Reservoir MRS, and a portion of the MRS was investigated by geophysical surveys and intrusive investigations. No MEC was identified within the 6.06 acres of investigation coverage and the investigation of

803 anomalies. MD was identified in subsurface soils. It is believed that the majority of the recovered MD was transported in fill material used for construction activities.

Based on the results of the SI and RI field investigations, it is not expected that a MEC source or explosive safety hazard is present at the Lusk Reservoir MRS. Because no MEC source or explosive safety hazard has been identified at the Lusk Reservoir MRS, there are no current receptor interactions or anticipated interactions under future land use.

4.8.1.2.1 Southern 74.4-Acre Portion

The revised CSM for MEC identifies incomplete pathways for surface and subsurface soils for all receptors having access to the southern portion of the Lusk Reservoir MRS (**Figure 4-10)**.

4.8.1.2.2 Northern 8.8-Acre Portion

Although only one MD item was recovered in the 8.8 acres of the Lusk Reservoir MRS within the Crows Nest impact area during the RI, the pathways for MEC to potential receptors are considered complete based on MEC and MD findings throughout adjacent West Point MRSs. Additionally, the UXO item, which was identified during construction activities at the West Point Middle School after the completion of the RI field work, is indicative of a potential source for MEC. The UXO was identified by construction support within the Crows Nest impact area portion of the Lusk Reservoir MRS. The exact depth of the UXO item is unknown; however, the item is considered to have been found in the subsurface. The MD was identified in the near surface (2 to 6 inches bgs). MEC items identified within the surrounding Crows Nest impact acre were identified on the surface; therefore, both the surface and subsurface MEC pathways are considered complete for the Lusk Reservoir MRS. A CSM pathway diagram is provided in **Figure 4-11** for the 8.8 acres in the northern portion of the Lusk Reservoir MRS.

4.8.2 Revised Munitions Constituents Conceptual Site Exposure Model

To supplement the historical data collected to evaluate MC during the SI, one sampling location was selected to assess potential MC contamination in soil in the Lusk Reservoir MRS. Because no other potential sources for MC (e.g., MEC, significant MD, or other indication of a release such as stained soil) were identified during either the SI or RI, the location was determined based on the Final Work Plan (WESTON, 2011a). One incremental sample, comprised of

30 increments, was collected within a 0.5-acre sampling unit in the vicinity of the former firing point to support the RI.

The MC sampling results are discussed in Section 4.5.2. The complete analytical results and data validation reports are provided in **Appendix 4-J**. The analytical results were used in the HHRA and SLERA (see Section 4.6) and to update the preliminary CSM as needed.

4.8.2.1 Revised Munitions Constituents Exposure Pathway Analysis

The MC exposure pathway analyses for the Lusk Reservoir MRS are summarized in this section. As previously described in Section 4.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. An exposure pathway for MC requires a source exposure medium (i.e., MC in soil), interaction (release mechanism and exposure route), and receptors. A pathway is considered complete when all components exist and imply potential risk. A pathway is considered potentially complete when data are required to determine whether the pathway is complete or incomplete. An incomplete pathway presents no associated risk and no further data are required.

4.8.2.1.1 Source

No known source for MC has been identified within the Lusk Reservoir MRS. No MEC was recovered, and the MD that was identified during the RI was not found in significant densities or associated with any field indications of a release (i.e., broken/leaking munitions, adjacent soil staining).

In accordance with the Final Work Plan (WESTON, 2011a), MC was assessed at the former firing point to confirm that no MC hazards were present. If present, MC would have been directly released to surface soil at the point of firing. The data evaluation and the HHRA activities did not identify any COPCs or potential risks to human receptors because no explosives were detected in any of the samples. The risk from the one COPEC identified during the SLERA, due to an SQL that did not meet the selected ESV, was determined to be minimal. The finding is consistent with the analytical sampling performed to support the SI, which did not identify any MC above the SI screening levels.

Although only one sample was collected during the RI, the intrusive investigation of 803 anomalies without evidence of MEC or significant densities of MD, soil staining, or a potential MC release at the firing point suggests that an MC source and the potential for encountering an MC hazard are not present within the Lusk Reservoir MRS.

4.8.2.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes an exposure route with a release mechanism for impacted media. The Lusk Reservoir MRS is located primarily within two land use zones, (1) Post Support and (2) Recreational, Industrial, Field Training. Once on the West Point installation, human and ecological receptors have unrestricted access to the MRS. A human or ecological receptor may encounter MC in soil through direct contact, including ingestion, inhalation, or dermal exposure routes.

Within the environment, fate and transport of MC in soil, if present, has to the potential to be affected by secondary release processes such as wet/dry erosion, infiltration/leaching to groundwater, and food web interactions. These processes may result in the movement or transformation of MC within environmental media. Because an MC release has not been identified in any environmental media, no interactions are expected to exist at the Lusk Reservoir MRS that would expose receptors to MC contamination.

4.8.2.1.3 Receptors

Potential receptors for MC at the Lusk Reservoir MRS are the same as those presented above under the revised MEC CSM in Section 4.8.1.1.3.

4.8.2.2 Munitions Constituents Exposure Pathway Conclusions

The analytical results from the one incremental sample and the risk assessment activities performed to support the RI were used to update the preliminary MC CSM for the Lusk Reservoir MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users.

4.8.2.2.1 Southern 74.4-Acre Portion

Sampling for MC was conducted only at the former firing point during the RI, and not within the range fan of the Lusk Reservoir MRS because no MEC items, soil staining, or visible evidence of a potential MC release were found in the southern 74.4-acre portion of the MRS. Explosives were not detected in the soil sample from the Lusk Reservoir MRS. The SQL for 2,6-DNT exceeded the project ESV, but not the NOAEL. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources, and thus no potential risk, are known to exist in the Lusk Reservoir MRS. The finding based on RI results is consistent with the preliminary CSM developed following the SI. **Figure 4-12** depicts the MC exposure pathways for the southern 74.4-acre portion of the Lusk Reservoir MRS.

4.8.2.2.2 Northern 8.8-Acre Portion

Although an MC assessment was not conducted in the 8.8 acres in the northern portion of the Lusk Reservoir MRS during the RI, analytical sampling was conducted in adjacent MRSs that included acreage in the Crows Nest impact area. These results, specifically the Fort Clinton West MRS results, were used to conservatively evaluate the MC exposure pathway for the Lusk Reservoir MRS in its northern extent. Data evaluation and risk assessment conducted for human and ecological receptors did not identify any unacceptable risks. Based on the RI assessment and the findings within the Fort Clinton West MRS, the Artillery Firing Range MRS, and the Siege Battery MRS, the pathway for MC exposure is considered incomplete for the northern 8.8 acres of the Lusk Reservoir MRS (see **Figure 4-13)**. Sections 2, 3, and 5 provide more details on MC in the Fort Clinton West MRS, the Siege Battery MRS, and the Artillery Firing Range MRS, respectively.

4.9 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT AND MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL UPDATE

4.9.1 Munitions and Explosives of Concern Hazard Assessment

The CERCLA process for responding to releases or potential releases of hazardous substances includes the development of site-specific risk assessments appropriate to the requirements of a site. The results of the risk assessments are used to help site managers decide whether a response action is required and to support the risk management decisions that are made through the remedy evaluation, selection, and implementation process.

The CERCLA methodology for human health chemical risk assessment was not designed to address explosive safety hazards at MEC sites. In October 2008, the Technical Working Group for Hazard Assessment, which included representatives from DoD, Department of the Interior, EPA, and others, made available the technical reference document *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). The document was designed to be used as the CERCLA hazard assessment methodology for MRSs where an explosive hazard exists from the known or suspected presence of MEC.

4.9.1.1 Southern 74.4-Acre Portion

No MEC was identified in the southern portion of the Lusk Reservoir MRS during either the SI or RI field activities. These results have been interpreted to indicate that no MEC source or explosive safety hazard is present in the southern portion of the MRS. As a result, the project team determined that the calculation of a MEC HA score was not warranted for the Lusk Reservoir MRS.

4.9.1.2 Northern 8.8-Acre Portion

No MEC was identified in the northern portion of the Lusk Reservoir MRS during either the SI or RI field activities; however, a 90mm APC-T projectile was identified during construction activities at the West Point Middle School. Although the UXO item is not consistent with the MEC and MD items identified in adjacent MRSs, the UXO item was identified within the delineated impact area associated with the Crows Nest (includes portions of the Fort Clinton West MRS, Siege Battery MRS, and Artillery Firing Range MRS) with abutting boundaries that terminate south of the Crows Nest. The delineated impact area associated with the Crows Nest includes the 8.8-acre northern portion of the Lusk Reservoir MRS. Although no MEC was identified during the SI or RI, UXO was identified during construction activities in the surrounding Crows Nest impact area. Therefore, the calculation of a MEC HA score was warranted (see Section 6.6).

4.9.2 Munitions Response Site Prioritization Protocol Scoring Update

The RI results were used to reapply the MRSPP. Priority 1 indicates the highest potential hazard and priority 8 the lowest potential hazard. Using the MRSPP, only MRSs with CWM can be assigned a priority of 1 and no MRS with CWM can be assigned a priority of 8.

4.9.2.1 Southern 74.4-Acre Portion

The MRSPP forms for the southern 74.4-acre portion of the Lusk Reservoir MRS that is not within the Crows Nest impact area are provided in **Appendix 4-K**. The MRSPP priority for the southern 74.4 acres of the Lusk Reservoir MRS is considered No Longer Required because no MEC was identified; therefore, there is no hazard within this portion of the MRS.

4.9.2.2 Northern 8.8-Acre Portion

The data and information relative to the northern 8.8-acre portion of the Lusk Reservoir MRS are included in the application of the MRSPP to the Artillery Firing Range North MRS (see Section 6.6.2).

4.10 SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI activities conducted at the Lusk Reservoir MRS. The RI was conducted to determine the nature and extent of MEC and MC and to determine the potential hazards and risks posed to human health and the environment by MEC and MC. The RI also provided additional data to assist in determining what remedial alternatives, if any, are necessary. As a result of the characterization activities conducted at the Lusk Reservoir MRS, the objectives of the RI have been satisfied.

4.10.1 Summary of Remedial Investigation Activities

The preliminary CSM for the Lusk Reservoir MRS aided in developing data needs and DQOs as documented in the Final Work Plan (WESTON, 2011a). In general, the data needs and DQOs focused on characterizing the nature and extent of MEC and MC that may be present in the MRS because of activities at the former artillery range. The characterization activities to support the data needs and DQOs were used to gather information to evaluate whether there are unacceptable potential risks to human health and the environment associated with MEC and/or MC to determine whether further action is required under the CERCLA process.

UXO Estimator was used to develop a statistically based characterization strategy. Geophysical surveys were performed at the Lusk Reservoir MRS between April and August 2011 to assess the nature and extent of MEC in the MRS. Both DGM (EM61-MK2) and mag and dig (White's all-metals detectors) surveys were performed as part of the RI field work. A total of 6.06 acres and a total of 803 anomalies were investigated as a result of geophysical surveys. Each of the eight anomalies detected along the mag and dig transects were intrusively investigated. DGM data were processed and interpreted, and 795 anomalies were selected as targets for further investigation based on the results from the IVS and subsequent USACE approval.

No MEC was observed in the Lusk Reservoir MRS during the RI field activities. A total of 13 MD items were recovered at depths ranging between 2 inches and 6 inches bgs. The MD items included four 3.5-inch cannonballs (solid shot), one MKII hand grenade (empty), and eight fragments from unknown munitions. The four 3.5-inch cannonballs (solid shot) were recovered in a grid near the Lusk Reservoir firing point, whereas the remaining MD was recovered from downrange within the range fan. The remaining non-MD related material included 765 items classified as cultural debris, 15 no contacts, and 10 quality control seeds. Non-MD-related material was recovered between the surface and 21 inches bgs.

Based on the lack of identified MEC, of significant densities of MD, or of other signs of MC release (e.g., soil staining, broken/leaking munition), only one sampling location was selected to assess the potential MC contamination in soil through incremental sampling at the Lusk Reservoir MRS. Thirty increments were collected within a 0.5-acre sampling unit in the vicinity of the former firing point. The sample was collected and analyzed to identify the presence of MC (if any) and to characterize the nature and extent of MC. No explosives were detected in the sample; however, elevated SQLs for several chemicals were further evaluated during the HHRA and SLERA.

4.10.2 Risk Assessment

The results of the HHRA showed that no MC was present that constituted a potential risk to human health. All explosives analytical results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs and were observed below the project screening levels selected to assess human health effects. Based on results of the HHRA, the surface soil incremental sample did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

There is little to no potential for adverse ecological impacts from explosives in surface soil at the Lusk Reservoir MRS because only the SQL for 2,6-DNT slightly exceeded the EPA conservative screening level. SQLs for 2,6-DNT were below the less conservative alternative screening value obtained to assess the NOAEL. Additionally, 2,6-DNT was not detected in any samples collected at the program-level at other West Point MRSs, and toxicological information indicates that this compound would not be likely to persist in surface soil. The risk of exposure to COPECs for ecological receptors at the Lusk Reservoir MRS is considered to be minimal.

4.10.3 Revised Conceptual Site Model

A discussion of the preliminary CSM, based on the available data and historical information compiled prior to RI activities, is presented in Section 4.2.1. The information collected during the RI was used to update the CSM (Section 4.8). The purpose of the CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and reasonably anticipated future land use activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, interaction (activity and access), and receptor.

The Lusk Reservoir MRS is a portion of the Lusk Reservoir artillery range fan nearest to the firing point. The MRS is an 83.2-acre area, which was defined based on the results of the SI. Potential MEC source areas for the Lusk Reservoir MRS were considered to be: (1) locations where MEC (in particular DMM) may have malfunctioned or been disposed of at the firing point during training activities and (2) locations downrange where UXO and/or MD resulted from impacts during intentional munitions firing activities. Concentrations of MEC and MD were not anticipated in the MRS because the impact area for the former artillery range is in the Crows Nest area and not included within the Lusk Reservoir MRS boundaries.

It is possible that MEC and MD may have been transported in fill material and placed within the Lusk Reservoir MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

A statistical approach was developed to assess the potential MEC density in the Lusk Reservoir MRS. UXO Estimator was used to develop the appropriate coverage necessary to make high confidence assessments. No MEC was identified on the ground surface or in the subsurface in the 6.06 acres where geophysical surveys and subsequent intrusive investigation of 803 anomalies were conducted. These results were then re-assessed in UXO Estimator. The statistical upper bound density of MEC was determined to be 0.469 MEC per acre based on the percentage of area surveyed at the Lusk Reservoir MRS and the actual intrusive investigation results. This value was within the DQO target density of 0.5 MEC per acre, which means that the investigation was adequate to be 95% confident that there is less than 0.469 MEC per acre within the Lusk Reservoir MRS. Although the UXO Estimator results indicate that a statistical potential for MEC may remain at the MRS, no MEC was found and it is anticipated that no MEC source or explosive safety hazard is present.

The four 3.5-inch cannonballs (solid shot) were recovered in a grid near the Lusk Reservoir artillery range firing point. Because these cannonballs were described as solid shot, they are not considered DMM. The cannonballs were stacked on top of one another so they were likely intentionally buried during the active use of the firing point. The majority, if not all, of the remaining MD recovered in the Lusk Reservoir MRS is believed to have been transported in fill used for prior construction activities.

Concentrations of MEC and MD were observed at MRSs in proximity to the Lusk Reservoir MRS during the RI, including the Fort Clinton West MRS, the Siege Battery MRS, and the Artillery Firing Range MRS. The MEC and MD are attributed to historical firing toward targets on Crows Nest. These concentrations of MEC and MD were located close to the northern boundary of the Lusk Reservoir MRS. Based on the RI results from the adjacent MRSs, the southern boundary for the Crows Nest impact area was delineated to extend to Washington Road where it traverses the Lusk Reservoir MRS. This represents a 8.8-acre portion of the Lusk

Reservoir MRS in its northern extent where the pathways for human and ecological receptors to contact MEC are considered complete based on the RI results. Within the remaining 74.4 acres of the Lusk Reservoir MRS, the results of the RI indicate that there is no MEC source; therefore, the pathways for MEC are incomplete for all receptors.

Media sampling was performed at the Lusk Reservoir artillery range firing point where a potential MC release might have occurred without the presence of MEC. No MC was detected at the firing point that would pose risks to human or ecological receptors. The pathways for human and ecological receptors to contact MC are considered incomplete based on the RI results.

4.10.3.1 Southern 74.4-Acre Portion

The revised CSM for MEC and MC identified incomplete pathways for all receptors having access to the southern portion of the Lusk Reservoir MRS.

4.10.3.2 Northern 8.8-Acre Portion

Although only one MD item was recovered in the 8.8 acres of the Lusk Reservoir MRS within the Crows Nest impact area during the RI, the pathways for MEC to potential receptors are considered complete based on MEC and MD findings throughout adjacent West Point MRSs. Additionally, the UXO item, which was identified during construction activities at the West Point Middle School after the completion of the RI field work, is indicative of a potential source for MEC. The UXO item was identified by construction support in the Crows Nest impact area portion of the Lusk Reservoir MRS. The exact depth of the UXO is unknown; however, the item is considered to have been found in the subsurface. The MD was identified in the near surface (2 to 6 inches bgs). MEC items identified within the surrounding Crows Nest impact acre were identified on the surface; therefore, both the surface and subsurface MEC pathways are considered complete for the Lusk Reservoir MRS. The revised CSM for MEC identified complete pathways for all receptors having access to the northern portion of the Lusk Reservoir MRS.

The revised CSM for MC identified incomplete pathways for all receptors having access to the northern portion of the Lusk Reservoir MRS.

4.10.4 Munitions and Explosives of Concern Hazard Assessment

An evaluation of the explosive hazard at the Lusk Reservoir MRS was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008).

4.10.4.1 Southern 74.4-Acre Portion

No MEC was identified in the southern portion of the Lusk Reservoir MRS during either the SI or RI field activities. These results have been interpreted to indicate that no MEC source or explosive safety hazard is present at the southern portion of the MRS. As a result, the project team determined that the calculation of a MEC HA score was not warranted for the southern portion of the Lusk Reservoir MRS.

4.10.4.2 Northern 8.8-Acre Portion

Although no MEC was identified during the SI or RI, UXO was identified during construction activities in the surrounding Crows Nest impact area. Therefore, the calculation of a MEC HA score was warranted (see Section 6.6).

4.10.5 Uncertainties

The primary uncertainty for the RI is based on the statistical calculations performed using UXO Estimator. The survey coverage for the Lusk Reservoir MRS was determined by UXO Estimator so that at a 95% confidence level, a minimum MEC density of 0.5 MEC/acre was expected to be found at the survey area. Following the investigation, UXO Estimator was used to calculate the statistical upper bound density of MEC to be 0.469 MEC/acre at a 95% confidence level. The average MEC density within the MRS was calculated to be 0.153 MEC/acre and represents the statistical lower bound density of MEC that may be present. It is statistically possible that MEC may be present at the Lusk Reservoir MRS even though no confirmed discoveries have been made to date that are consistent with historical munitions use. The 90mm APC-T projectile was not identified during RI field activities, is not consistent with the historic munitions use within the MRS, and was identified within fill. The projectile, therefore, was most likely transported to the MRS from an outside source. Additional MEC may be present either as a result of misfires or undershots during artillery range use or within fill material transferred to the Lusk Reservoir

MRS from other portions of West Point. Because the DQOs were met and no MEC was found during the RI field activities, the MEC density is anticipated to be low.

4.10.6 Conclusions and Recommendations

Based on the results of the RI field activities, the following conclusions were determined for the Lusk Reservoir MRS:

- A total of 6.06 acres were investigated at the MRS during the RI, exceeding the required spatial coverage needed to achieve a high statistical confidence to determine MEC density.
- No MEC was identified during the RI field activities; however, one UXO item was reported in construction fill within the MRS.
- Based on the investigation coverage and statistical assessment, the anticipated MEC density is low and an explosive safety hazard is not anticipated to exist at the southern 74.4-acre portion of the MRS. In the northern 8.8-acre portion of the MRS, the anticipated MEC density is low, but an explosive safety hazard is anticipated to exist.
- MEC exposure pathways in the southern 74.4-acre portion of the MRS were determined to be incomplete because there is no MEC source.
- MEC exposure pathways in the northern 8.8-acre portion of the MRS were determined to be complete because of the one UXO item identified in the MRS and the MEC and MD delineated in the Crows Nest impact area.
- MC exposure pathways to potential receptors in both portions of the MRS were determined to be incomplete.

The DQOs for the Lusk Reservoir MRS have been satisfied and the nature and extent of MEC and MC have been adequately characterized. It is recommended that the northern 8.8-acre portion of the Lusk Reservoir MRS associated with the Crows Nest impact area be transferred to the Artillery Firing Range North MRS (WSTPT-001-R-02). The Artillery Firing Range North MRS consolidates the areas of the Main Post that have increased concentrations of MEC and MD associated with the Crows Nest impact area. The recommendations, which are further documented in **Table 4-15** and **Figure 4-9**, are as follows:

- Revise the Lusk Reservoir MRS to 74.4 acres.
- Transfer the 8.8-acre portion of the Lusk Reservoir MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS.

Table 4-15 Lusk Reservoir Recommendations

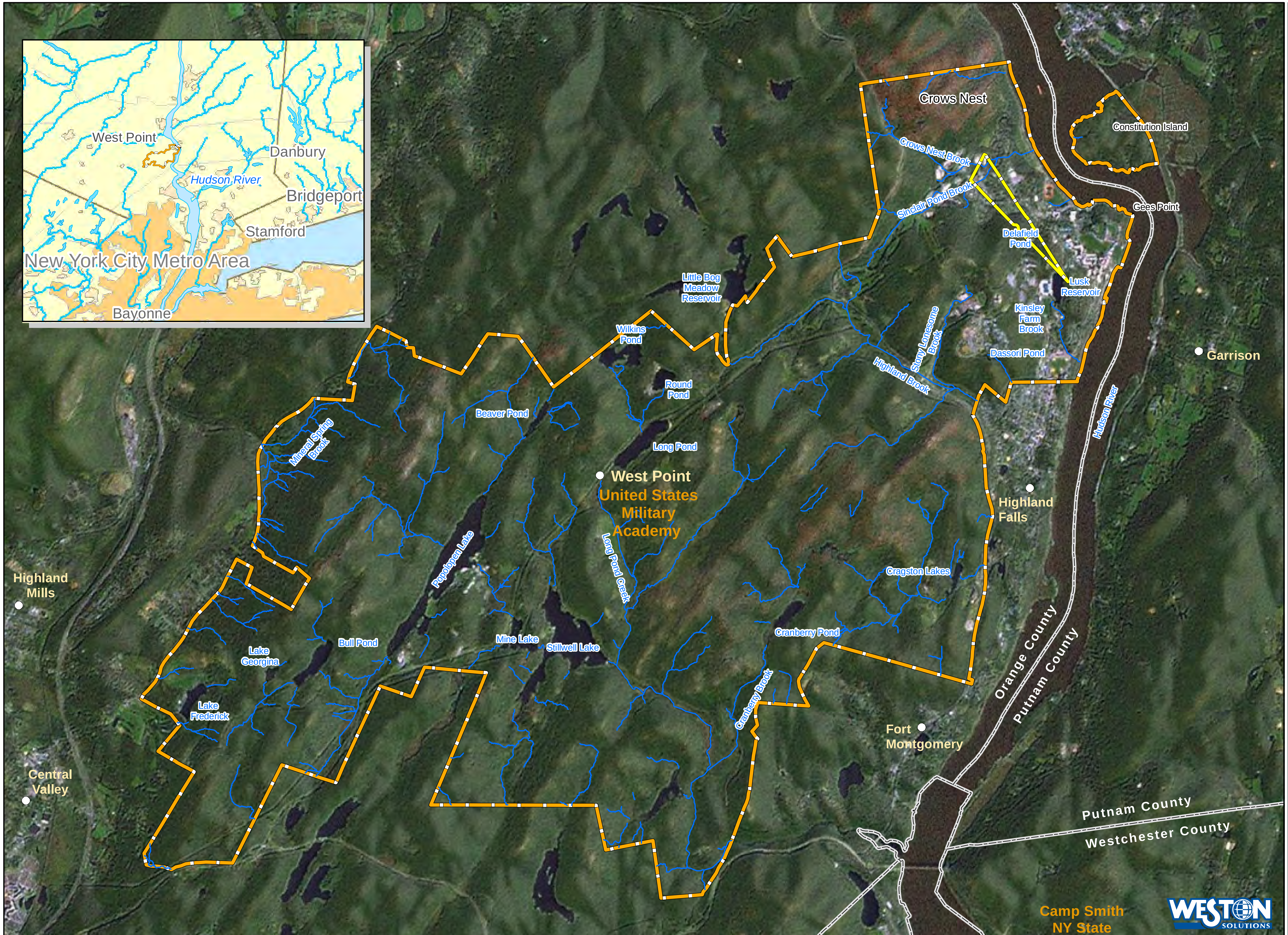
Original Configuration		Configuration Following Recommendations	
MRS Name	**Area (acres)**	**MRS Name**	**Area (acres)**
Lusk Reservoir (WSTPT-019-R-01)	83.2 acres	Lusk Reservoir (WSTPT-019-R-01)	74.4 acres
		Artillery Firing Range North (WSTPT-001-R-02)	143.3 acres (includes 8.8 acres within the original boundaries of the Lusk Reservoir MRS)*

* The Artillery Firing Range North MRS acreage is a combination of areas from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir, and the Artillery Firing Range MRS that have increased concentrations of MEC and MD associated with the Crows Nest impact area (see Section 6).

Adjusted Lusk Reservoir MRS (WSTPT-019-R-01)—Based on the conclusions, no further action under the MMRP is recommended for the adjusted Lusk Reservoir MRS (WSTPT-019-R-01). Future actions for the Lusk Reservoir MRS may include the preparation of a No Further Action Proposed Plan for public review followed by issuance of a Decision Document.

Artillery Firing Range North MRS (WSTPT-001-R-02)—The Artillery Firing Range North MRS is discussed in Section 6. It is recommended that the Artillery Firing Range North MRS be further evaluated for potential action in an FS to address hazards related to the presence of MEC from the identified Crows Nest impact area. Sections 2 through 5 present details about the Crows Nest impact area that was identified within the original boundaries of the Lusk Reservoir MRS, the Fort Clinton West MRS, the Siege Battery MRS, and the Artillery Firing Range MRS.

SECTION 4
FIGURES



Legend

Installation Boundary

Lusk Reservoir MRS - 83 Acres

Streams

Imagery Source: ESRI, World Imagery USAD FSA, NAIP 2009

N S E W

0 1 2
Miles

Figure 4-1
Regional Location Map
Showing the Location of
Lusk Reservoir MRS
U.S. Army Garrison West Point

WESTON SOLUTIONS

File: Y:\West_Point\mxd\RI\Location Map.mxd, 2/27/2014 3:33:36 PM, johna

Figure 4-2
Lusk Reservoir MRS
(WSTPT-019-R-01)
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\LR.mxd, 11/4/2014 2:14:00 PM, ricksc

Legend

Lusk Reservoir MRS - 83 Acres

Lusk Reservoir Soil Series

- Hollis soils, sloping
- Hollis soils, moderately steep
- Rock outcrop-Hollis complex, sloping
- Rock outcrop-Hollis complex, moderately steep
- Rock outcrop-Hollis complex,very steep
- Udorthents, smoothed

Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 375 750 Feet

Figure 4-3
Lusk Reservoir MRS
(WSTPT-019-R-01)
Soil Series
U.S. Army Garrison West Point

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Legend

Lusk Reservoir MRS - 83 Acres

MC Sampling Location

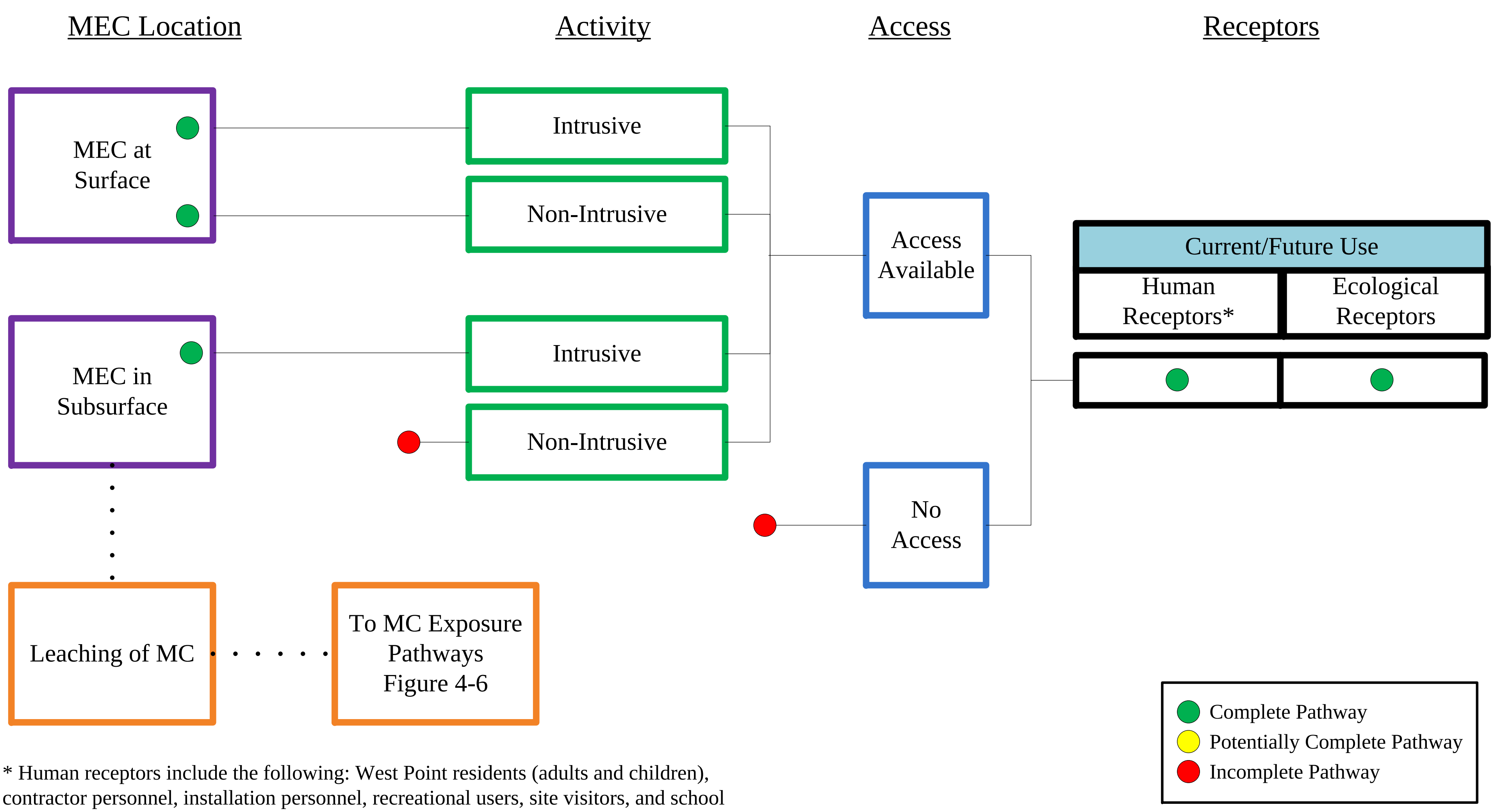
Visual Survey

Imagery Source: ESRI, Bing Mapping Service. 2013

0 375 750 Feet

Figure 4-4
Lusk Reservoir MRS
(WSTPT-019-R-01)
SI Results
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\LR_SI_Update.mxd, 7/15/2013 1:36:44 PM, ricksc

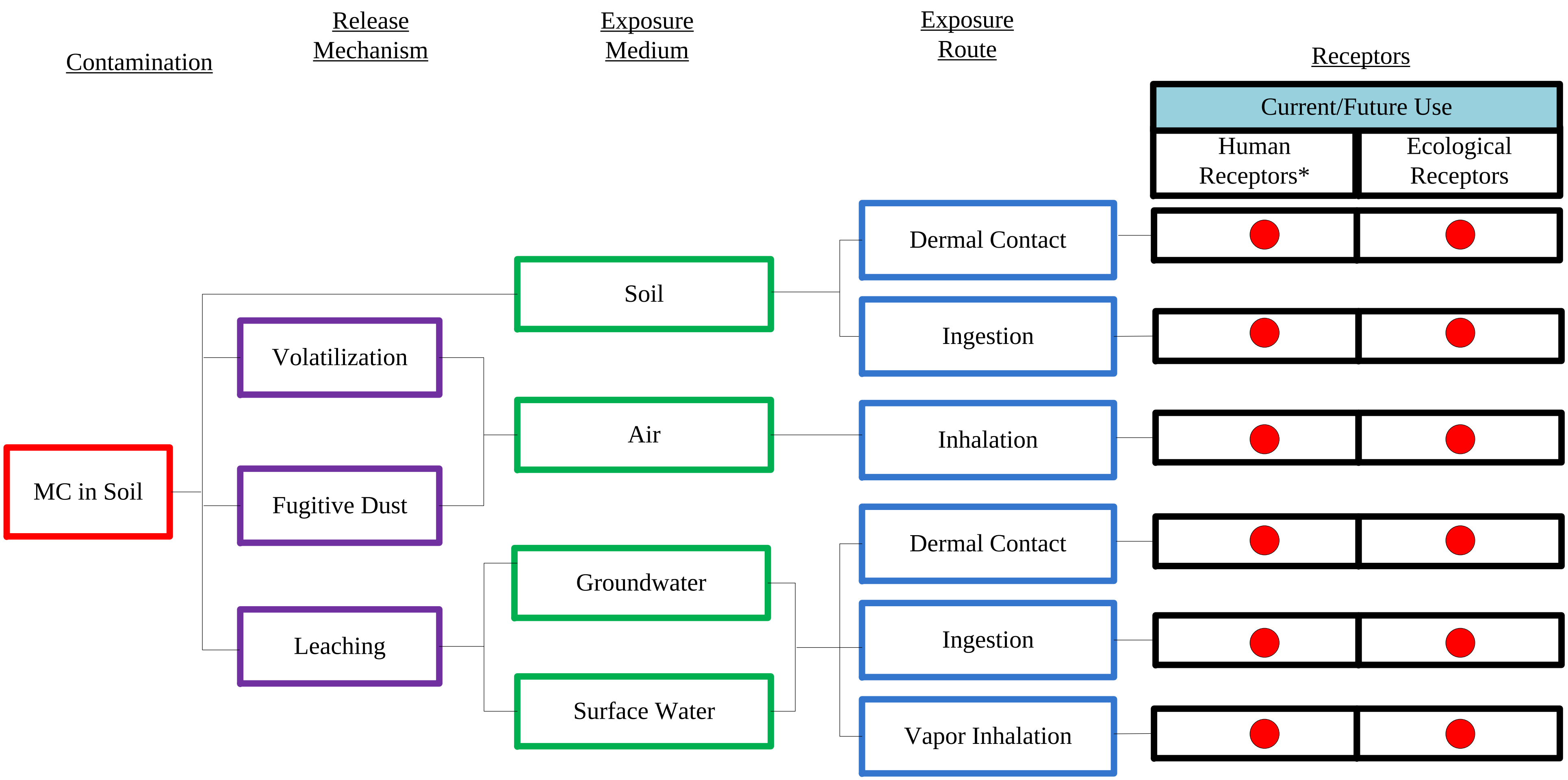


* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

Source: TLI Solutions, Inc., 2007.

Figure 4-5
SI Exposure Pathways for
Receptors to MEC, Lusk Reservoir MRS

Fig 4-5 and Fig 4-6_Lusk_Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

Source: TLI Solutions, Inc., 2007.

Complete Pathway
Potentially Complete Pathway
Incomplete Pathway

Figure 4-6
SI Exposure Pathways for Receptors to MC, Lusk Reservoir MRS

Fig 4-5 and Fig 4-6_Lusk_Exposure Pathways for MEC and MC.vsd

Legend

Lusk Reservoir MRS - 83 Acres

DGM Survey Area

Sampling Unit

Mag and Dig Transects

Imagery Source: ESRI, Bing Mapping Service. 2013

0 550

Feet

Figure 4-7
Lusk Reservoir MRS
(WSTPT-019-R-01)
Grid and Transect Locations
U.S. Army Garrison West Point

Path: Y:\West_Point\mxd\RI\LR_Grid_Transect_locs.mxd Author: ricksc 7/15/2013 1:49:57 PM

WESTON SOLUTIONS

Legend

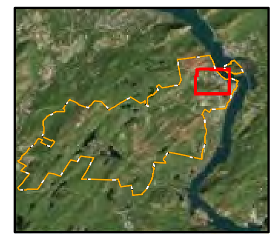
Lusk Reservoir MRS - 83 Acres

DGM Survey Area

Mag and Dig Transects

Found During Construction Support

90mm APC-T Projectile



Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 375 750 Feet

Figure 4-8
Lusk Reservoir MRS
(WSTPT-019-R-01)
Dig Results
U.S. Army Garrison West Point

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WESTON SOLUTIONS

Legend

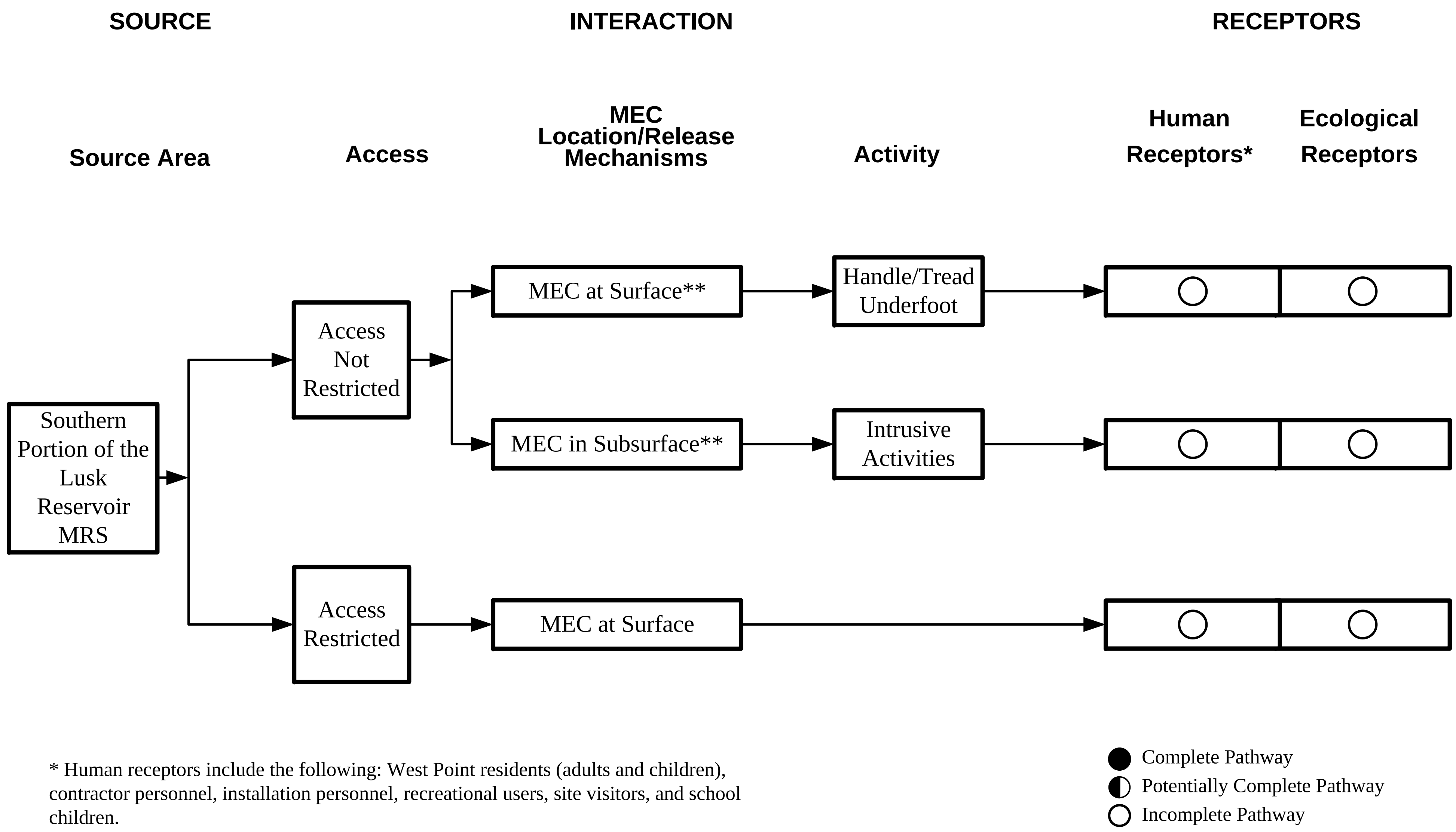
- Lusk Reservoir MRS (WSTPT-010-R-01) - 74.4 Acres
- Portion of Lusk Reservoir (8.8 acres) Transferred to Artillery Firing Range North MRS (WSTPT-001-R-02)
- Crows Nest Impact Area

Imagery Source: ESRI, Bing Mapping Service. 2011

0 375 750 Feet

Figure 4-9
Lusk Reservoir MRS
Revised Boundaries
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\LR_Revised_MRS.mxd, 11/4/2014 2:41:27 PM, ricksc

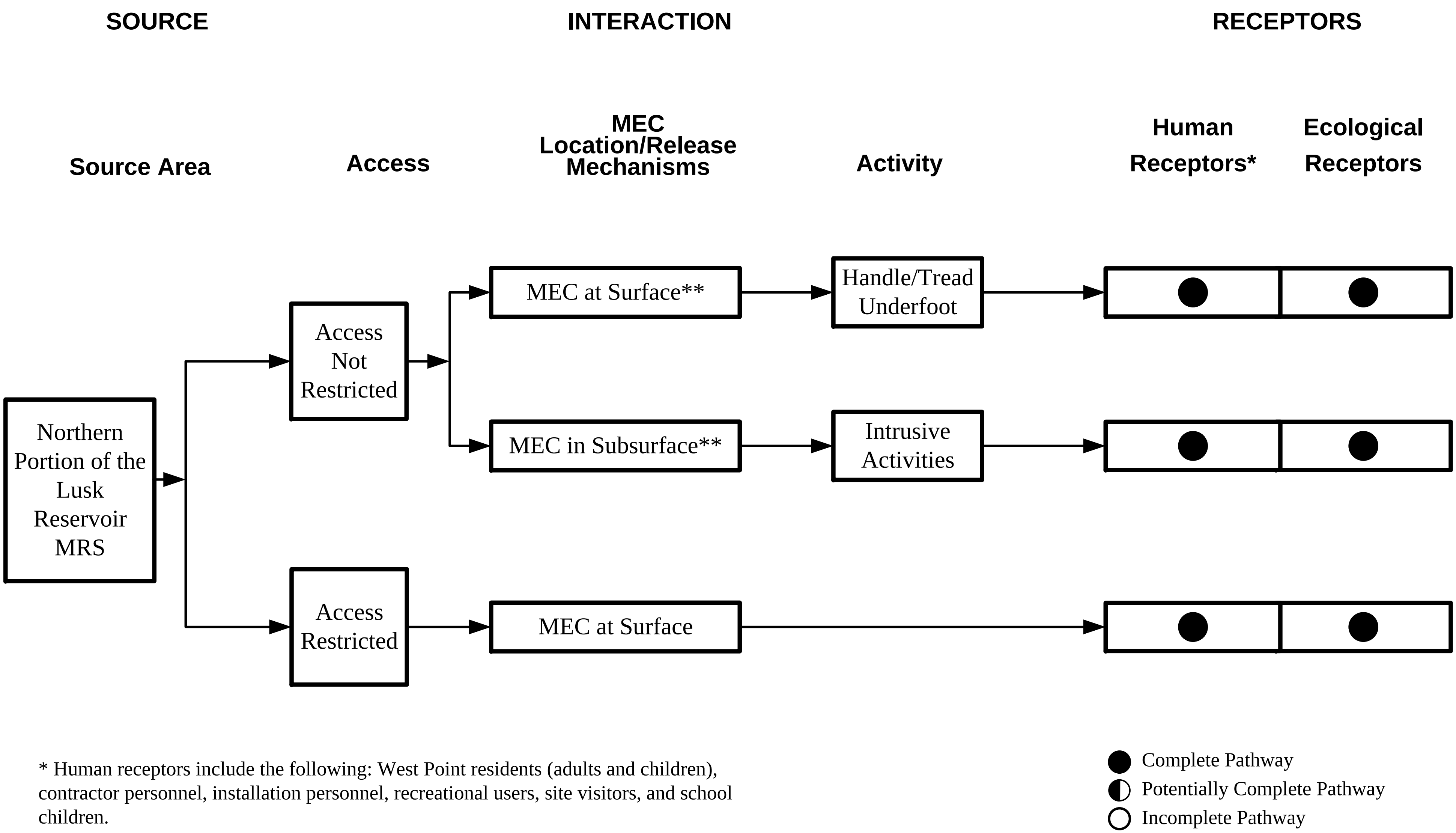


* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

** No MEC was recovered during the RI; MD that was recovered was found between 2 and 6 inches bgs.

Figure 4-10
RI Exposure Pathways for Receptors to MEC in the Southern 74.4-Acre Portion of the Lusk Reservoir MRS

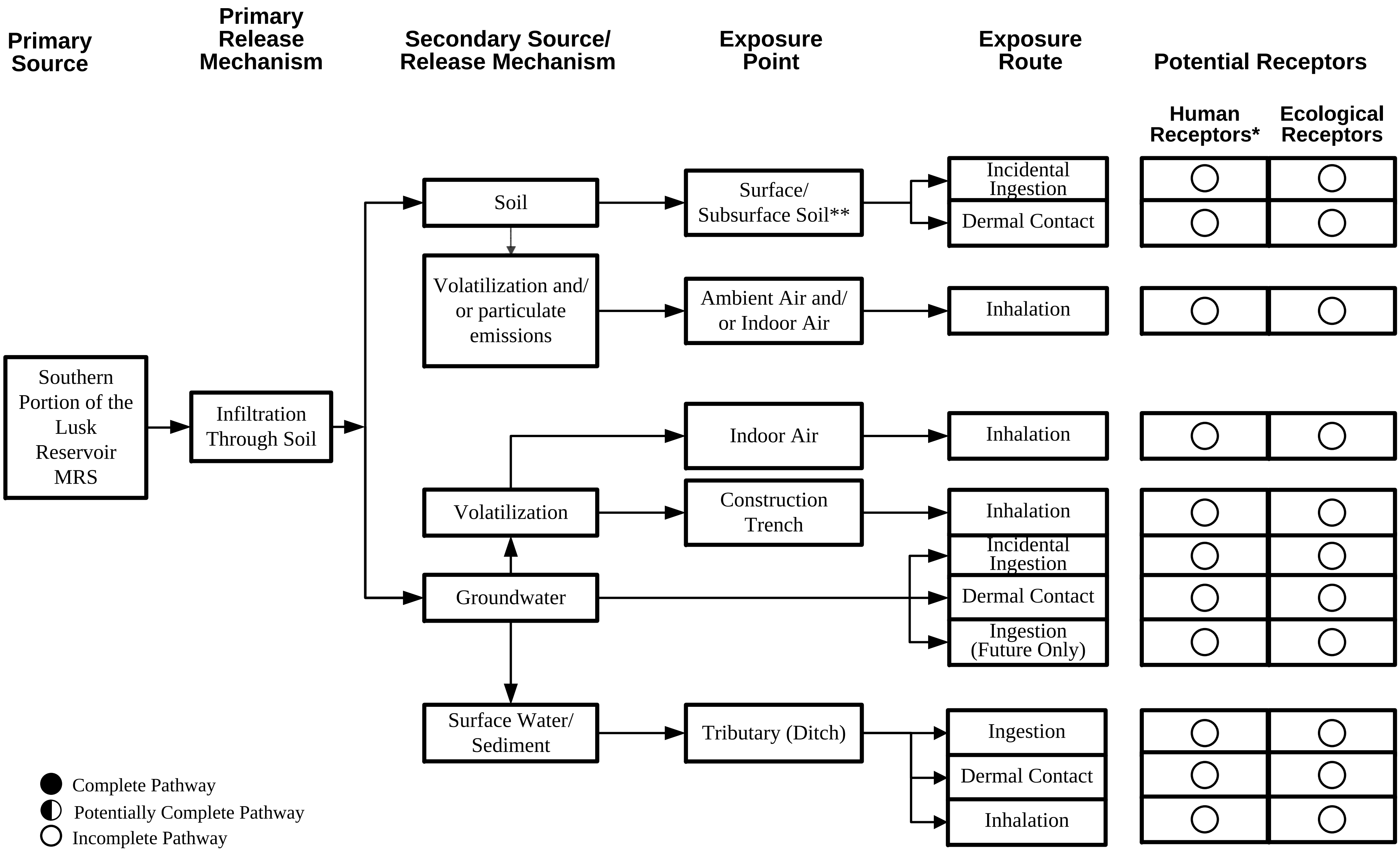
Fig 4-10_4-11_4-12_4-13_Lusk_Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

** No MEC was recovered during the RI; MD recovered in subsurface at 3 inches bgs. UXO recovered in the adjacent Fort Clinton West MRS was found between 3 and 8 inches bgs.

Figure 4-11
RI Exposure Pathways for Receptors to MEC in the
Northern 8.8-Acre Portion (Crows Nest Impact Area) of the Lusk Reservoir MRS

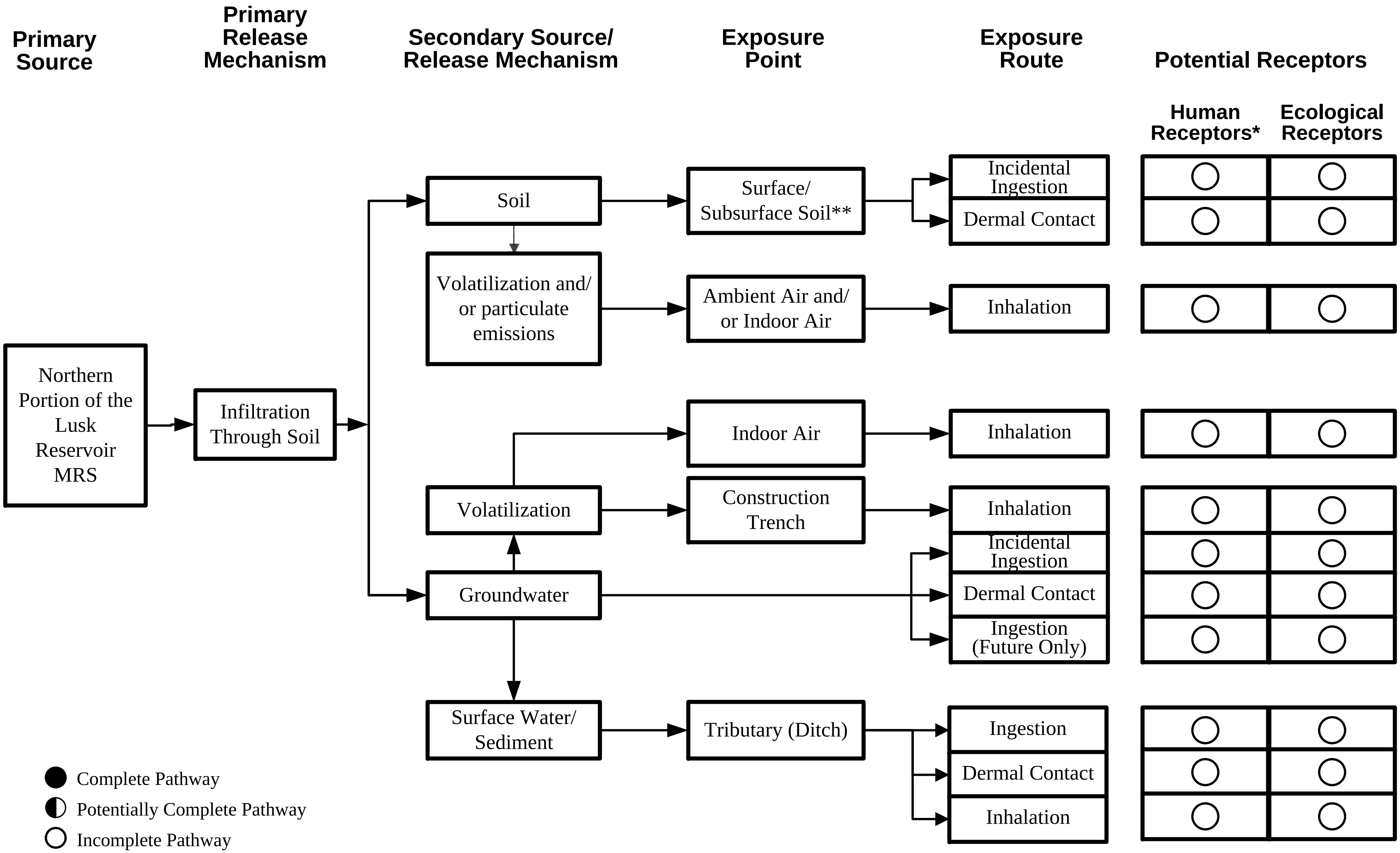


* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

** No MEC was recovered during the RI; MD that was recovered was found between 2 and 6 inches bgs.

Figure 4-12
RI Exposure Pathways for Receptors to MC in the Southern 74.4-Acre Portion of the Lusk Reservoir MRS

Fig 4-10_4-11_4-12_4-13_Lusk_Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), contractor personnel, installation personnel, recreational users, site visitors, and school children.

** No MEC was recovered during the RI; MD recovered in subsurface at 3 inches bgs. UXO recovered in adjacent Fort Clinton West MRS was found between 3 and 8 inches bgs.

Figure 4-13
RI Exposure Pathways for Receptors to MC in the Northern 8.8-Acre Portion (Crows Nest Impact Area) of the Lusk Reservoir MRS

Fig 4-10_4-11_4-12_4-13_Lusk_Exposure Pathways for MEC and MC.vsd

5. ARTILLERY FIRING RANGE MRS

5.1 INTRODUCTION

Section 5 presents the activities, results, and conclusions from the Military Munitions Response Program (MMRP) remedial investigation (RI) performed to characterize the Artillery Firing Range munitions response site (MRS) tracked under WSTPT-001-R-01 in the Army Environmental Database – Restoration Module.

5.1.1 Site Description

The Artillery Firing Range MRS (WSTPT-001-R-01) encompasses 172.4 acres in the northern portion of the West Point installation, the majority of which is located between Storm King Highway (State Highway 218) and the operational range area (**Figure 5-1**). Three overlapping former artillery ranges were combined into the Artillery Firing Range MRS, including Sacred Heart Cemetery Range, Silver Depository Range, and Adolphs Pond Range. The MRS includes two noncontiguous areas of land located to the south and west of the main campus, which are separated by the operational range area (see **Figure 5-2**). The firing point for the Silver Depository Range was located in the middle of the larger of the two Artillery Firing Range MRS areas. The firing point for the Sacred Heart Cemetery Range was located in the 7-acre, noncontiguous area of the Artillery Firing Range MRS, south of where the operational range area bisects the MRS. The firing point for the Adolphs Pond Range was located in the current operational range area.

Portions of the three range fans extend beyond the Artillery Firing Range MRS northern boundary into the Crows Nest and/or to the northeast into the Fort Clinton West MRS and Siege Battery MRS. The Artillery Firing Range MRS also includes portions of range fans extending from both the Lusk Reservoir and Redoubt No. 2 MRSs. The Artillery Firing Range MRS is located to the east of State Highway 218, bordered on the east and west by operational range areas, and to the north by the Fort Clinton West MRS. The southern boundary of the Artillery Firing Range MRS crosses the West Point Golf Course.

The Artillery Firing Range MRS includes portions of the West Point Golf Course and the Victor Constant Ski Slope. Approximately 51 structures are located in the Artillery Firing Range MRS, including the U.S. Treasury Depository, the U.S. Military Academy Preparatory School

(USMAPS), the West Point Elementary School, Keller Army Community Hospital, laundry plant, residential housing, Sacred Heart Cemetery, maintenance shops, water tank, salt dome, and structures associated with the Victor Constant Ski Slope (**Figure 5-2**).

5.1.1.1 Climate

The climate of the region that includes West Point is characterized as a humid, continental climate. Summers are warm and have periods of high humidity. The semi-permanent Bermuda High brings south to southwest warm and humid air to the area. July is the hottest month, with a mean temperature of 86 degrees Fahrenheit (ºF); and the coldest month of the year is January, which has a mean temperature of 27 ºF. Winters are cold with extended periods of snow cover and are influenced by the cold Hudson Bay air masses. Most winters are characterized by one or more warm periods when soils nearly or completely thaw (Tetra Tech, Inc., 2011).

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 (Tetra Tech, Inc., 2011).

Thunderstorms occur approximately 20 times per year. Tornadoes occur at a frequency of 3 to 4 times a 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 the least amount (approximately 3.5 inches each month) occurring in January and February, and the most precipitation occurring in May (approximately 4.9 inches) (Tetra Tech, Inc., 2011).

5.1.1.2 Geology

West Point lies in the Hudson Highlands, a low, rugged mountain range, that forms a zone of folded and faulted metamorphic and igneous rocks subjected to extensive weathering and erosion. Precambrian-age granite, diorite, gneiss, and schist compose the majority of the crystalline bedrock underlying West Point. Granite, the most prevalent rock type in the bedrock, is typically medium-grained and composed of quartz, feldspar, and mica. Granite and pegmatite are igneous rocks that occur as dikes and sills within the gneiss. Igneous rocks on the West Point installation consist of plagioclase feldspar, hornblende, pyroxene, and biotite mica and quartz (Tetra Tech, Inc., 2011).

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 (Tetra Tech, Inc., 2011).

Faults mapped at the surface near and within the habitation area at West Point include the Long Pond, the Crown Ridge, and the Highland Brook faults. 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 (NY 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 between the Long Pond and Crown Ridge faults (Tetra Tech, Inc., 2011).

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 features are 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 (Tetra Tech, Inc., 2011).

Site-specific geologic investigations were not conducted for the Artillery Firing Range MRS, and information regarding site-specific geology is not available for the MRS**.** Regional geologic maps (Cadwell, 1989; Fisher et al., 1970) indicate that the bedrock geology of the Artillery Firing Range MRS consists of the following:

- Amphibolite, pyroxenic amphibolite, hornblende gneiss, commonly biotitic, garnetiferous; subordinate calcsilicate rock.
- Leucogranitic gneiss.
- Quartz plagioclase gneiss; may contain pyroxenes, hornblende, biotite; locally interlayered with amphibolite; subordinate biotite mesoperthite gneiss.
- Rusty and gray biotite-quartz-feldspar gneisses; rusty facies containing variable amounts of garnet, sillimanite, cordierite, graphite, sulfides; minor marble and calcsilicate rock.

5.1.1.3 Topography

The topography of West Point is described as having moderately steep hills and numerous escarpments. Slopes from 10 to 60% are common on the West Point 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 (Tetra Tech, Inc., 2011). The elevation ranges between 240 feet (73 meters) and 770 feet (235 meters) above mean sea level (amsl). The golf course and the developed areas of the Artillery Firing Range MRS have relatively level terrain, but the land is steeply sloped on the southeast side approaching the ski slope and the western edge behind the Keller Army Community Hospital.

5.1.1.4 Soils

Eight soil types exist within the Artillery Firing Range MRS based on the soils mapped within West Point (Tetra Tech Inc., 2011). Sloping Hollis soils are dominant within the MRS, followed by moderately steep Rock outcrop-Hollis soils and Charlton fine sandy loam. The remaining soils include extremely stony and sloping Charlton-Paxton complex, Erie gravelly silt loam, sloping and moderately steep Rock outcrop-Hollis complex, and smoothed Udorthents. The Hollis, Charlton, Charlton-Paxton, and Udorthents soils are well drained to somewhat excessively drained, whereas the Erie soil is somewhat poorly drained. **Figure 5-3** presents the locations of the specific soil types within the Artillery Firing Range MRS.

5.1.1.5 Hydrology

5.1.1.5.1 Surface Water

Sinclair Pond Brook and Crows Nest Brook are located in the Artillery Firing Range MRS and drain towards the Hudson River. The following surface water bodies are located within a 3-mile radius of the MRS: the Hudson River, Delafield Pond, Lusk Reservoir, Kinsley Farm Brook, Stony Lonesome Brook, Highland Brook, Dassori Pond, Round Pond, Wilkins Pond, Cragston Lakes, Long Pond, Popolopen Lake, and Stillwell Lake (see **Figure 5-1**).

5.1.1.5.2 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 West Point installation, but the deposits are thin and generally have fairly small well yields that average about 40 gallons per minute (gpm). 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 (Tetra Tech, Inc., 2011; TLI Solutions, Inc. [TLI], 2007). Based on the geology, an unconsolidated aquifer does not exist within the Artillery Firing Range MRS. Site-specific groundwater investigations were not conducted for the Artillery Firing Range MRS.

5.1.1.6 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 in that five physiographic provinces—the Appalachian Plateaus, Folded Appalachians (Valley and Ridge), New England, Piedmont, and Coastal Plain—converge within a 35-mile radius of the West Point installation. West Point is located in the New England Province in an area known as the Hudson Highlands (Tetra Tech, Inc., 2011).

5.1.1.6.1 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

West Point installation. None of the 12 specially managed sites is within the Artillery Firing Range MRS (Tetra Tech, Inc., 2011).

5.1.1.6.2 Wetlands

Approximately 1,010 acres of wetlands are located throughout West Point in association with streams, ponds, depressions, and seeps (Tetra Tech, Inc., 2011). No wetlands are located in the Artillery Firing Range MRS.

5.1.1.6.3 Flora

The Artillery Firing Range MRS consists primarily of disturbed areas. Approximately half of the MRS is developed and includes roads, parking lots, various buildings, and some residential housing. Vegetation within this half of the MRS is primarily the mowed lawn and trees that are characteristic of developed, landscaped areas. Pockets of forested areas are located throughout the Artillery Firing Range MRS. Portions of the MRS that include sections of the golf course and the ski slopes contain spans of open, grassy space bordered by the forested areas.

5.1.1.6.4 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 species of fish and invertebrate species (Tetra Tech, Inc., 2011). It is unlikely that the majority of these species are present in the developed areas of the Artillery Firing Range MRS. The forested areas may provide habitat for some of these species.

5.1.1.6.5 Ecological Receptors

Potential ecological receptors were provided by West Point and are presented in the overall conceptual site model (CSM) for West Point. The following list of ecological receptors was modified from the list of receptors in the overall CSM for West Point to include only those species that have the potential to exist within the Artillery Firing Range MRS:

- Mammals: Small-footed bat and Indiana bat.
- Birds: Cooper’s hawk, Northern goshawk, sharp-shinned hawk, golden eagle, American bittern, red-shouldered hawk, whip-poor-will, common nighthawk, cerulean warbler, Peregrine falcon, common loon, bald eagle, yellow-breasted chat, least bittern, red-headed woodpecker, osprey, pied-billed grebe, vesper sparrow, and golden-winged warbler.

- Reptiles: Eastern wormsnake, spotted turtle, wood turtle, timber rattlesnake, Eastern hognose, and Eastern box turtle.

- Amphibians: Jefferson salamander, blue-spotted salamander, and marbled salamander.

- Insects, Dragonflies, and Damselflies: Lateral bluet, Needham's skimmer.

- S1* Plants: Virginia snakeroot, glomerate sedge, stripe-fruited sedge, and Carolina cranesbill.

- S2* Plants: Long's bittercress, midland sedge, slender crabgrass, violet wood sorrel, Carey's smartweed, and small-flowered crowfoot.

- S2S3* Plants: Cluster sedge, purple milkweed, Emmon's sedge, Bicknell's sedge, Bush's sedge, false hop sedge, weak stellate sedge, yellow harlequin, racemed pinweed, violet bush clover, slender knotweed, and gemmed bladderwort.

  *Notes:

  S1 = Critically imperiled in New York State because of extreme rarity (5 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.

An MRS-specific inventory of floral and faunal species was not conducted in the Artillery Firing Range MRS. The *Integrated Natural Resources Management Plan for the United States Army Garrison – West Point* (Tetra Tech, Inc., 2011) contains an extensive list of species that have been documented at West Point.

5.1.1.7 Sensitive Environmental Resources within the MRS

Weston Solutions, Inc. (WESTON®) submitted a request for review by the New York Natural Heritage Program (NYNHP) to determine whether there are records of any known rare, threatened, and endangered species or species of special concern located within or near the West Point MRSs. In response, the 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 the 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*]). The three fish species are typically salt-water species residing in brackish water, which does not exist in either water body (Sinclair Pond Brook or Crows Nest Pond Brook) within the Artillery Firing Range MRS. The remaining species listed above have the potential to occur within the Artillery Firing Range MRS. However, because a large component of the Artillery Firing Range MRS is developed, it is unlikely that these species would rely on the developed area for habitat. The open grassy areas and forested parts of the MRS may provide potential habitat for these species; however, the NYNHP did not identify any federally threatened or endangered plant species within any of the West Point MRSs.

5.1.1.8 Cultural and Archaeological Resources

Because West Point is one of the older training grounds in the United States that is still intact, it contains numerous cultural, archaeological, and historical sites. Sacred Heart Cemetery is located within the southern parcel of the Artillery Firing Range MRS. Additionally, historical rock walls cross the southern parcel (TLI, 2007; WESTON, 2011a).

5.1.1.9 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 four land use zones based on the functional categories that reflect the West Point missions (Tetra Tech, Inc., 2011):

- Cadet Use: Academic, intramural athletic, billeting, and parading.
- Cadet Support: Intercollegiate athletic fields and some cadet support facilities.
- Post Support: Housing, commercial, and service support to staff and faculty, non-West Point military personnel, and military retirees.
- Recreational, Industrial, Field Training: Building and storage area support for industrial operation, field training areas, recreation areas, and open space.

The Artillery Firing Range MRS includes each of the four land use zones. The MRS is used for housing; academics, including the USMAPS and the West Point Elementary School; and recreational uses, including the West Point Golf Course, the Victor Constant Ski Slope and associated structures, and the USMAPS athletic field house. The MRS also includes Keller Army

Community Hospital, the U.S. Treasury Depository, the laundry plant, maintenance shops, water tank, and the salt dome, and four closed solid waste landfills (the Motor Pool, Ski Lot, Motor Pool East, and the Organic Compost Landfill). The small undeveloped areas located throughout the Artillery Firing Range MRS may be used recreationally for activities such as hiking, bird watching, and cross-country skiing. Hunting and trapping are not permitted within the MRS or in the vicinity (Tetra Tech, Inc., 2011). There are no plans to change the current land use.

5.1.2 Previous Investigations

5.1.2.1 Historical Information

The Artillery Firing Range MRS includes three former artillery ranges: Sacred Heart Cemetery Range, Silver Depository Range, and Adolphs Pond Range (**Figure 5-2**). According to the Range Inventory, the ranges were used for practice firing of 75 millimeter (mm) rounds from 1909 until the late 1930s. They were also used for 2.95-inch Vickers-Maxim Mountain Howitzers. According to a document created by the West Point Historian that summarizes artillery activities, artillery firing occurred as early as 1906. The firing points for the range were located to the southwest of the main campus. Although no specific target locations were identified, general references were made to firing into the Crows Nest area (TLI, 2006).

The Storm King Highway (now referred to as the Old Storm King Highway or Route 218) was constructed along the northern boundary of West Point between 1919 and 1922. Although the highway made the Crows Nest area unsuitable for field artillery practice because firing occurred over the highway, artillery practice in the area continued into the early 1930s. When firing occurred, traffic on the highway was suspended. To alleviate the problem, West Point acquired approximately 15,000 acres of additional property to the south and west, and target practice toward the Crows Nest was discontinued by the mid-1930s. The “New Storm King Highway” was built in 1940 after artillery practice activities ceased; therefore, interference with the highway, currently referred to as Highway 9W, was not an issue (TLI, 2006).

Several unexploded ordnance (UXO) investigations and removals have been conducted in relation to the Storm King site, located due north of West Point within what is currently Storm King State Park. In addition to the West Point Foundry (located upstream of West Point along the Hudson River in Cold Spring, New York, and also referred to as the Cold Spring Foundry), the UXO identified at the Storm King site could have been fired from several locations within West Point at targets on Crows Nest mountain, resulting in overshots that were deposited within the Storm King area (AMI, 2006). Historical documentation indicates that former munitions training at West Point included firing in the direction of Crows Nest from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and the Redoubt No. 2 MRS (TLI, 2006 and 2007). Therefore, UXO similar to the type of UXO identified at the Storm King site and the Crows Nest area may also be present in these MRSs (see Section 6.1.2 for details regarding historical investigations related to the Crows Nest).

5.1.2.2 Geophysical Survey at West Point Elementary School

In September 2000, a digital geophysical mapping (DGM) project was conducted during the construction of a gymnasium at the West Point Elementary School, which is located within the Artillery Firing Range MRS in its northeastern most extent where it abuts the Lusk Reservoir MRS and the Fort Clinton West MRS. As a follow-up to the geophysical study, an anomaly investigation and removal was conducted in 2001. Three ordnance or ordnance-related items were identified – a 6.5-inch projectile, rifled, and two fragments from an 8-inch Parrott round.

According to the report compiled following the study, "scouring and deformation on the rear of the 6½-inch projectile indicate it might have deflected at a shallow angle." In addition, the report stated the two 8-inch Parrott fragments appeared to fit together even though they were recovered over 75 feet apart. These two fragments fitting together may indicate that the projectile exploded in the area (TLI, 2006). Although the location from which these items were fired could not be determined, there is historical documentation of Parrott rifle use at the Siege Battery (see Section 3.1.2.1). Firing from the Siege Battery was directed toward targets located on Crows Nest mountain to the north of where the Artillery Firing Range MRS boundary terminates. Parrott rounds and Parrott fragments may also be indicative of former testing activities that involved firing from the nearby West Point Foundry (east side of the Hudson River) towards targets on Crows Nest mountain. The foundry was the primary supplier of heavy cannon, including the Parrott Gun to Union land and naval forces during the Civil War (Smithsonian, 2013).

5.1.2.3 Site Inspection Report and Results

The SI field activities at the Artillery Firing Range MRS, which were conducted in spring 2006, included visual surveys along approximately 25.2 linear miles, 3.7 linear miles (1.5 acres) of geophysical mapping, and the collection of three sediment samples and six surface soil samples for munitions constituents (MC) analysis (TLI, 2007).

During the visual survey, each team member walked individual transects, nominally spaced at 10- to 50-foot intervals (based on terrain, ground cover, and vegetation) to identify and record all munitions and explosives of concern (MEC), munitions debris (MD), and munitions-related materials. Hand-held Global Positioning System (GPS) units were used to track the visual survey transects, and a waypoint was logged when items were observed. GPS units were accurate to within 15 to 40 feet, depending on satellite availability and the tree canopy. In addition, Schonstedt magnetic locators and hand-held electromagnetic metal detectors were used during the visual survey to aid in the identification of metallic items at ground surface. The use of the hand-held electromagnetic metal detectors was particularly important in the areas of tall grass and thick leaf coverage on the ground. At times it was necessary to extend the visual surveys beyond the boundaries of the MRS. Work outside the MRS boundaries was required for several reasons, including attempts to accurately locate firing points, the need to circumvent unsafe terrain or dense vegetation, and the need to access sites from outside locations (TLI, 2007). The visual survey coverage and sample locations are presented in **Figure 5-4**.

Approximately 25.2 linear miles of visual surveys were conducted using a meandering path approach within the Artillery Firing Range MRS (**Figure 5-4**). The surveyors targeted the three firing points and the areas that appeared to be undeveloped. Items, such as MD or evidence of military activity identified during the visual survey, were marked as waypoints on the GPS units.

No MEC was found during the SI; however, as discussed in the following paragraphs, several MD items were located. The southernmost parcel (approximately 7 acres) is predominantly comprised of the Sacred Heart Cemetery. An expended slap flare was identified in the area of the cemetery. In addition, the area contains several cultural sites, including a stone foundation, numerous stone walls, and graves (TLI, 2007).

Two MD items were identified just beyond the boundary of the larger of the two parcels investigated as the Artillery Firing Range MRS, where the operational range area lies to the east and the golf course to the west. Both items were expended signal flares. The MRS boundary was modified to encompass the area where the MD was identified. As a result, the acreage associated with the Artillery Firing Range MRS was increased by 2.6 acres, from approximately 170.9 to 172.4 acres (TLI, 2007).

The larger parcel of the Artillery Firing Range (165.4 acres) encompasses the northern end of the golf course, a portion of the Victor Constant Ski Slope, the U.S. Treasury Depository, the Keller Army Community Hospital, and part of the West Point Elementary School. Two pieces of fragment from the Civil War era were found during the SI in the larger parcel of the Artillery Firing Range near where it intersects the range fan from Fort Clinton, and south of the Crows Nest within West Point. One piece was over 12 inches long and 2.5 inches thick. The piece weighed approximately 25 pounds. The other piece was smaller and thinner. No other evidence of military munitions was found in the remainder of the area northeast of the ski slope (TLI, 2007).

Several pieces of MD were found during the SI in the area southwest of the ski slopes, including four signal flares of various sizes, a wax cap for a signal flare, a fuze for a grenade, and several small arms blanks. An obstacle course that included barbed wire was located in the woods to the east of the golf course and a series of wooden barriers with numbers painted on them had been erected between trees. These are indications that the area was used for training exercises and possibly was still being used during the time the SI was conducted (TLI, 2007). The obstacle course is located outside the current Artillery Firing Range MRS boundary in the adjacent operational range.

The SI geophysical survey covered approximately 3.7 linear miles (1.5 acres) of transects in the Artillery Firing Range MRS. The survey was completed in areas to the east of the golf course and to the east of the U.S. Treasury Depository. These areas were surveyed because a geophysical survey conducted in April 2001 had identified anomalies within the Artillery Firing Range MRS, but farther to the north. The goal of the geophysical survey was to determine whether anomalies existed in additional areas of the MRS (TLI, 2007).

There were 359 subsurface anomalies of interest (i.e., anomalies with a geophysical response similar to MEC items found at other MEC sites) identified along the geophysical survey transects. A precise number of anomalies or their specific locations could not be determined because of the "noise" in the data created by traversing the rough terrain. The number of anomalies selected was a conservative one, and additional anomalies may still be present in the "noise." Based on the estimated length of the survey transect and the number of anomalies identified in the data, the portion of the Artillery Firing Range MRS mapped had an anomaly density of 240 anomalies per acre (TLI, 2007).

Six surface soil samples and three sediment samples were collected from the areas of interest during the SI. One sample was inadvertently collected within the boundary of the operational range area located to the east of the Artillery Firing Range MRS boundary. On September 7, 2006, Sample USMA-AFR-SD003 was collected from a small rill that drained the hillside as a replacement sample for USMA-AFR-SO003. The rill ran into a small intermittent streambed that flows in a northwest direction, before turning west towards the West Point Golf Course.

The sediment and surface soil samples were analyzed for Target Compound List (TCL) explosives by Method 8330 and a subset of the Target Analyte List (TAL) metals by Methods SW846 6010B and 7471A. Metals were selected for analysis based on the metals known to be associated with the munitions historically used at West Point. The sediment and surface soil samples were analyzed for antimony, copper, iron, lead, mercury, potassium, and zinc. The analytical results for seven TAL metals and TCL explosives were compared, for evaluation purposes only, against U.S. Environmental Protection Agency (EPA) Region 9 preliminary remediation goals (PRGs) for residential soils (current screening levels at that time), where available.

Explosives were not detected in the samples other than the trace amounts of explosives noted below. All of these concentrations were below the corresponding EPA Region 9 PRGs and laboratory reporting limit required by Method SW 8330 (TLI, 2007).

- 1,3,5-Trinitrobenzene was detected in four samples: USMA-AFR-SO004 at 0.031 milligrams per kilogram (mg/kg), USMA-AFR-SO005 at 0.031 mg/kg, USMA-AFR-SO006 at 0.027 mg/kg, and USMA-AFR-SD002 at 0.038 mg/kg. All of these concentrations were less than the EPA Region 9 PRG of 1,800 mg/kg. These samples were collected from the western side of Sacred Heart Cemetery, the northern portion of the Artillery Firing Range MRS near the intersection with the Fort Clinton West MRS, to the east of the golf course, and in a drainage located to the west of the Victor Constant Ski Slope.

- 4-Amino-2,6-dinitrotoluene was detected in two samples: USMA-AFR-SO003 at 0.32 mg/kg and USMA-AFR-SO004 at 0.14 mg/kg. There was no established EPA Region 9 PRG for 4-amino-2,6-dinitrotoluene at the time; however, the detected levels were less than the EPA Region 9 PRG for aminodinitrotoluene (12 mg/kg), which is used as the standard for comparison. These samples were collected near the obstacle course within the operational range area and northeast of the Silver Depository firing point in the area where expended small arms rounds were located.

- 2-Amino-4,6-dinitrotoluene was detected in USMA-AFR-SD003 at 0.11 mg/kg. There was no established EPA Region 9 PRG for 2-amino-4,6-dinitrotoluene at the time. The detected levels were less than the EPA Region 9 PRG for aminodinitrotoluene (12 mg/kg), which is used as the standard for comparison. The sample was collected to the east of the golf course.

- Methyl-2,4,6-trinitrophenylnitramine was detected in USMA-AFR-SD003 at a concentration of 0.006 mg/kg, which is less than the PRG of 611 mg/kg. The sample was collected to the east of the golf course.

- Pentaerythritol tetranitrate (PETN) was detected in USMA-AFR-SD003 at a concentration of 0.19 mg/kg. There was no established EPA Region 9 PRG at the time. The sample was collected to the east of the golf course.

Copper, iron, lead, mercury, potassium, and zinc were detected in the samples collected within the Artillery Firing Range MRS. A trace amount of antimony was also detected in one sample. All concentrations were below the applicable screening criteria with the exception of iron in one sample (TLI, 2007):

- Iron was detected in sample USMA-AFR-SO001 at 24,200 mg/kg, which exceeds the EPA Region 9 PRG of 23,000 mg/kg. Sample USMA-AFR-SO001 was collected from the southern portion of the Artillery Firing Range near Sacred Heart Cemetery. The sample location is approximately 750 feet north of the estimated firing point for one of the historical artillery firing ranges. The sample was collected at a location where munitions-related materials were identified.

The elevated levels of iron are believed to be naturally occurring in the soils at the Artillery Firing Range MRS. Based on the geology of the area that includes the presence of rocks with a highly oxidized iron content, it is assumed that the level of iron in the soil is the result of local geologic conditions. Background data regarding the naturally occurring level of iron in the soil were not available from West Point (TLI, 2007).

In addition to the analysis for explosives by Method 8330 (High Performance Liquid Chromatography/Ultraviolet (HPLC/UV), the two additional samples collected on September 7, 2006 were subjected to confirmatory analysis by Method 8321A (HPLC/MS). Method 8321A provides analytical results with less interference and better resolution than Method 8330. The explosives identified in the samples analyzed by Method 8330 were not confirmed through the analysis by Method 8321A. A trace amount of hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX) (0.13 mg/kg) was detected in sample USMA-AFR-SD003 by Method 8321A. RDX was not identified in any samples analyzed by Method 8330. The result for RDX was also less than the PRG. Information received from EPA Region 2 indicated that Method 8321A is not a method approved by the EPA for the analysis of explosives. Therefore, the analytical results derived from this method were not used in making any decisions regarding recommendations for the Artillery Firing Range MRS (TLI, 2007).

The SI provided the following recommendations for the Artillery Firing Range MRS (TLI, 2007):

- The acreage of the MRS should be modified to encompass the additional area where MD was found, thus increasing the acreage from 170.9 to 172.4 acres.
- Based on the results of the visual survey and geophysical survey conducted during the SI field work in the Artillery Firing Range MRS, the previous geophysical survey completed in 2001, and the potential for MEC to be found within the area, it was recommended that the MRS, consisting of 172.4 acres, be further investigated for MEC.
- Based on the analytical results for the Artillery Firing Range MRS, it appeared that MC did not require further investigation at the MRS, at the time of the SI. However, if the further investigation of MEC identifies areas of concern, additional sampling may be warranted.

5.1.2.4 Time Critical Removal Action Investigation and Construction of the U.S. Military Academy Preparatory School

A Time Critical Removal Action (TCRA) investigation was conducted in January 2009 in the area of the Artillery Firing Range MRS that is south of the former motor pool and water tower area. The investigation was conducted as part of the ground clearance activities prior to the construction of the USMAPS. No MEC items were encountered during the TCRA investigation. The following MD items were recovered: two MK1A1 training hand grenades, two M21 practice hand grenades, ninety .30-06 caliber small arms blanks, one fragment of 75mm high explosive (HE) projectile, one 37mm HE projectile fragment, and one expended carrier for signal illumination. The MD was transferred to the Mercer Company, located in Sharon, Pennsylvania, for final disposition. No MC sampling or laboratory analyses were conducted during the TCRA investigation (PIKA, 2009).

Construction of the USMAPS occurred between October 2009 and November 2010. Eight 7.62mm linked blanks small arms and two MEC items, including one 3-inch Stokes mortar (unfuzed) and one 8-inch projectile (circa 1851), were recovered during construction. The 7.62mm linked blanks were transferred to the West Point Military Police (MP) office for disposal. The 3-inch Stokes mortar and 8-inch projectile were transferred to an Explosive Ordnance Disposal (EOD) unit and were explosively rendered safe prior to disposal. The following five MD items were also recovered during the USMAPS construction project: two empty launch tubes for ground signal illumination, one 7.62mm fired blank, one 5.56mm fired blank, and one 105mm cartridge (empty). MD items that were assessed to be entirely free of energetic materials were retained by Earth Resources Technology, Inc. (ERT), the construction support contractor, for training aids (ERT, 2011).

5.1.2.5 Munitions Response Site Prioritization Protocol Scoring

The Munitions Response Site Prioritization Protocol (MRSPP) reflects the statement in 10 United States Code (U.S.C.) §2710(b)(2) that the priority assigned should be based on the overall conditions at each location, taking into consideration various factors relating to safety and environmental hazard potential. As required under 10 U.S.C. §2710(b)(1), the priority assigned to each MRS will be included with the inventory information made publicly available. The requirement for an inventory of MRSs known or suspected of containing UXO, discarded military munitions (DMM), or MC is found at 10 U.S.C. §2710(a). The assigned priority will be reviewed annually, and the MRSPP will be reapplied to reflect new information that becomes available.

The MRSPP was applied to the Artillery Firing Range MRS following the SI. The Artillery Firing Range MRS was assigned a Priority 5 (out of 8) based on the potential explosive hazard identified during construction activities. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with chemical warfare materiel (CWM) can be assigned to Priority 1, and no MRS with CWM can be assigned to Priority 8. The Artillery Firing Range MRS falls among the lesser priorities of the ranking system. The MRSPP was reapplied based on the RI results and is presented in Section 5.9.2.

5.1.3 Remedial Investigation Report Organization

Section 5 is organized as follows:

- Section 5.1 provides the purpose and scope of the project, a description and history of the MRS, and a summary of the previous investigations.
- Section 5.2 includes a discussion of the preliminary CSM, preliminary remediation goals, data needs, and data quality objectives (DQOs) used to develop the RI.
- Section 5.3 provides details on the approach, methods, and procedures used to characterize MEC.
- Section 5.4 provides the details of the MC sampling.
- Section 5.5 provides the results of the RI characterization activities.
- Section 5.6 presents the results of the human health and ecological baseline risk assessment activities for MC and also presents the preliminary identification of potential applicable or relevant and appropriate requirements (ARARs).
- Section 5.7 addresses MEC and MC fate and transport processes.
- Section 5.8 presents the revised CSM developed for the MRS based on the RI findings.
- Section 5.9 addresses the MEC hazard assessment and the reapplication of the MRSPP to the Artillery Firing Range MRS based on the data collected during the RI.
- Section 5.10 presents the RI summary and conclusions.

References cited in Section 5 are provided in Section 8.

5.2 PROJECT REMEDIAL RESPONSE OBJECTIVES

The goal of the RI was to conduct an investigation at the Artillery Firing Range MRS to characterize the nature and extent of potential MEC and MC, and to assess the hazards and baseline risks to human health or the environment from MEC and MC. The overall RI approach included the following:

- Developing DQOs and data needs through the Technical Project Planning (TPP) process.
- Performing mag and dig and DGM surveys.
- Intrusively investigating anomalies detected during mag and dig and DGM surveys.
- Removing and disposing of recovered MEC and material documented as safe (MDAS).
- Conducting MC sampling at the Artillery Firing Range MRS based on the presence of two known firing points.
- Reporting results through the TPP process throughout the RI to gain stakeholder concurrence.
- Revising the CSM and reapplying the MRSPP based on the RI data collected.
- Submitting the RI Report.

The specific processes and procedures used to conduct the investigation are detailed in the *Final Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (Final RI Work Plan) (WESTON, 2011a). The characterization approach follows the methods presented and approved in the TPP 1 and TPP 2 meetings (see Section 5.2.2). The investigation methods are summarized in Sections 5.3 and 5.4, and the RI results are presented in Section 5.5.

5.2.1 Preliminary Conceptual Site Model

5.2.1.1 Development of a Conceptual Site Model

The CSM is used as a planning tool to integrate MRS information from a variety of sources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process of further data collection or action. The CSM development should be viewed as a process that reflects the progress of activities at an MRS from initial assessment through closeout. The CSM is divided into three primary components: potential sources, interaction, and receptors for MEC and/or MC, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. Each component is described below:

- Sources — Sources are those areas where MEC or MC has entered (or may enter) the physical system. An objective of the RI is to detect and delineate sources using geophysical surveys and intrusive investigations.
- Interactions — The hazard from MEC and the risk from MC are a result of direct human contact through an activity. Interactions describe ways that receptors come into contact with a MEC and/or MC source. For MC, interactions can include physical transport of the contaminant and transfer from one media to another through various processes so that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. For MEC, movement is not typically significant, and interaction will occur only at the source area, limited by access and activity. There can be movement of MEC through natural processes such as frost heave and soil erosion.
- Receptors — A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use because receptors are determined on that basis. Receptors include human receptors, such as West Point residents (adults and children), school children, site visitors, recreational uses, installation personnel, maintenance workers, and contractor personnel, and ecological receptors.

The preliminary CSM for the Artillery Firing Range MRS was based on the information collected during the SI (TLI, 2007). Based on the SI results, MEC exposure pathways are complete because MD was observed at the Artillery Firing Range MRS. The primary exposure mechanism for human and ecological receptors to surface MEC is through handle/tread underfoot. In addition, a subsurface pathway may occur because biota may nest or burrow at the Artillery Firing Range MRS (TLI, 2007). **Figure 5-5** depicts the MEC exposure pathways for the Artillery Firing Range MRS based on the results of the SI.

Based on the results of the SI soil sampling, only iron was identified above the EPA Region 9 PRGs (screening levels current at the time) at the Artillery Firing Range MRS. The observed concentrations were determined to be consistent with the expected background levels due to the naturally occurring geology and not to be indicative of a munitions source. Therefore, the exposure pathways for MC in soil to human and ecological receptors were considered incomplete (TLI, 2007). **Figure 5-6** depicts the SI exposure pathways for receptors to MC at the Artillery Firing Range MRS.

The CSM is updated as new data and information become available. The data collected during the RI were used to revise the preliminary CSM developed following the SI, and the revised CSM is presented in Section 5.8.

5.2.2 Technical Project Planning

Prior to the initiation of RI field activities, representatives and stakeholders from the United States Army Corps of Engineers (USACE), West Point, EPA, New York State Department of Environmental Conservation (NYSDEC), WESTON, and TLI participated in two TPP meetings. TPP 1 was conducted on 29 July 2010. At this meeting, the MRS summary and RI approach, objectives, planning documentation, and field investigation and reporting requirements were discussed.

TPP 2 was conducted on 3 February 2011. The project stakeholders reviewed the Draft Final RI Work Plan and identified and discussed project goals and DQOs. Details regarding the implementation of the MMRP RI were presented and discussed among the group. Based on the results of the second meeting, specific details of the investigation approach for the MRS, including coverage area, survey type (grid versus transect), and quantities, were determined. The results from the TPP 2 meeting were integrated into the Artillery Firing Range MRS DQOs and presented in the Final RI Work Plan (WESTON, 2011a).

5.2.3 Data Quality Objectives

The data needs and DQOs were determined at the planning stage and are discussed in more detail in the Final RI Work Plan (WESTON, 2011a). The data needs include characterization of the nature and extent of MEC and MC at the Artillery Firing Range MRS. The DQOs were developed to ensure the reliability of field sampling, chemical analyses, and physical analyses; the collection of sufficient data; the acceptable quality of the data generated for its intended use; and the ability to infer valid assessments from the data. The DQO process includes the following seven steps:

1. **State the problem:** Provide a concise description of the problem.
2. **Identify the decisions:** Develop decision statements to solve the problem.
3. **Identify inputs to the decision**: Identify information and measurements needed to make the decisions.
4. **Define study boundaries:** Identify conditions such as spatial and temporal boundaries.
5. **Develop a decision rule:** Qualify the decisions to understand data needs.
6. **Specify tolerable limits on decision errors:** Develop performance criteria.
7. **Optimize the design:** Design an effective data collection strategy based on the previous steps.

5.2.3.1 Artillery Firing Range MRS Data Quality Objectives

The following DQOs were developed specifically for the Artillery Firing Range MRS and were agreed upon by the stakeholders during the TPP sessions:

1. **State the problem:** This MRS is associated with five overlapping former artillery ranges. The target area for these ranges was located north of West Point and not in this MRS. The land area associated with this MRS is located in the artillery range fans near the former firing points. MD was observed in the MRS; however, the approximate density of MEC, if present, has not been verified. MC may also be present if a MEC release is detected within the MRS. Two former firing points (Sacred Heart Cemetery and Silver Depository) are also located within the MRS. There is a potential for MC to be present at these locations because of former training activities. Burial of unused munitions was sometimes practiced during training. Buried MEC may be present at each of the firing points. The Silver Depository Firing Point has been significantly developed over the years.

2. **Identify the decisions:** The primary decisions for this MRS include:

   - Determine the approximate MEC density in the MRS based on UXO Estimator coverage requirements.

   - If a MEC release is observed in the MRS, characterize the nature and extent of MEC and evaluate MC.

   - Characterize the nature and extent of MC if it is detected at the two firing points.

   - Detect and investigate the potential burial features associated with munitions disposal at the two firing points.

3. **Identify inputs to the decision:** Several inputs will be acquired during the course of the RI to support the decision. UXO Estimator requires that 5.78 acres be investigated to determine at a 95% confidence level that less than 0.5 MEC/acre is present within the MRS. DGM and mag and dig surveys will be performed along transects and in grids to accomplish the UXO Estimator requirements. All anomalies will be investigated. Intrusive results for MEC, MD, and non-MD will be evaluated in the project Geographic Information System (GIS). If a MEC release is detected, discrete or incremental soil and sediment sampling will be performed to determine whether MC is present. Incremental sampling will be performed at the firing points to determine the nature and extent of potential MC. DGM and intrusive investigations as necessary will be used to detect burial features at the firing points.

4. **Define study boundaries:** This MRS is a 172-acre area bounded to the north and south by operational range areas. The MRS also intersects with the Fort Clinton West and Lusk Reservoir MRSs. The extent of potential MEC and MC observed during the RI will be delineated using DGM, mag and dig, discrete MC sampling, and incremental MC sampling; however, the operational range areas will not be accessed.

5. **Develop a decision rule:** The results of the RI at the Artillery Firing Range MRS will be used to:

   - Assess, based on intrusive anomaly investigations, whether MEC density is less than 0.5 MEC/acre across the MRS.

   - Reassess the characterization approach if MEC density is found to be greater than 0.5 MEC/acre or if the CSM is not valid.

   - Determine whether MC is present at the firing points and fully characterize the nature and extent of MC.

   - Determine whether MEC burial features are present at the firing points and determine the nature and extent of MEC at burial sites.

6. **Specify tolerable limits on decision error:** It is anticipated that a low density of MEC exists at this MRS because of its location near the firing points of the overall range fan complex. The characterization approach will confirm that less than 0.5 MEC/acre is present at the MRS. If there is less than 0.5 MEC/acre within the MRS, no additional MEC investigations will be required to validate MEC density. If MEC is identified during intrusive work within the MRS, additional sampling may be warranted to achieve the desired confidence level. Additional sampling will be performed only if the MRS is still assumed to have a low density of MEC consistent with the CSM for the MRS. Additional coverage requirements will be determined by UXO Estimator.

7. **Optimize the design:** DGM surveys using a Geonics EM61-MK2 and mag and dig surveys using White's XLT all-metals detectors will be performed across the required 5.78 acres consistent with UXO Estimator assumptions. This includes ten 100-foot by 100-foot grids and approximately 2.9 miles of transects. Mag and dig surveys will be used in areas inaccessible to the DGM instrumentation. All anomalies will be investigated to determine the approximate MEC density. Grid locations will be placed at the firing points to identify large anomalies indicative of burial features. The grid location at the Silver Depository Range firing point has been shifted to the closest undisturbed area near the wooded area adjacent to the ski slope.

5.3 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS AND EXPLOSIVES OF CONCERN

This section provides the comprehensive approach, methods, and operational procedures used for the MEC characterization performed at the Artillery Firing Range MRS. The RI field activities were conducted between April 6 and August 11, 2011 (see **Table 5-1**).

Table 5-1 Artillery Firing Range RI Field Activities

RI Field Activity	Dates
Location Surveying and Mapping	04/06/11 and 04/07/11
DGM Survey	04/19/11 and 05/02/11
Mag and Dig Survey	06/24/11 to 08/10/11
Anomaly Reacquisition and Intrusive Investigation	08/08/11 to 08/09/11
MC Sampling (Sacred Heart Cemetery and Silver Depository Firing Points)	06/21/11 to 06/23/11
MC Sampling (Crows Nest Impact Area)	08/08/11 to 08/11/11

5.3.1 Investigation Coverage Requirements

UXO Estimator (Version 2.2) is a software package developed by USACE to assist in designing field sampling plans to determine MEC density for MRSs and to analyze field data after the data have been collected. UXO Estimator calculates the amount of acreage within an MRS that needs to be investigated to determine that a specific MEC density is present across the MRS to a preselected confidence level. The software inputs include the size of the MRS, the anticipated MEC density, and the confidence level to which the anticipated MEC density is to be tested.

A 0.5 MEC/acre density and a 95% statistical confidence at which to test the MEC density hypothesis were selected for the Artillery Firing Range MRS. The 0.5 MEC/acre density was chosen by the project team during the project planning phase based on the historical use and the munitions previously found in and surrounding the MRS, and the guidelines provided in the help menu of the UXO Estimator software. Based on these factors, at least 5.78 acres would require investigation to be 95% confident that there are less than 0.5 MEC/acre at the Artillery Firing Range MRS.

UXO Estimator provides a quantitative assessment of the upper bound MEC density. In the case of the Artillery Firing Range MRS, the upper bound density is 0.5 MEC/acre, which means that the MEC density can range from 0 MEC/acre to 0.5 MEC/acre if no MEC is recovered in the MRS. As part of the post-results analysis, qualitative assessments using information from the revised CSM should be conducted to determine the actual MEC density in this range.

5.3.1.1 Data Collection and Site Coverage

To achieve the investigation coverage calculated by UXO Estimator, geophysical surveys were performed at pre-planned transect and grid locations across the Artillery Firing Range MRS based on the Final RI Work Plan (WESTON, 2011a). Both DGM and analog surveys were performed to locate surface and subsurface anomalies for further investigation along transects and/or grids within the MRS. Both methods of anomaly detection were employed to maximize the coverage based on MRS accessibility and terrain. A total of 6.4 acres of coverage were performed at the Artillery Firing Range MRS, which exceeded the amount of coverage required based on the initial UXO Estimator calculation. Grids were specifically placed and investigated in the vicinity of the two former firing points in the Artillery Firing Range MRS. The following sections detail the geophysical investigations performed as part of the RI.

5.3.1.1.1 Location Surveys and Mapping

Location surveys and mapping activities were conducted within the Artillery Firing Range MRS in accordance with the procedures outlined in the Final RI Work Plan. Surveying was performed by Beatty & Watson, a New York-licensed surveyor. The location surveys and mapping task included the following:

- Establish site control relative to North American Datum 1983 (NAD 83), Universal Transverse Mercator (UTM) coordinate system, in units of U.S. Survey Feet.
- Install DGM survey control and mark out with survey nails.

The survey control locations used during the DGM surveys are listed in **Appendix 5-A**.

5.3.1.1.2 Mag and Dig Surveys

UXO Technicians traversed 3.08 miles of pre-planned transects using GPS as a navigational aid. Each transect was 10 feet wide, equating to a total of 3.74 acres. Additionally, 1.83 acres of mag and dig grids were surveyed within the Artillery Firing Range MRS. UXO Technicians used analog instrumentation (White's XLT all-metals detectors) to detect anomalies. A mag and dig approach was selected for a portion of the MRS because the terrain and vegetation would have limited the ability to perform DGM surveys. Eight 100 x 100-foot grids were established across the MRS, but located primarily to the south of the more heavily developed northern portion **Figure 5-7** and **Appendix 5-B** present the survey locations within the Artillery Firing Range MRS.

5.3.1.1.3 Digital Geophysical Mapping Surveys

A total of 0.83 acre of DGM transect and grid surveys were completed at the Artillery Firing Range MRS. **Appendix 5-B** presents the survey locations within the MRS. DGM transect surveys were performed over 0.93 mile (0.37 acre) of the golf course and ski slopes. DGM grid surveys covered a cumulative 0.46 acre at the Sacred Heart Cemetery firing point and the Silver Depository Range firing point. Once the general locations of the DGM survey locations were established, the surveyor set survey control at regular intervals to be used for digital data positioning. DGM surveys were then performed using a Geonics EM61-MK2 with GPS positioning for the transects and line and fiducial navigation and positioning for the grids. DGM surveys were conducted within the Artillery Firing Range MRS in accordance with the procedures outlined in the Final RI Work Plan (WESTON, 2011a). Any obstructions, such as trees or large boulders, were documented in field notes. Tests for instrumentation detection capabilities and functionality were conducted for the Artillery Firing Range MRS in accordance with the procedures outlined in the Final Work Plan.

Geophysical System Verification

The Geophysical System Verification (GSV) approach was used to monitor and verify the geophysical equipment functionality during the DGM surveys. The GSV approach includes an Instrument Verification Strip (IVS) and a blind seeding program to monitor the sensor detection performance throughout the duration of the DGM survey effort. IVS-specific data and results are provided in **Appendix 5-C**.

Instrument Verification Strip

The IVS was installed near current H-Block Field and linearly seeded with five items, including one small industry standard object (ISO), two medium ISOs, one inert 37mm projectile, and one inert 75mm projectile. Item types were confirmed with the USACE Quality Assurance (QA) Geophysicist prior to construction. **Table 5-2** lists the IVS seed items and descriptions.

Table 5-2 Instrument Verification Strip Seed Items and Descriptions

IVS Seed Item Type	Northing	Easting	Orientation	Depth	Description
Small ISO[a] (1 inch by 4 inches)	15033479.01	1921684.05	Horizontal	4.2 inches	Part Number[b]: 44615K466 ASTM Specification: A53/A773.
Medium ISO[a] (2 inches by 8 inches)	15033473.57	1921675.82	Horizontal	7.7 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.
37mm projectile	15033467.92	1921667.50	Horizontal	4.3 inches	Inert projectile.
75mm projectile	15033462.55	1921659.03	Horizontal	10.7 inches	Inert shrapnel projectile.
Medium ISO[a] (2 inches by 8 inches)	15033457.11	1921650.70	Horizontal	6.8 inches	Part Number[b]: 44615K529 ASTM Specification: A53/A773.

Notes:
[a] ISOs are schedule 40 pipe nipples, threaded on both ends, made from black welded steel and manufactured to an American Society for Testing and Materials (ASTM) specification.
[b] Part number from the McMaster-Carr catalog.

The items were seeded linearly over 70 feet and were spaced 10 feet apart horizontally (least favorable orientation) with the long axis aligned parallel to the ground surface. Item types were confirmed with the USACE QA Geophysicist prior to construction. After the IVS construction, a DGM survey was performed to demonstrate the instrument functionality and to verify that the seed item responses were consistent with the instrument response curves calculated for the EM61-MK2. All responses matched the appropriate response curves based on the seed item type and depth. IVS-specific data and results are provided in **Appendix 5-C**.

The IVS and unseeded test strip were visited daily before and after the DGM surveys and intrusive investigations. Both the EM6-MK2 and White's XLT were tested at the IVS. The results were then compared to the seed item response baseline and sensor response curves to determine that the geophysical equipment was operating properly. On June 24, 2011, four White's XLT all-metal detectors were deemed to be malfunctioning after testing at the IVS. Several spare White's XLTs were kept on-site; therefore, the data collection and the quality of the data were not affected. The malfunctioning White's XLTs were returned for servicing and replacements were ordered.

The pre- and post-survey IVS results for the days that DGM data were collected at the Artillery Firing Range MRS are presented in **Table 5-3**. The results collected for each day of DGM at the IVS show agreement and repeatable results for the series of seeds. The seed items placed within the IVS were observed in the geophysical data with signals consistent with the sensor response curves developed for the EM61-MK2. All peak responses from the seed items were observed to be greater than the least favorable orientation response and to have consistent responses between the surveys. These results demonstrate that the digital geophysical equipment was functioning within a tolerable range to achieve detection performance metrics. Photographs of the equipment are provided in **Appendix 5-D**.

Table 5-3 Instrument Verification Strip Results

Item Description	Small ISO	Medium ISO	37mm Projectile	75mm Projectile	Medium ISO
Item Depth (inches)	4.2	7.7	4.3	10.7	6.8
Least favorable orientation response (mV)	10.8	64.2	14.8	60.6	73.4
IVS Date	**Response (mV)**				
19 April 2011 Pre-Survey	26.62	101.73	45.27	83.7	89.4
19 April 2011 Post-Survey	20.96	88.21	38.04	71.41	83.63
02 May 2011 Pre-Survey	25.49	111.18	44.67	88.34	88.03
02 May 2011 Post-Survey	29.42	113.1	44.36	87.95	90.55

Blind Seeding

A seeding program was instituted in the geophysical survey grids to provide ongoing monitoring of the geophysical instrumentation detection performance. Seeds were blind to the geophysical data collection teams. After the medium ISO seed items were initially placed within the DGM grids, the locations and depths of the items were surveyed. All blind seed items were observed in the geophysical data with a signal consistent with the sensor response curves developed for the EM61-MK2, and within the 3.25-feet offset metric established in the project-specific measurement quality objectives (MQOs).

The seeds were recovered by the UXO teams during intrusive investigations. **Table 5-4** lists the depth, type, geophysical response, and offset of the seed items placed within the DGM grids. The location and depth of the seeds items were surveyed by Beatty & Watson.

Table 5-4 Blind Seeding Results

Grid	Item	Depth (inches)	Orientation	Target ID	Status	Peak Response (mV)	Offset (inches)
AFR-04	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	AFR-04-26	Recovered	91.59	2
AFR-09	Medium ISO (2-inch x 8-inch pipe)	6	Horizontal	AFR-09-144	Recovered	139.78	6

5.3.2 Data Processing and Quality Control

The EM61-MK2 data were imported into the Geonics® DAT61MK2 software for pre-processing. The DAT61MK2 is used to convert the raw binary sensor data into a Geosoft®-compatible XYZ data file. Each XYZ file contains data for each of the four time gates recorded, the position, and the time stamp associated with each reading. Digital data were processed by the Site Geophysicist using Geosoft's Oasis montaj software. The IVS and quality parameters that were monitored and assessed daily during data processing included:

- Coverage.
- Velocity.
- Sample separation.
- Noise.
- Function tests: static, static response, and cable connection tests.

Instrument functionality tests were conducted before and after DGM surveying adjacent to the IVS located at H-Block Field. The Static Test and Static Response Test involved collecting non-dynamic data for a period of 1 minute without and with a small ISO item, respectively. Tests for the EM61-MK2 show background noise levels ranging from 0.5 to 2.2 standard deviations, with minimum and maximum readings between -6 mV and 2 mV. The Static Spike Test measurements range from minimum and maximum values of 38 mV to 46 mV with a standard deviation between 0.66 and 1.86. Static Response Test data for the EM61-MK2 show consistent response values within the ±20% metric over the test object in pre- and post-survey tests. The project metric for test data was established at a standard deviation of less than 2.5. No anomalous data spikes or outside interference was observed during the static instrument tests.

Background noise was evaluated for each dataset by windowing a section of the data and generating statistics using the UX-Process QC module. Statistics calculated for Artillery Firing

Range MRS DGM data are presented in **Table 5-5**. Channel 2 was then gridded using a grid cell size of 0.25 feet with a search radius of 2 feet and blanking distance of 2.25 feet.

Table 5-5 DGM Data Parameters

Data Metric		Mean Sample Separation (ft)	Mean Velocity (mph)	Background Noise (mean)	Background Noise (standard deviation)
	DQO	**< 0.5 ft**	**< 3 mph**	**MRS Specific**	**< 2.5**
Grid ID	AFR-04	0.24	1.61	0.41	0.44
	AFR-09	0.03	2.19	0.98	1.86

Anomalies were selected from the Channel 2 gridded data using the Blakely Test target selection algorithm. A target threshold value of 7.2 mV on Channel 2, as approved by the USACE QA Geophysicist, was used to select the initial target list. The threshold value was based on the sensor response curve for a 75mm projectile at a depth of 3 feet in the least favorable (horizontal) orientation. Target review consisted of manually evaluating all selected targets and removing or merging multiple targets associated with large anomalies. Processing parameters are listed in **Table 5-6**.

Table 5-6 EM61-MK2 Data Processing Parameters

Process	Parameter
Drift – Non-Linear Drift Correction Filter (UCEDRIFT.GX)	Window Length: 100 % lowest values ignored: 10% % highest values ignored: 70% All data channels were processed using the same parameters.
Statistical Evaluation of Background Noise	Windowed section of background/using UX-Process QA/QC module to evaluate standard deviation and mean noise values.
Grid	Cell Size: 0.25 ft Blanking Distance: 2.25 ft Search Radius: 2 ft
Blakely Peak Picking Algorithm	Smooth Filter: 3 Normal Peak Detection Grid Value Cutoff: EM 7.2 mV
Target Decay Analysis	Performed based on each data channel.
Target Review	Performed.

A target decay analysis was run to remove targets that had an atypical decay between the four time gate channels. An atypical decay is observed when an anomaly signal does not decrease through time, but instead shows an increase in any of the subsequent time gate channels. The most common causes of atypical decay are due to external radio frequency interferences or rough terrain encountered during data collection. **Appendix 5-B** presents the DGM data results with target locations.

All data related to DGM surveys were managed using Geosoft® Oasis montaj software. All spatial data were managed using a GIS, and are stored in Environmental Systems Research Institute® (ESRI)-compatible GIS formats, primarily ArcInfo coverage and ArcView shape files. All DGM data were provided electronically to the USACE QA Geophysicist for QA.

5.3.2.1 Anomaly Investigation Activities

A total of 154 anomalies were selected as part of the DGM data analysis. The anomalies were compiled into a dig list. The dig list data were logged into a hand-held computer and managed using WESTON's RespondFast® UXO Investigation software. Each of these anomalies was reacquired and intrusively investigated. Anomaly reacquisition was performed using a Trimble® S8 Robotic Total Station (RTS) for navigation to the precise location of each target. A reacquisition team navigated to the location and marked it with a non-metallic pin flag designated by the unique anomaly ID. All detected anomalies were investigated during the mag and dig surveys. Dig lists developed following digital data analysis for DGM and during the mag and dig surveys are presented in **Appendix 5-E**.

5.3.2.1.1 Anomaly Investigation Procedures

Intrusive investigations were conducted at the locations of anomalies detected as part of the geophysical surveys in accordance with the Final RI Work Plan (WESTON, 2011a), including the approved Accident Prevention Plan (APP)/Site Safety and Health Plan (SSHP) and the Explosives Site Plan (ESP). Intrusive investigations at selected anomaly locations were performed to positively identify and recover MEC, material potentially presenting an explosive hazard (MPPEH), and MD. All recovered items were treated as MPPEH and were subject to field inspection to determine the nature of recovered anomalies. All items were verified free of explosives hazards prior to being relocated for future disposal.

The Senior UXO Supervisor (SUXOS) conducted oversight of all intrusive investigations, and the UXO Quality Control Specialist (UXOQCS) conducted daily quality control (QC) following target reacquisition and intrusive investigation as documented in the Daily Reports for the RI (see **Appendix 5-F)**.

UXO Technicians began the anomaly investigations by sweeping a 3-foot radius around the pin flag with a White's XLT all-metals detector to focus the excavation at the peak response. The offset and northing and easting positions of the peak response were recorded for each anomaly. Intrusive operations at each anomaly location were performed using hand tools. The UXO Technicians excavated at the location of the highest detector response until the source of the anomaly was found. The target location was considered clear when a signal source was no longer detected after removal of the conductive item, or the source of the signal was identified to be associated with a cultural feature such as a fence or building.

Exclusion zones during intrusive operations were based on the project munition with the greatest fragmentation distance, which is a 75mm HE projectile. The minimum separation distance for nonessential personnel was 238 feet.

Dig teams used the personal hand-held computers with RespondFast UXO Investigation software to electronically log the target characteristics real-time in the field. Characteristics logged in RespondFast include item category, item type, depth, dig data, and final disposition.

The results of the intrusive investigation are provided in the expanded dig lists in **Appendix 5-E.** Photographs of the anomaly reacquisition process are provided in **Appendix 5-D.**

5.3.2.1.2 Inspection of Munitions-Related Items

Munitions-related items underwent a three-step inspection process during intrusive investigations. Munitions-related items were inspected in the grid by a UXO Technician II and then a Technician III and were classified as MPPEH or MD. After the Technician III inspected the item, the item underwent a third inspection by the SUXOS, with verification by the UXOQCS, to determine the final disposition. The item was then determined to be MD or material documented as an explosive hazard (MDEH). Items classified as MDEH were to be disposed of by detonation. At the Artillery Firing Range MRS, no items were classified as MDEH.

MD was recovered from the grids, certified and verified as free from explosives, and stored in a locked container as MDAS. Items classified as MDAS pose no explosive hazard and were transported to a collection point for final disposal. A final inspection was conducted immediately prior to the transfer of MDAS to the West Point Recycle Center. Certified MDAS was transferred to the West Point Recycle Center with the completed DoD Form 1348-1A, signed by the SUXOS to certify that the material listed had been thoroughly inspected and, to the best of the SUXOS's knowledge and belief, was inert and/or free of explosives or related materials.

After the DoD Form 1348-1A was verified and signed by the UXOQCS, a copy was maintained and the original accompanied the MDAS to its final disposition at the West Point Recycle Center. Copies of the forms are provided in **Appendix 5-G**.

Intrusive Investigation Quality Control

In accordance with the Final RI Work Plan, the UXOQCS inspected at least 10% of the dig locations using a White's XLT all-metals detector to determine whether the removal was effective. The UXOQCS joined the intrusive team and inspected all digs made during one day. The results of the QC inspections for the intrusive investigation are provided in the UXOQCS reports (**Appendix 5-F**). The USACE Ordnance and Explosive Safety Specialist (OESS) also performed a QA inspection at the Artillery Firing Range MRS grids. The Form 948 accepting the QC results is provided in **Appendix 5-H**.

5.4 INVESTIGATION AND CHARACTERIZATION OF MUNITIONS CONSTITUENTS

5.4.1 Purpose of Munitions Constituent Sampling

Characterization activities for MC were conducted in accordance with the Final RI Work Plan, specifically the Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) and the MC Sampling Memorandum (Appendix G of the Work Plan). Based on the MC Sampling Memorandum, sampling activities would be performed at locations based on the information obtained during the MEC investigation activities. MC investigations would be initiated in the following instances:

- Further investigation of MC at currently unknown but potential MEC releases (i.e., concentrated munitions use areas) identified during geophysical surveys conducted as part of the West Point RI.

- Further investigation of MC at known former artillery range firing points that potentially contain MC.
- MC sampling at individual MEC item locations where soil staining or visible evidence of a potential MC release is observed.

Because no MEC was identified during the RI, incremental sampling for MC in surface soil was performed only at the two former firing points in the Artillery Firing Range MRS (**Figure 5-7**), where MC may have been released from firing activities even though MEC was not found at the firing point locations. The results of the MC characterization are reported in Section 5.5.2.

5.4.2 Remedial Investigation Munitions Constituent Sampling

An RI MC sampling scheme for each MRS based on historical data was developed prior to field work and was presented in the Final RI Work Plan. After the intrusive investigation at the Artillery Firing Range MRS, it was determined that the MRS-specific sampling scheme for incremental sampling at the firing points did not require revision because no significant MEC or MD was identified at the two incremental sampling locations. As presented in the Final RI Work Plan, a 0.5-acre incremental sampling unit was designated to encompass each artillery firing point – the Silver Depository Range firing point and the Sacred Heart Cemetery Range firing point. The acreage associated with each sampling unit and the number of increments collected from within each sampling unit were based on the USACE Interim Guidance Document 09-02, *Implementation of Incremental Sampling of Soil for Military Munitions Response Program* (USACE, 2009).

The MC sampling plan for the Artillery Firing Range MRS consisted of the following:

- Two incremental samples (plus one duplicate/triplicate pair) were collected from the two areas that were historically defined as artillery firing points (see **Figure 5-7**).

Once the location of the sampling units had been identified, the increment locations were selected using a random number generator. The increment coordinates for each incremental sample were then loaded into the GPS units as waypoints for the field team and were also printed on aerial maps that were used in the field. The field maps showing the locations of the planned incremental samples within the sampling units are included in **Appendix 5-I**.

One field team consisting of two environmental scientists and one UXO Technician II performed incremental sampling at the Artillery Firing Range MRS. The field team located each increment in accordance with the waypoint data that was loaded into the GPS unit prior to field activity. The sample team used a hand-held GPS unit to navigate to each increment location, or used a measuring tape to locate a specific offset, and placed numbered pin flags at each increment location. Sample increments were then collected by field personnel travelling a meandering path. Field personnel confirmed the collection of each increment in the field logbook according to the numbered flags in the sampling unit. The sample team did not record the specific path travelled to collect increments.

Once a surface soil increment area was located, the UXO Technician II performed anomaly clearance using a metal detector. After the area was deemed safe, the environmental scientists collected a soil sample using a Multi-Incremental Sampling Tool (MIST) and placed the sample in a resealable plastic bag. If an area could not be cleared by the UXO Technician II, or if rocks or other debris were in the way, the field team sampled an area 1 meter away. There were no cases in which the location had to be eliminated because of UXO clearance issues.

For some locations, surface features such as tree roots, rocky areas, standing water, or steep drop-offs were found at an increment location that was selected by the random number generator prior to mobilization. In these cases, the incremental sample was collected as close as possible to the original location. The direction and the distance the incremental sample was moved were noted in the field logbooks included in **Appendix 5-I**. All incremental samples were surface samples and were collected from a depth of 0 to 3 inches. Sufficient sample mass, approximately 1 kilogram, was obtained for each sampling unit. Once all the increments were placed in the plastic resealable bag, the soil contents were labeled, homogenized, sealed, placed on ice, and shipped to the laboratory for analysis. The incremental samples were collected using new, clean, dedicated, and disposable equipment; therefore, no investigation-derived waste (IDW) (solid or liquid) was generated.

All increments were collected at the surface of the soil. No subsurface soil sampling was conducted at the Artillery Firing Range MRS. The incremental samples collected at the firing points were analyzed for explosives (see **Table 5-7**) consistent with Appendix G, MC Sampling Memorandum presented in the Final RI Work Plan (WESTON, 2011a).

Table 5-7 Incremental Sample Summary at the Artillery Firing Range MRS

MRS	No. of Incremental Sample (Sample Numbers)	Size of Incremental Sample (acres)	No. of Increments	Analysis
Artillery Firing Range MRS Firing Points	2 samples (plus 1 duplicate/triplicate pair): ▪ WPR01-SS03 (Sacred Heart Cemetery Firing Point) ▪ WPR01-SS06 (Silver Depository Firing Point), WPR01-SS07 (duplicate) and WPR01-SS08 (triplicate)	0.5	30	Explosives

5.4.3 Analytical Laboratory and Analyses

Explosives were analyzed in surface soil for the firing points in the Artillery Firing Range MRS. Compounds potentially associated with the Artillery Firing Range MRS were evaluated for MC sampling. Because of the time period during which munitions were used at the MRS, specific nomenclature for the munitions was not available in the historical records; therefore, generic MC information was compiled for these items. The explosives used in the greatest quantity at the Artillery Firing Range MRS were trinitrotoluene (TNT), nitroglycerin, PETN, and RDX. These explosives are insoluble in water and do not hydrolyze, volatilize, or bioconcentrate under normal environmental conditions. They have average adsorption coefficients, suggesting that they reasonably adsorb to soil and sediments and maintain low soil mobility. Also, their volatilization rate from soil is extremely low. Therefore, TNT and its breakdown products, as well as nitroglycerin, PETN, and RDX are anticipated to remain in the environment and are good indicators for explosives at the Artillery Firing Range MRS. **Table 5-8** lists the specific explosive compounds and metals included in the analyses of the soil samples.

Table 5-8 Artillery Firing Range MRS Surface Soil Explosives

Analyte*	Firing Points
Nitroglycerin	Known MC associated with munitions
Pentaerythritol tetranitrate (PETN)	Known MC associated with munitions
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Known MC associated with munitions
2,4,6-Trinitrotoluene (TNT)	Known MC associated with munitions
2,4-Dinitrotoluene (2,4-DNT)	Breakdown product of TNT
2,6-Dintrotoluene (2,6-DNT)	Breakdown product of TNT
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	Breakdown product of TNT
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	Breakdown product of TNT

*Explosives were analyzed using EPA Method SW-846 535A/8330B.

Soil samples were submitted for analysis to a DoD Environmental Laboratory Accreditation Program (ELAP)-certified and National Environmental Laboratory Accreditation Conference (NELAC)-accredited laboratory, TestAmerica, Inc., located in South Burlington, VT. The laboratory provided a Level IV data package for validation that met the reporting requirements of *DoD Quality System Manual for Environmental Laboratories Version 4.2* (QSM 4.2) (DoD, 2010). The Level IV data package included all elements required to perform a full data validation, such as sample and QC data, chromatograms, raw data, instrument printouts, chain of custody records, log pages, and instrument calibration data. Samples were analyzed in accordance with the requirements of the analytical method, method-specific requirements of DoD QSM 4.2, and the project's UFP-QAPP to ensure that sample results met project requirements for quality and technical competency. The analytical laboratory results are provided in **Appendix 5-J**.

Data validation was performed by an independent third party, MEC^x, LP. Explosives data were validated in accordance with the requirements of the following:

- Method 8330B, Nitroaromatics, Nitroamines, and Nitrate Esters by High Performance Liquid Chromatography (HPLC) (EPA, 2006).
- Validation of Data, Nitroaromatics and Nitroamines by HPLC, SW-846 Method 8330A (SOP HW-16, Rev. 2) (EPA Region 2, 2006).
- Data Validation Procedure for Explosives, Nitroaromatics, and Nitroamines (DVP-16, Rev. 0) (MEC^x, LP, 2009).
- Standard Operating Procedure for Routine Validation of High Explosive (HE) Analytical Data (SOP-5164, Rev. 0) (Los Alamos National Laboratory [LANL], 2008).

- *Final Uniform Federal Policy Quality Assurance Project Plan, Remedial Investigation for Military Munitions Response Program Sites, U.S. Army Garrison West Point, West Point, NY (UFP-QAPP)* (WESTON, 2011b), as presented in Appendix J of the *Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (WESTON, 2011a).
- *EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA, 1999).

5.4.4 Screening Levels

The MC sample analysis results were compared against two sets of screening levels, human health soil screening values and soil ecological screening values (ESVs), which were defined in the Final RI Work Plan prior to the RI field work for the Artillery Firing Range MRS. To facilitate RI data evaluation and comparisons, the Final RI Work Plan list of selected ESVs was expanded to include all potential ESVs available from various sources.

For human health soil screening values, Oak Ridge National Laboratory (ORNL) regional screening levels (RSLs) for residential soils and NYSDEC soil cleanup objectives (SCOs) for residential and unrestricted use were compared for each analyte. The ORNL RSLs, which are updated by ORNL (EPA, 2012) semi-annually, are now used by EPA as risk-based screening benchmarks (in place of the EPA Region 9 PRGs that were used in the SI).

For ESVs, NYSDEC, EPA ecological soil screening level (EcoSSL), EPA Region 5 ecological screening level (ESL), ORNL Benchmark 1, and ORNL Benchmark 2 were compared for each analyte. In the case of analytes for which there was no benchmark available (NBA) in the screening values listed in the Final RI Work Plan, additional research was conducted to identify ESVs. Publications, including U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM) and scientific reports written by Efroymson et al. (1997a and 1997b) and Kuperman et al. (2006), were evaluated.

The screening values referenced in this section are deemed to-be-considered information (TBCs), except for NYSDEC SCOs, which are considered ARARs, as discussed in more detail in Section 5.6.3. **Table 5-9** lists the analytes and the lowest of the human health and ecological screening values used for sample comparison. MC sampling and analytical results are described in Section 5.5.2.

Table 5-9 Screening Levels for Explosives

Analyte	Human Health Soil Screening Value	Human Health Soil Screening Value Method Used	Ecological Soil Screening Value	Ecological Soil Screening Value Method Used[1]
Explosives (μg/kg)				
Nitroglycerin	610	ORNL Residential RSL[2]	3,000	USACHPPM[4]
Pentaerythritol tetranitrate (PETN)	NBA	NBA	170,000	USACHPPM[5]
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)[1]	5,500	ORNL Residential RSL	21,000	Kuperman et al., 2006[6]
2,4,6-Trinitrotoluene (TNT)	3,600	ORNL Residential RSL	70	USACHPPM[7]
2,4-Dinitrotoluene (2,4-DNT)	1,600	ORNL Residential RSL	1,280	EPA Region 5 ESL[8]
2,6-Dintrotoluene (2,6-DNT)	1,030	NYSDEC Unrestricted Use SCO[3]	32.8	EPA Region 5 ESL
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[9]
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	15,000	ORNL Residential RSL	9,000	USACHPPM[9]

Notes:
[1] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the following hierarchy was used to select the screening value: EPA EcoSSL, EPA Region 5 ESL, ORNL Benchmark 1, ORNL Benchmark 2.
[2] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (April 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.
[3] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html
[4] USACHPPM, 2000.
[5] USACHPPM, 2001a.
[6] Kuperman et al., 2006.
[7] USACHPPM, 2001b.
[8] EPA. 2003. Region 5 Resource Conservation and Recovery Act (RCRA) Ecological Screening Levels - http://www.epa.gov/reg5rcra/ca/ESL.pdf
[9] USACHPPM, 2005.

NBA=no benchmark available
μg/kg =microgram/kilogram

5.5 REMEDIAL INVESTIGATION RESULTS

This section presents the results of the RI MEC characterization (Section 5.5.1) and of the MC characterization (Section 5.5.2).

5.5.1 Results for Munitions and Explosives of Concern Characterization

As described in Section 5.3, the characterization performed at the Artillery Firing Range MRS during the RI involved the following tasks:

- Mag and dig and DGM data collection.
- Digital data processing, analysis and anomaly selection.
- Anomaly reacquisition.
- Intrusive investigation of detected anomalies.

The following paragraphs detail these activities.

5.5.1.1 Geophysical Survey Results

A total of 6.4 acres within the Artillery Firing Range MRS were investigated using DGM and mag and dig surveys. Mag and dig transect and grid surveys were conducted over 5.57 acres using a White's XLT all-metals detector. All anomalies detected were investigated by UXO Technicians to determine the anomaly source. A total of 0.83 acre of DGM surveys were performed using a man-portable EM61-MK2 sensor in cart mode. A total of 154 anomalies were selected from the DGM data for intrusive investigation. The intrusive investigation of all anomalies are discussed in the following subsection.

5.5.1.2 Intrusive Investigation Results

No MEC was observed in the Artillery Firing Range MRS, but 58 MD items were recovered at depths ranging between 0 inches and 10 inches below ground surface (bgs). The MD items included 49 fragments from unknown munitions, three slap flares, two MKII practice grenades (empty), one 4.6-inch Parrott round (empty), one rifle grenade (illumination), one M69 practice grenade, and one M18A1 rifle grenade (illumination) (see **Figure 5-8**). The remaining non-MD related material included 144 items classified as cultural debris, two no contacts, and two quality control seeds. These items were recovered between the surface and 9 inches bgs. **Appendix 5-B** shows the locations of the items recovered, and **Table 5-10** provides a summary of the recovered MD. The complete dig list is provided in **Appendix 5-E**.

Table 5-10 MD Summary at the Artillery Firing Range MRS

Target ID No.	Item Type	Item Description	Investigation Type	Dig Date	Depth (inches)	Weight (lb)	Quantity
AFR	MD	Slap Flare	Mag and Dig	4/11/2011	0.0	0.5	1.0
AFR-02	MD	MKII Practice Grenade (empty)	Mag and Dig	8/5/2011	4.0	1.0	1.0
AFR-05	MD	Fragment	Mag and Dig	7/5/2011	2.0	2.0	2.0
AFR-05	MD	M69 Practice Grenade	Mag and Dig	7/5/2011	4.0	1.0	1.0
AFR-06	MD	Fragment	Mag and Dig	6/28/2011	6.0	10.5	8.0
AFR-06	MD	Slap Flare	Mag and Dig	6/28/2011	3.0	0.5	1.0
AFR-06	MD	Rifle Grenade (illumination)	Mag and Dig	6/28/2011	6.0	0.5	1.0
AFR-08	MD	Fragment	Mag and Dig	6/29/2011	2.0	2.0	4.0
AFR-09-09	MD	Fragment	DGM	5/1/2012	6.0	1.0	1.0
AFR-09-125	MD	Fragment	DGM	5/1/2012	0.0	0.5	1.0
AFR-09-156	MD	Fragment	DGM	5/1/2012	0.0	2.0	1.0
AFR-09-156-2	MD	Fragment	DGM	5/1/2012	0.0	2.0	1.0
AFR-09-197	MD	Fragment	DGM	5/1/2012	3.0	0.5	1.0
AFR-09-60	MD	Fragment	DGM	5/1/2012	6.0	0.5	1.0
AFR-10	MD	Fragment	Mag and Dig	6/24/2011	0-10	94.0	21.0
AFR-10	MD	4.6-inch Parrott round (empty)	Mag and Dig	6/24/2011	6.0	20.0	1.0
AFR-T01	MD	Fragment	Mag and Dig	6/24/2011	6.0	3.0	1.0
AFR-T01	MD	Fragment	Mag and Dig	6/24/2011	6.0	3.0	1.0
AFR-T02	MD	Fragment	Mag and Dig	6/24/2011	6.0	3.0	1.0
AFR-T03	MD	Fragment	Mag and Dig	6/24/2011	6.0	2.0	1.0
AFR-T08	MD	M18A1 Rifle Grenade (illumination)	Mag and Dig	7/15/2011	2.0	2.0	1.0
AFR-T10	MD	MKII Practice Grenade (empty)	Mag and Dig	8/10/2011	2.0	1.0	1.0
AFR-T10	MD	Fragment	Mag and Dig	8/11/2011	3.0	2.0	1.0
AFR-T10	MD	Fragment	Mag and Dig	8/11/2011	4.0	2.0	1.0
AFR-T10	MD	Fragment	Mag and Dig	8/11/2011	6.0	2.0	1.0
AFR-T10	MD	Fragment	Mag and Dig	8/11/2011	1.0	2.0	1.0
AFR-T11	MD	Slap Flare	Mag and Dig	8/10/2011	1.0	0.5	1.0

5.5.1.3 Geophysical Surveys and Intrusive Investigation Analysis

The Artillery Firing Range MRS is part of a surface danger zone for several former ranges. Geophysical transect and grid surveys performed within the MRS were used to assess the nature and extent of MEC and MD. No MEC was observed during the RI in the two noncontiguous areas of the Artillery Firing Range MRS (the firing point area and the northeastern area). No MD was observed in the firing point area, but MD was observed in the northeastern area of the MRS. A majority of the MD items recovered within the Artillery Firing Range MRS are fragments from former munitions use. Several inert projectiles and grenades were also recovered in the northeastern area of this MRS. The northeastern area of the MRS is split based on two separate concentrations of MD; a southern high concentration area and a northern high concentration area. The increase in MD density observed within the northern high concentration area of the Artillery Firing Range MRS was also observed laterally extending across several MRSs, including the Fort Clinton West, Siege Battery, and Lusk Reservoir MRSs. The northeastern area of the MRS is closer to the range impact area where MEC and MD are most likely to be encountered.

Based on the observed density, distribution, and the type of MD, the source of these items in the northern high concentration area is attributed to the historical firing at targets on Crows Nest mountain. The collective RI characterization strategy using geophysical transects and grids allowed the successful delineation of the southern boundary of the Crows Nest impact area.

In accordance with the DQOs, the RI field results were also evaluated using the UXO Estimator *Analyze Field Data Module*. The following inputs were assessed in UXO Estimator:

- **Total number of acres in MRS:** 172.4 acres
- **Number of acres investigated:** 6.4 acres
- **Number of MEC recovered in the investigated area:** 0 MEC recovered.
- **Specify the MEC target density per acre (same value used to develop DQOs):** 0.5 MEC/acre
- **Specify the desired upper confidence level (same value used to develop DQOs):** 95% confidence

The UXO Estimator calculations were initially designed to evaluate the 172.4-acre MRS. UXO Estimator calculated a statistical upper bound MEC density of 0.458 MEC/acre at a 95% confidence level based on the RI field results. The calculated average MEC density across the Artillery Firing Range MRS based on the UXO Estimator results is 0.150 MEC/acre.

It is statistically possible that MEC may be present across the entire Artillery Firing Range MRS. However, based on the results of the geophysical transect and grid characterization and because no MEC or MD was recovered in the southern firing point area of the MRS, there are no MEC anticipated in this area of the MRS. The MD items recovered in the Artillery Firing Range MRS were concentrated in the northeastern area of the MRS where it is more likely additional MD and potential MEC are present because of the proximity to the range impact area. The northeastern area of the MRS was identified as having two separate MD high density areas, a southern high concentration area and a northern high concentration area. The results observed within the northern high concentration area of the Artillery Firing Range MRS are consistent with the RI findings in adjacent MRSs. The CSM for the Artillery Firing Range MRS is discussed further in Section 5.8.

5.5.1.4 Additional Findings

After completion of the RI field investigations, four additional munitions were discovered and responded to within the northern portion of the Artillery Firing Range MRS (see **Figure 5-8**). The following findings were included in the overall assessment of the MRS:

- On February 15, 2012, a construction crew working near the Keller Army Community Hospital encountered an MD item, an 8-inch Butler projectile (concrete filled). The Fort Drum EOD responded to the discovery and fired two explosive demolition shots at the item in a designated disposal area.
- On May 9, 2012, a UXO item, an 8-inch Butler projectile, was encountered by the operator of a front-end loader working near the Keller Army Community Hospital. The Fort Drum EOD responded to the discovery and detonated the item in a designated disposal area.
- On June 21, 2012, a second UXO item, an unfuzed 8-inch Parrott shell, was encountered by a construction crew working near the Keller Army Community Hospital. The 705th Ordnance EOD Company responded to the discovery, positively identified the item, and relocated it to a demolition range on West Point for disposal.
- On June 26, 2012, a third UXO item, an unfuzed 8-inch Parrott shell, was encountered by a construction crew working near the Keller Army Community Hospital. The 705th Ordnance EOD Company responded to the discovery, positively identified the item, and relocated it to a secure holding area (SHA) for disposal at a later date.

5.5.2 Results for Munitions Constituents Characterization

No MEC indicating that a confirmed source for MC was present was identified during the RI field investigations. In accordance with the Final RI Work Plan and the UFP-QAPP, sampling to investigate MC was conducted only at the firing points in the Artillery Firing Range MRS. As depicted on **Figure 5-7,** two incremental samples and one duplicate/triplicate pair were collected at the known former Sacred Heart Cemetery Range and Silver Depository Range firing points (WPR01-SS03, WPR01-SS06, WPR01-SS07 [duplicate], WPR01-SS08 [triplicate]). The field duplicate/triplicate pair were collected for QC purposes. The incremental samples collected from the firing points were comprised of 30 increments collected over a 0.5-acre sampling unit area.

The incremental samples were collected and analyzed to identify the presence of MC (if any) and to fully characterize the nature and extent of MC. The incremental samples were collected using new, clean, dedicated, and disposable equipment; therefore, no IDW (solid or liquid) was generated. Analytical results for the Artillery Firing Range MRS are provided in **Table 5-11**.

5.5.2.1 Explosives

There were no reported detections of explosives in the samples collected from the firing points. Analytical results included a U qualifier with each reported value, indicating that the explosive was analyzed for, but was not detected at a concentration greater than the reported sample quantitation limit (SQL). The analytical results for 2-amino-4,6-dinitrotoluene and 4-amino-2,6-dinitrotoluene reported for WPR01-SS08 (triplicate of WPR01-SS06) were reported with a UJ qualifier, which indicates that the analyte was not detected at a concentration greater than the reported SQL. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample (**Table 5-11**). Data qualifiers are discussed in more detail in Section 5.5.2.3.2.

The analytical results in comparison to the human health and ecological screening values (**Table 5-9**) and any potential impacts on human and ecological receptors are presented in Section 5.6.

5.5.2.2 MC Data Quality

An assessment of data quality for MC sampling was conducted in accordance with the Final RI Work Plan (WESTON, 2011a) and the UFP-QAPP (WESTON, 2011b). Field QC samples were collected and analyzed to assess the quality of the data resulting from the field sampling program at a program-wide level for the MMRP RI at West Point. Additionally, as discussed in Section 5.4.3, 100% of the MC data results were validated by an independent third party, MEC^{x}, LP.

Table 5-11 Analytical Results for Soil Sampling for MC, Artillery Firing Range MRS Firing Points

Sample ID:	WPR01-SS03		WPR01-SS06		WPR01-SS07		WPR01-SS08	
Lab Sample ID:	200-5727-3		200-5727-6		200-5727-7		200-5727-8	
Sample Type:	Soil		Soil		Soil		Soil	
Date Sampled:	6/21/2011		6/23/2011		6/23/2011		6/23/2011	
					Duplicate QC Sample of SS06		Triplicate QC sample of SS06	
	Sacred Heart Range Firing Point		Silver Depository Range Firing Point		Silver Depository Range Firing Point		Silver Depository Range Firing Point	
EXPLOSIVES (µg/kg)	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**
RDX	23	U	23	U	23	U	23	U
Nitroglycerin	1400	U	1400	U	1400	U	1400	U
2,4,6-Trinitrotoluene	14	U	14	U	14	U	14	U
4-Amino-2,6-dinitrotoluene	23	U	23	U	23	U	23	UJ
2-Amino-4,6-dinitrotoluene	23	U	23	U	23	U	23	UJ
2,6-Dinitrotoluene	14	U	62	U	14	U	14	U
2,4-Dinitrotoluene	29	U	29	U	28	U	29	U
PETN	1700	U	1700	U	1700	U	1700	U

Notes:
U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection per QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).
QC = quality control
µg/kg = micrograms per kilogram

The field QC samples specified in the UFP-QAPP include rinsate, field blanks, field duplicates, and triplicates. Field duplicates, which consist of one soil sample split into two parts with each aliquot analyzed by the laboratory for the identical parameters, are collected to estimate sampling and laboratory analysis precision, including sample homogeneity. Precision is measured using routine and duplicate sampling results and is expressed as the relative percent difference (RPD). Calculation of the RPD is described in the UFP-QAPP.

The incremental duplicate/triplicate (also referred to as replicates) involves the collection of three individual samples from within the same sampling unit (routine sample, duplicate, and triplicate). Each sample of equal volume is comprised of the same number of unique increments. The collection of random increments from within the sampling unit is performed three separate times to create the routine, duplicate, and triplicate samples. This collection approach allows the comparison of relative standard deviation (RSD) between the three incremental sample results for the same sampling unit to evaluate whether the sampling procedure was accurate. RPD can also be calculated for the incremental duplicate sample.

Matrix spike/matrix spike duplicate (MS/MSD) samples are the introduction of a known concentration of a compound into a sample to provide information about the effect of the sample matrix on the extraction and/or measurement methodology. MS/MSDs are reviewed as part of the data validation process and are discussed in the data validation narrative.

5.5.2.2.1 Field QC Samples and Sampling QC

Field QC samples were collected and assessed during the MMRP RI at West Point at a program-level based on the sample delivery groups submitted to the laboratory for analysis. Some MRSs had one or very few soil samples, and samples were batched together where possible. Incremental replicates (duplicate and triplicates) were collected at the Artillery Firing Range MRS and represent field QC for other MRSs at West Point because of the similarities in past munitions use, soil types, and land use. The unique increments collected for incremental replicate samples were obtained by following the same path of travel that had been used to collect the primary sample.

High-quality MC data were collected at the Artillery Firing Range MRS as evidenced by the following parameters employed to assess data usability:

- Precision is represented as the RPD between measurements of an analyte in duplicate samples, or as the RSD when the number of samples exceeds two. The RPD and RSD were evaluated as part of the data validation task during the RI. Sample WPR07-SS02 was collected as a field duplicate of sample WPR07-SS01 from the Siege Battery MRS firing point, and the samples were analyzed in the sample delivery group with the Artillery Firing Range MRS samples. The pair of samples did not have reportable detects of explosive chemicals, and thus the RPDs were not calculated. Overall precision was assessed by evaluating the RSD between primary and replicate incremental samples, which accounts for both field and laboratory processing/analytical error. Incremental primary and replicate samples were collected from a sampling unit placed at a firing point within the Artillery Firing Range MRS (WPR01-SS06, WPR01-SS07, and WPR01-SS08). None of the three samples had reportable detects of explosive chemicals; therefore, the RSD could not be calculated and quantitatively evaluated. These data do not indicate a concern about the sampling or laboratory precision; however, the data usability parameter could not be quantitatively evaluated. This information is discussed in the data validation reports provided in **Appendix 5-J**.

- Accuracy was ensured by selecting appropriate data collection instruments, having clearly delineated instructions for their correct use, and following the sampling plan discussed in Section 3.13 of the Final RI Work Plan (WESTON, 2011a) and the UFP-QAPP (Appendix J) of the Final RI Work Plan. No deviations from the sampling plan were documented during the RI field activities **(Appendix 5-F and Appendix 5-I)**. Rinsate and field blanks were not obtained during the soil investigation because of the use of new, clean, dedicated disposable equipment (i.e., scoops, aluminum pans, and sterile gloves).

- Data representativeness at the Artillery Firing Range MRS was accomplished by implementing approved sampling procedures discussed in Section 3.13 and the UFP-QAPP (Appendix J) of the Final RI Work Plan. Incremental sampling reduces data variability and increases sample representativeness. No significant deviations from the sampling procedures were documented during the RI field activities (**Appendix 5-F and Appendix 5-I)**. However, incremental samples WPR01-SS06, WPR01-SS07, and WPR01-SS08 collected within the Artillery Firing Range MRS sampling unit had several increments (approximately 6 per sample) relocated because of obstructions observed in the field (e.g., stream, fence, paved roadway) that precluded collection where planned. Because the increment locations were randomly selected initially within the sampling unit, the impact to data usability relative to representativeness is considered minimal. Increment placement within the sampling unit and collection along a random meandering path was inconsistent with the approach detailed in the Final RI Work Plan that stated, "Increments will be collected using a systematic random approach." However, the simple random approach for sampling unit design that was employed is an equivalent approach supported by industry and USACE guidance, and all increment locations were sampled. Therefore, the impact to data usability relative to representativeness is considered minimal.

- Completeness was achieved because the number of locations (**Figure 5-7**) sampled equaled the number of planned sample locations as discussed in the Final RI Work Plan.

- Comparability of data sets generated for the project was obtained through the implementation of, and adherence to, the standard sampling procedures discussed in Section 3.13 and the UFP-QAPP (Appendix J) of the Final RI Work Plan. A review of the field daily reports (**Appendix 5-F**) indicated no deviations from standard sample management procedures.

The high-quality data meet the data quality objectives of the RI established in the Final RI Work Plan for the Artillery Firing Range MRS and provided in Section 5.2.4 of the RI Report. These data are sufficient to support the risk assessment and the evaluation of alternatives.

5.5.2.2.2 Data Validation Results

The data validation guidelines are listed in Section 5.4.3. The data validation package for the Artillery Firing Range MRS, including the validation report narratives for the MRS analytical results and a glossary of QA/QC terms and data qualifier codes, is provided in **Appendix 5-J**. The data validation guidelines ensure that all data meet uniform requirements for accuracy and determine the validity of the data. If the data quality parameters for the MRS-specific analyses did not meet the criteria of the EPA and DoD Quality Systems Manual (QSM) Version 4.2 or the laboratory standard operating procedure (SOP), a discussion of the implications regarding the guidelines was included in the data validation narrative.

No major issues were identified during data validation. The results for one of the replicate incremental samples for the Artillery Firing Range MRS showed two nondetects with elevated SQLs. These values were qualified as UJ due to poor photodiode array spectral match, which is a method routinely used for further identification of any detection above the limit of quantitation. A validation note consisting of an “H8” code was added to the UJ qualifier verifying that the analyte was not confirmed on a second dissimilar column or that the diode array spectrums did not match the library. These UJ values are considered estimated, but still usable data, which meet all remaining acceptance criteria. A number of sample results were below the detection limit and had an elevated intercolumn RPD; as a result, they were qualified with a nondetect, U.

Overall, the data validation showed that the data received from the laboratory were valid. The preceding data usability assessment (Section 5.2.2.2.1) determined the data are usable for assessing the environmental conditions related to MC. Sufficient usable data were available for the Artillery Firing Range MRS to meet the objectives of the RI and to complete the risk assessment.

5.6 RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS

5.6.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was performed for the Artillery Firing Range MRS. Based on the revised CSM in Section 5.8, the potential human receptors include West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

5.6.1.1 Data Evaluation

Sampling at the Artillery Firing Range MRS consisted of two incremental samples (plus 1 duplicate/triplicate pair) collected from areas historically defined as artillery firing points. One sample was collected at the Sacred Heart Cemetery Range firing point and the second sample (plus 1 duplicate/triplicate pair) was collected at the Silver Depository Range firing point. The samples consisted of a 0.5-acre sampling unit from which 30 increments were collected and analyzed for explosives (**Figure 5-7**). **Table 5-11** presents the analytical results for the Artillery Firing Range MRS surface soil incremental samples. No explosives were detected above the SQLs. Because elevated SQLs were reported in one sample, a human health risk evaluation was initiated as a conservative measure. A discussion of the results in relation to human health screening levels is provided in the following subsections.

5.6.1.2 Selection of Chemicals of Potential Concern

Typically, soil chemicals of potential concern (COPCs) are identified by comparing the maximum detected concentration of each chemical with the recommended human health screening value. All samples collected from the Artillery Firing Range MRS firing points were analyzed for explosives. All explosives in the surface soil incremental samples at Artillery Firing Range MRS were reported as U and UJ values, indicating the analytes were not detected above their reported SQLs.

To be conservative, a screening was performed to ensure the protectiveness of the SQLs. As presented in **Table 5-12**, the recommended human health screening value is the lowest human health NYSDEC value (NYSDEC, 2006). If a NYSDEC value was not available, the ORNL residential RSL (EPA, 2012) was used. For COPC screening purposes, noncarcinogenic RSLs were adjusted to correspond to a target hazard quotient (THQ) of 0.1 rather than 1. Thus chemicals with additive effects were not prematurely eliminated during screening. If RSLs were available for carcinogenic and noncarcinogenic endpoints and both ingestion and inhalation exposure routes, the lower (i.e., more stringent) value was used for the screening comparison.

The results presented in **Table 5-12** show that no explosives had SQLs above the recommended screening level used to assess baseline risk to human health. The nitroglycerin SQL exceeded its benchmark when using the risk-based screening level at a THQ of 0.1 (610 µg/kg).

Table 5-12
Human Health Soil Screening for MC,
Artillery Firing Range MRS Firing Points, West Point MMRP, West Point, New York

Analyte	WPR01-SS06 200-5727-6 6/23/2011 (Silver Depository)		WPR01-SS07 200-5727-7 6/23/2011 Dup of SS06 (Silver Depository)		WPR01-SS08 200-5727-8 6/23/2011 Trip of SS06 (Silver Depository)		WPR01-SS03 200-5727-3 6/21/2011 (Sacred Heart)		ORNL Residential RSL[a]		NYSDEC Residential SCO[b]	NYSDEC Unrestricted Use SCO[b]	Recommended Human Health Screening Value[c]		HH COPC?
Explosives (µg/kg)															
2,4,6-Trinitrotoluene	14	U	14	U	14	U	14	U	3,600	n	NBA	NBA	3,600	n	No
2,4-Dinitrotoluene	29	U	28	U	29	U	29	U	1,600	c	NBA	NBA	1,600	c	No
2,6-Dinitrotoluene	62	U	14	U	14	U	14	U	6,100	n	NBA	1,030	1,030		No
2-Amino-4,6-Dinitrotoluene	23	U	23	U	23	UJ	23	U	15,000	n	NBA	NBA	15,000	n	No
4-Amino-2,6-Dinitrotoluene	23	U	23	U	23	UJ	23	U	15,000	n	NBA	NBA	15,000	n	No
Nitroglycerin	1,400	U	1,400	U	1,400	U	1,400	U	610	n	NBA	NBA	610	n	No [d]
RDX	23	U	23	U	23	U	23	U	5,600	c	NBA	NBA	5,600	c	No
PETN	1,700	U	1,700	U	1,700	U	1,700	U	12,000	n	NBA	NBA	12,000	n	No

Notes:

[a] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (April 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.

[b] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html

[c] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the ORNL Benchmark was used.

[d] When using the ORNL RSL values, noncarcinogens were reduced by an order of magnitude to yield a risk-based screening level with a THQ of 0.1 to address the additivity of noncancer effects when there is exposure to multiple chemicals. However, because no other chemicals were detected, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg.

c = cancer effects at a target risk of 1.0E-06.
µg/kg = micrograms per kilogram.
n = noncancer effects, at a target hazard quotient of 0.1.
NBA = no benchmark available.
RSL = regional screening level.
SCO = soil cleanup objectives.
U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis using photo diode array confirmed that the analyte was not present.

No other chemicals were detected (i.e., no additive effects from multiple chemicals). Therefore, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg, which is above the nitroglycerin maximum SQL of 1,400 µg/kg.

5.6.1.3 Human Health Risk Assessment Summary and Conclusions

No evidence of military munitions was observed within the sampling units at the firing points. The sample results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs. Based on the results of the HHRA, the surface soil incremental samples did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

5.6.2 Ecological Risk Assessment

A focused Screening Level Ecological Risk Assessment (SLERA) was completed to assess the potential adverse impacts on current and future ecological receptors exposed to MC in surface soil at the Artillery Firing Range MRS. The assessment endpoint for the SLERA is the protection of local populations and communities of biota from exposure to explosive chemicals of potential ecological concern (COPECs) in soil. The revised CSM for the Artillery Firing Range MRS is presented in Section 5.8.

5.6.2.1 Ecological Screening Values

Average concentrations of chemicals detected in soil at the Artillery Firing Range MRS (based on incremental sampling) were compared to conservative ESVs selected to assess baseline risks during the RI. All chemicals detected in soil at concentrations greater than the ESV were considered to potentially adversely impact ecological receptors and were identified as COPECs. The ecological screening values are presented in **Table 5-9** and **Table 5-13**.

The ESVs used for comparison to chemicals detected in soil samples were obtained from the NYSDEC Remedial Program SCOs, EPA EcoSSLs, EPA Region 5 Resource Conservation and Recovery Act (RCRA) ESLs, information obtained from select ORNL guidance, and additional appropriate guidance, as necessary. The primary source for the recommended screening value was the NYSDEC value. If a NYSDEC value was not available, ecological screening values were selected in accordance with the hierarchy listed above.

If no value was established within the hierarchy presented in the Final RI Work Plan, additional research was conducted to identify ESVs during the development of the SLERA. ESVs were obtained for the following analytes: 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, nitroglycerin, PETN, RDX, and 2,4,6-trinitrotoluene (**Table 5-13**).

Table 5-13 Screening Level Ecological Risk Assessment Results for Soil

Analyte	Recommended Ecological Screening Value	Firing Point Sample Number	Maximum Detected Incremental Sample Value at the Firing Point[h]	Maximum Background Screening Value[i]	COPEC?
Explosives (µg/kg)					
2-Amino-4,6-dinitrotoluene	9,000[a,b]	all samples	23 UJ	N/A	N
4-Amino-2,6-dinitrotoluene	9,000[a,b]	all samples	23 UJ	N/A	N
2,4-Dinitrotoluene	1,280[c]	all samples except WPR01-SS07	29 U	N/A	N
2,6-Dinitrotoluene	32.8[c]	WPR01-SS06	62 U (31)	N/A	Y
Nitroglycerin	3,000[a,d]	all samples	1,400 U	N/A	N
PETN	170,000[a,e]	all samples	1,700 U	N/A	N
RDX	21,000[f]	all samples	23 U	N/A	N
2,4,6-Tinitrotoluene	70[a,g]	all samples	14 U	N/A	N

Notes:
µg/kg = micrograms per kilogram
[a]µg/kg/d = micrograms per kilogram per day, no observed adverse effect level (NOAEL).
[b]USACHPPM, 2005.
[c]EPA, 2003.
[d]USACHPPM, 2000.
[e]USACHPPM, 2001a.
[f]Kuperman et al., 2006.
[g]USACHPPM, 2001b.
[h]Second value is half of the detection limit.
[i]NYSDEC, 2005.
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).
U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection per QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

5.6.2.2 Habitat and Receptors

The Artillery Firing Range MRS, which encompasses 172.4 acres, is located on the northern edge of the West Point installation along Storm King Highway (State Highway 218) near the operational range areas. The Sacred Heart Cemetery Range firing point is located near the intersection of U.S. Highway 9W and State Highway 218. Although the firing point is located on West Point property, the location is outside the West Point installation fence and access to the area is unrestricted. The Silver Depository Range firing point is located adjacent to the Victor Constant Ski Slope along State Highway 218. The firing point is located on West Point property, the area is not fenced, and access is unrestricted once on-post. Over half of the Artillery Firing Range MRS has been disturbed through development of the area. The direction of the several range fans that fall within the boundary of the Artillery Firing Range MRS is towards the Crows Nest mountain to the north/northeast of the MRS. There are no wetlands within the MRS. Two surface water bodies (Sinclair Pond Brook and Crows Nest Brook) traverse the Artillery Firing Range MRS and drain towards the Hudson River.

Ecological receptors that could potentially be exposed to MC at the Artillery Firing Range MRS include terrestrial plants, terrestrial invertebrates, and terrestrial avian and mammalian species, including herbivores, omnivores, and carnivores. Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Artillery Firing Range MRS. Although habitat is present at West Point that could support threatened and endangered species, no threatened or endangered species are known to reside or breed within the areas sampled at the Artillery Firing Range MRS firing points. A list of the potential ecological receptors for West Point is presented in Section 5.1.1.6.5.

5.6.2.3 Screening of Chemicals of Potential Ecological Concern

The maximum detected values for incremental soil samples at the Artillery Firing Range MRS were compared to appropriate ESVs. At the firing point areas, one sample was collected at the Sacred Heart Cemetery Range firing point (WPR01-SS03), with another sample collected at the Silver Depository Range firing point (WPR01-SS06), which also included a duplicate and triplicate sample (WPR01-SS07 and WPR01-SS08).

Explosives were not detected at the firing points, and all but one result was reported with SQLs that were less than the selected ESV. In soil sample WPR01-SS06 collected from the Silver Depository Range firing point, the explosive compound 2,6-DNT was reported as a nondetect (U) with an SQL of 62 µg/kg, which is greater than the ESV. Because all firing point samples for 2,6-DNT were qualified as nondetects, half of the SQL (31 µg/kg) was used for comparison to the ESV (32.8 µg/kg) (**Table 5-13**). In addition, all sample results for 2,6-DNT at the firing points were less than the alternative no observed adverse effect level (NOAEL) value of 700 µg/kg for ingestion exposure for mammals (USACHPPM, 2006).

5.6.2.4 Uncertainty Assessment

Although all of the 2,6-DNT concentrations were reported as nondetect (U) values, one SQL exceeded the established conservative ESV. Because all samples were qualified as nondetects, half of the SQL was compared to the ESV. Using this method, the 2,6-DNT concentration was below the ESV and below alternative screening values. Because of the elevated SQLs observed in several samples collected at the program-level for the MMRP RI at West Point, a secondary spectral analysis was performed by the laboratory, which confirmed that no explosives were present. Therefore, it is assumed that 2,6-DNT is not present and does not pose a risk of exposure to ecological receptors in the firing point area.

5.6.2.5 Summary of Ecological Risk

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Artillery Firing Range MRS. No threatened or endangered species are known to be present within the area sampled at the Artillery Firing Range MRS. There is little to no potential for adverse ecological impacts from MC in surface soil at the Artillery Firing Range MRS based on the following reasons. Previous sampling performed during the SI in media associated with munitions did not indicate a risk was present. No UXO or DMM was identified during the RI to warrant further assessment, and sampling performed in the firing point area did not positively detect any explosive compounds. The SQL for 2,6-DNT in one sample was reported at a value greater than the conservative ESVs and was further evaluated. The SQL value was less than the alternative NOAEL value and, when considered at ½ of the reported value to assess risk, was below the conservative screening level (**Table 5-9** and **Table 5-13)**.

In addition, an elevated SQL for 2,6-DNT is not considered a potential risk to ecological receptors because there was no evidence of military munitions within the incremental sampling unit at the firing point. The chemical 2,6-DNT was not positively detected in any of the program-level MC samples collected at West Point to support the ongoing RIs, and the toxicological information indicates that 2,6-DNT would not be likely to persist in surface soil. The uncertainty associated with the estimated SQLs observed using Method 8330B analysis was minimized by obtaining secondary confirmation by spectral analysis that this compound was not present. The ecological habitat for the majority of the Artillery Firing Range MRS, particularly the northern portion, is not considered to be of high quality as a result of the development in the area. It is expected that ecological receptors would use other habitats within the surrounding area. The risk of exposure to COPECs for ecological receptors at the Artillery Firing Range MRS is considered to be minimal.

5.6.3 Preliminary Identification of Applicable or Relevant and Appropriate Requirements

A preliminary identification of ARARs is conducted during RI characterization. The ARARs are used as a "starting point" in determining remedial action objectives and the protectiveness of a remedy to be assessed in a feasibility study (FS).

As the RI/FS process continues, the list of ARARs is further refined. The ARARs are used to establish the appropriate extent of cleanup; to aid in scoping, formulating, and selecting proposed treatment technologies; and to govern the implementation and operation of the selected remedial alternative.

Pursuant to Section 300.400(g) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), a list of ARARs and other to be considered advisories, criteria, and guidance (TBCs) is developed for a site or sites to identify the requirements that may apply to response actions. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the NCP provide that the development and evaluation of remedial actions must include remedial alternatives to attain ARARs and to ensure protection of public health and the environment.

ARARs are defined as follows:

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

First, it is determined whether a requirement is applicable to the site. If a requirement is not applicable, then it is determined whether the requirement is relevant and appropriate. The procedure for determining whether a requirement is relevant and appropriate is a two-step process. First, to determine relevance, it is evaluated whether the requirement addresses problems or situations sufficiently similar to the circumstances of the proposed response action. Second, for appropriateness, the determination must be made about whether the requirement would also be well-suited to the conditions of the site. In some cases, only a portion of a requirement would be both relevant and appropriate. Once a requirement is deemed relevant and appropriate, it must be attained (or waived). If a requirement is not both relevant and appropriate, it is not an ARAR. The results of the selection process for the Artillery Firing Range MRS are provided in **Table 5-14**.

"Applicable requirements" and "relevant and appropriate requirements" are considered to have the same weight under CERCLA. Section 121(d) of CERCLA requires the attainment of federal ARARs and of state ARARs if the state environmental or facility siting laws are promulgated, are more stringent than federal laws, and are identified by the state in a timely manner.

Table 5-14 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments (Applicable or Relevant and Appropriate)
Action-Specific			
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	*Applicable* Identify when military munitions become a solid waste; and, if these wastes are also hazardous under this subpart or 40 CFR Part 261, identify the management standards that apply to these wastes.
NY Division of Water - Classes and Standards of Quality and Purity and EPA National Pollutant Discharge Elimination System	6 NYCRR §750-1.5 and 40 CFR Part 122.26	Establishes water quality standards, including classifications of New York waters and water quality criteria to protect the ground and surface water resources; and controls stormwater and effluent discharges, including toxic substances, into State waters.	*Relevant and Appropriate* For remedial alternatives where soil excavation activities are performed and require stormwater management. Construction activities disturbing one or more acres of soil must be authorized under the NY General Permit for Stormwater Discharges from Construction Activities.
Hazardous Waste Manifest System and Related Standards For Generators, Transporters and Facilities	6 NYCRR Part 372	Establishes standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its record keeping requirements.	*Applicable* In the event that hazardous waste is generated as part of a remedial alternative; for example, if MEC were removed and would need to be shipped (by a party other than the Army) as hazardous waste.
Waste Transporter Permits	6 NYCRR Part 364	Protects the environment from mishandling and mismanagement of regulated waste transported from the site of generation to the site of ultimate treatment, storage or disposal.	*Applicable* To any off-site transport and disposal of classified hazardous wastes, if generated as part of remedial alternative.
Air Quality Classifications and Standards	6 NYCRR Part 257-1.3 and 257-1.4	Designed to provide protection from the adverse health effects of air contamination; intended to protect and conserve the natural resources and environment.	*Relevant and Appropriate* In the event that a remedial alternative, such as soil excavation/grading, could impact ambient air quality for an extended period of time. The state regulation has 12-month average standards for dust levels from a specific source.

Notes:
CFR Code of Federal Regulations
NYCRR New York Codes, Rules and Regulations

CERCLA and the NCP also identify the TBC category, which includes nonpromulgated federal and state criteria, advisories, and guidance documents, which are also considered. TBCs do not have the same status as ARARs; however, if no ARAR exists for a substance or particular situation, TBCs may be used to ensure that a remedy is protective.

Generally, ARARs pertain either to contaminant levels or to performance or design standards to ensure protection at all points of potential exposure. ARARs are divided into three general categories: chemical-specific ARARs, location-specific ARARs, and action-specific ARARs. ARARs are identified and used by taking into account the following:

- Contaminants suspected or identified to be at the MRS.
- Chemical analysis performed or scheduled to be performed.
- Types of media (air, soil, groundwater, surface water, and sediment).
- Geology and other MRS characteristics.
- Use of MRS resources and media.
- Potential contaminant transport mechanisms.
- Purpose and application of potential ARARs and TBCs.
- Remedial alternatives considered for MRS cleanup.

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 an MRS. The preliminary ARARs are summarized in **Table 5-14.** MEC was not found during the RI in the Artillery Firing Range MRS, and there were only limited findings during construction activities in the northern portion of the MRS following the RI. No MC chemicals of concern were identified. It is anticipated that future remedial alternatives will not include on-site treatment or on-site storage (greater than 90 days); therefore, potential action-specific ARARs related to these activities were not considered applicable at this time.

Location-specific ARARs were not identified for the revised Artillery Firing Range MRS. Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. The Artillery Firing Range MRS does not contain any ecologically sensitive or unique areas. The Sacred Heart Cemetery and the historical rock walls are located in the southern parcel of the MRS. Based on the findings of the RI, it is anticipated that the remedial alternatives will not include activities that would impact these historical resources; therefore, potential action-specific ARARs related to these activities were not considered applicable at this time,

Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Chemical-specific ARARs are used to provide benchmarks with which to compare environmental sampling results for metals and explosives. Residential SCO values published in NYSDEC regulations (NYSDEC, 2006) would be considered chemical-specific ARARs for MC concentrations at the MRS. However, MC was not found at levels of concern (i.e., not detected) at the Artillery Firing Range MRS. Therefore, chemical-specific ARARs did not need to be carried forward based on the information available at the time of the RI. TBCs were identified for the Artillery Firing Range MRS (see Section 5.4.4).

NYSDEC participated in TPP 1 (General Project Introduction and Approach) and TPP 2 (Presentation of RI Field Work Approach). Discussions at TPP 1 and TPP 2 generally consisted of establishing which NYSDEC and EPA standards for MC would apply to the whole project (WESTON, 2011a). The RI reports will be presented at the TPP 3 meeting.

The ARARs will be further refined during future phases of work at the Artillery Firing Range MRS.

5.7 CONTAMINANT FATE AND TRANSPORT

The intent of this section is to describe the fate of contaminants in the environment and the potential transport mechanisms for MEC and MC identified at the Artillery Firing Range MRS. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to the migration mechanisms away from the source area. Although no MEC was found at the Artillery Firing Range MRS during the SI and RI field activities, UXO items were found during the construction activities in the northern portion of the MRS. Therefore, MEC fate and transport dynamics are discussed in Section 5.7.1.

Sampling was conducted to evaluate the potential MC impacts at the firing points. Based on the analytical data evaluation and the subsequent risk assessment performed for the RI, it was concluded that an MC risk is not present within the Artillery Firing Range MRS to provide the basis for a detailed discussion of MC fate and transport dynamics. These RI findings are consistent with the previous surface inspections and sampling conducted within the MRS during the SI. Fate and transport for MC is not applicable to the Artillery Firing Range MRS.

5.7.1 MEC Fate and Transport

Potential routes of migration include those physical processes that might result in movement or relocation of MEC from its original placement. If not removed, the MEC will have the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement and are active at the Artillery Firing Range MRS:

- Potential MEC being picked up or moved by a person(s).
- Disturbance of potential MEC during construction, excavation, or other soil moving activities.
- Natural processes such as erosion/deposition or frost heave.

Consistent with the preliminary CSM, the RI identified the following potential human receptors for the Artillery Firing Range MRS: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel. All of these potential receptors engage in activities at ground surface and may contact and subsequently transport MEC. Soil moving activities that may involve contact with and transport of MEC at ground surface and in subsurface soil, or involve the transport of MEC to the Artillery Firing Range MRS in construction fill material may be performed by MRS residents (e.g., gardening and construction) or by construction and installation personnel.

Over time, natural erosion of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, the process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of the wash).

In addition to erosion, buried objects have been known to move or migrate toward the surface during freezing and thawing cycles. This movement occurs when cold penetrates the ground, and the water below the buried objects freezes and expands, gradually pushing the objects upward. This phenomenon is often referred to as "frost heave" and is most likely to affect items buried above the frost line. Soil type influences the occurrence of frost heave. Gravel, sand, and clay are not typically susceptible to the process, whereas silty soil is susceptible. All soils in the Artillery Firing Range MRS are low to moderately susceptible to frost heave based on their capacity to retain moisture (see Section 5.1.1.4) and on the seasonally cold temperatures typical for the regional location of West Point. The Erie gravelly silt loam is poorly drained and moderately susceptible to frost heave; however, this soil type is found in only a very small portion of the MRS at the firing point area. The majority of the MRS consists of well to somewhat excessively drained soils that are not readily susceptible to frost heave. The maximum frost penetration depth for the region is 1.00 to 1.25 meters (approximately 3.28 feet to 4 feet) below ground surface (NOAA, 1978).

No MEC was observed during the RI field activities in the two noncontiguous portions of the Artillery Firing Range MRS (the firing point area and the northeastern area). No MD was observed in the firing point area, but MD was observed in the northeastern area of the MRS. After the RI, three UXO and one MD were identified during construction near the Keller Army Community Hospital in the northeastern area of the MRS. The UXO items were an 8-inch Butler projectile and two unfuzed 8-inch Parrott shells. The MD consisted of an 8-inch Butler projectile (concrete filled). The exact depth of the UXO items is unknown; however, the items are considered to have been found in the subsurface.

The firing point area of the MRS is partially developed as the location of the Sacred Heart Cemetery and has a southwest sloping topography and a moderate potential for erosion. The northeastern noncontiguous area is partially developed and includes housing, schools, the Keller Army Community Hospital, the ski slope, and the golf course, with undeveloped forested areas surrounding the golf course and the ski slope. The northeastern area has a varied topography with relatively flat/gently sloping areas with a low potential for erosion near the buildings and golf course. The ski slope and the undeveloped areas have steeper slopes and a greater potential for erosion. The UXO items identified within the northeastern area of the MRS are classified as small (less than 100 pounds) and capable of being moved by surface erosion. The UXO was identified above the frost line. The soils in the northeastern area are not readily susceptible to frost heave. Surface interactions such as wet/dry erosion have the potential to impact source material; however, frost heave is unlikely in the northeastern area.

No MEC or MD that could potentially be impacted by frost heave or erosion was identified within the firing point area.

There is the potential for surface erosion in the northeastern area of the Artillery Firing Range MRS, especially the undeveloped area with steep slopes where MD was identified. However, because of the development (buildings, roads, parking lots), erosion is unlikely in the developed areas. Burrowing biota might come in contact with residual MEC and MD because of the shallow depth of MEC observed during the RI, which was identified within the zone of biological activity.

5.8 REVISED CONCEPTUAL SITE MODEL

This section presents the revised MEC and MC CSMs for the Artillery Firing Range MRS based on the RI data and the previous information provided in the SI report. The preliminary CSMs are discussed in Section 5.2.1.

5.8.1 Revised Munitions and Explosives of Concern Conceptual Site Model

The Artillery Firing Range MRS was documented in the preliminary CSM as a 172.4-acre MRS comprised of two adjacent parcels (165.4 acres) in the northern portion of West Point, and one noncontiguous parcel (7 acres), located to the south of the main portion of the MRS. The MRS consists of two firing points, and portions of several range fans that overlap and extend northward towards the Crows Nest, which were used approximately from 1906 until the late 1930s. Operational ranges border the Artillery Firing Range MRS to the north and along a portion of the southern boundary. Several other MRSs at West Point included in the current RI border the Artillery Firing Range MRS to the northeast (Fort Clinton West MRS) and to the east (Lusk Reservoir MRS).

After completion of RI field work across all MRSs at West Point, an increase in MEC and/or MD densities was observed laterally extending across several MRS with overlapping ranges, including the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, and the Artillery Firing Range MRS. Based on the observed distribution of densities, and the type of MEC and MD recovered, the source of increased clustering and densities is related to the former target area at the Crows Nest in the northern extent of West Point. The Crows Nest impact area includes 42 acres of the Artillery Firing Range MRS in its northern extent where the MRS borders the Fort Clinton West MRS and the Lusk Reservoir MRS, and abuts the Crows Nest to the north. Although only MD was found during the SI and RI in the northern portion of the Artillery Firing Range MRS, the UXO discovered during construction events near the northern boundary of the MRS after the RI field activities was found in the delineated impact area.

Farther south within the main portion of the Artillery Firing Range MRS, only MD was found during the RI. Additionally, investigation activities did not recover any munitions-related items from the noncontiguous Sacred Heart Cemetery Range firing point area to the south.

Separating the northern 42-acre portion of the MRS where MEC and MD have been confirmed and the southern 123.4-acre portion of the MRS where MD has been confirmed from the original boundary of the Artillery Firing Range MRS would reduce the total acreage to the noncontiguous 7 acres (the Sacred Heart Cemetery Range firing point area) (see **Figure 5-9**). The revised CSM for the Artillery Firing Range MRS addresses each area separately (see **Figure 5-10, Figure 5-11,** and **Figure 5-12**).

5.8.1.1 Revised Munitions and Explosives of Concern Exposure Pathway Analysis

As described in Section 5.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered potentially complete when a source (MEC) has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered incomplete if any one of the three components (source, interaction, or receptors) is not present at an MRS.

5.8.1.1.1 Source

A MEC source is the location where MEC is situated or is expected to be found. Potential MEC source areas in the Artillery Firing Range MRS were considered to be UXO and MD in former range areas and DMM and/or MD at the firing point. High concentrations of MEC and MD were not anticipated within the MRS because the impact area for the former ranges included in the MRS was located on Crows Nest and not included within the Artillery Firing Range MRS boundary. Low concentrations of MEC, in particular UXO, were anticipated within the MRS as a result of misfires or undershots toward the former targets.

It is possible that MEC and MD may have been transported in fill material and placed within the Artillery Firing Range MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

Historical MEC and MD recovered within the Artillery Firing Range MRS were primarily associated with the MD removed during the 2009 TCRA and the MEC and MD removed during the 2009-2010 USMAPS construction. During the 2009 TCRA performed in advance of the USMAPS construction, no MEC items were recovered. The following MD items were recovered: two MK1A1 training hand grenades, two M21 practice hand grenades, ninety .30-06 caliber small arms blanks, one fragment of a 75mm HE projectile, one 37mm HE projectile fragment, and one expended carrier for signal illumination. During the USMAPS construction, two MEC items were recovered, one 3-inch Stokes mortar (unfuzed) and one 8-inch projectile (circa 1851), as well as eight small arms (7.62mm linked blanks). Five MD items were also recovered: two empty launch tubes for ground signal illumination, one 7.62mm fired blank, one 5.56mm fired blank, and one 105mm cartridge (empty).

During the SI survey activities, no MEC items were identified. MD items (consisting of a slap flare, signal flare, hand grenade fuze, several small arms blanks, and miscellaneous components) were identified throughout the Artillery Firing Range MRS. Over 340 subsurface anomalies were detected during the geophysical survey. These subsurface anomalies supplement survey data collected in 2001 in the northern portion of the MRS, which indicated that over 1,500 subsurface anomalies were present.

During the RI characterization coverage of 6.4 acres, 58 MD items were recovered from depths ranging between 0 inches and 10 inches bgs. No UXO or DMM was identified along the downrange areas or at the firing points. The MD was located in the larger of the two MRS noncontiguous areas, with no evidence of military munitions found at the Sacred Heart Cemetery Range firing point. The MD items included 49 fragments from unknown munitions, three slap flares, two MKII practice grenades (empty), one 4.6-inch Parrott round (empty), one rifle grenade (illumination), one M69 practice grenade, and one M18A1 rifle grenade (illumination) (see **Figure 5-8**). The remaining non-MD related material included 144 items classified as cultural debris, two no contacts, and two quality control seeds. These items were recovered between the surface and 9 inches bgs. These items are consistent with the historical information about munitions findings in the Artillery Firing Range MRS.

After completion of the RI field investigations, four additional munitions were found in 2012 and responded to during construction events associated with the expansion of the Keller Army Community Hospital in the northern portion of the Artillery Firing Range MRS. These findings were included in the overall assessment of the MRS. Of the findings, one 8-inch Butler projectile and two unfuzed 8-inch Parrott shells were documented as UXO. The remaining item was documented as MD (a concrete-filled 8-inch Butler projectile).

The MEC and MD were recovered within the northeastern 165.4-acre portion of the Artillery Firing Range MRS. No MEC or MD was observed in the southwestern 7-acre firing point area of the MRS. The northeastern area of the MRS is split based on two separate concentrations of MD—a southern high concentration area (123.4 acres) and a northern high concentration area (42 acres). The increase in MEC and MD density observed within the northern 42-acre portion of the Artillery Firing Range MRS was also observed laterally extending across several MRSs, including the Fort Clinton West MRS, the Siege Battery MRS, and the Lusk Reservoir MRS. Based on the observed density distribution and the type of MEC and MD recovered, the source of increased clustering and densities is related to the former target area at the Crows Nest in the northern extent of West Point. The MEC sources for the northern 42-acre portion, the southern 123.4-acre portion, and the firing point 7-acre portion of the Artillery Firing Range MRS are discussed separately in the following subsections.

Northern Portion

Potential MEC source areas in the northern portion were considered to be UXO and MD in former range areas. In the northern portion of the Artillery Firing Range MRS, only MD was recovered during RI field investigations. After the RI, UXO was found in this portion of the MRS. Clustering of MD, including unidentifiable fragments and a 4.6-inch Parrott round, was observed in the northern portion of the MRS. This clustering is consistent with findings of clustering and increases in MEC and/or MD densities in the portions of the Fort Clinton West, Siege Battery, and Lusk Reservoir MRSs that are at the toe of the slope below Crows Nest. Therefore, a MEC source and thus explosive hazard is considered present in the northern portion of the MRS. The UXO and MD are attributed to the historical firing toward targets on Crows Nest. The delineated Crows Nest impact area includes the 42-acre northern portion of the Artillery Firing Range MRS. Based on the RI results from the four MRSs observed to be impacted by UXO and/or MD, the southern boundary for the Crows Nest impact area was determined to traverse the Artillery Firing Range MRS south of the Keller Army Community Hospital along Washington Road.

Southern Portion

Potential MEC source areas in the southern portion were considered to be UXO and MD in former range areas and DMM and/or MD at the firing point. The MD recovered during the RI did not confirm the presence of MEC. The MD recovered from the central and southern portions of the Artillery Firing Range MRS was consistent with the MD removed during the 2009 TCRA and the MEC and MD removed during the 2009-2010 USMAPS construction. Therefore, a MEC source and thus an explosive hazard are still considered present for the southern portion of the MRS. Qualitatively, the probability of MEC being present is low because no additional UXO or DMM was found during RI characterization and the investigation met all DQOs. The southern portion of the Artillery Firing Range MRS was delineated to encompass 123.4 acres, including the golf course and the former Silver Depository Range firing point.

Firing Point Area

Potential MEC source areas in the firing point area were considered to be UXO and MD in former range areas and DMM and/or MD at the firing point. At the former Sacred Heart Cemetery Range firing point area south of the main portion of the Artillery Firing Range MRS on the noncontiguous parcel, no evidence of military munitions was observed during the RI. Only one MD item was found during the preceding SI. Therefore, no MEC source and thus no explosive hazard are anticipated to be associated with the 7-acre firing point area of the MRS.

5.8.1.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes both access and activity considerations. Access describes the degree to which a MEC source or an environment containing MEC is available to potential receptors. Activity describes the action by which receptors come in contact with a source. Typically, a receptor may contact MEC, if present, on the ground surface simply by walking. A receptor may contact MEC in the subsurface, if present, by performing intrusive activities.

The Artillery Firing Range MRS falls within all four land use zones at West Point (see Section 5.1.1.9) and is used for residential and military housing, academics, recreational and industrial uses. Specific details applicable to each of the portions of the Artillery Firing Range MRS delineated based on RI findings are presented in the following subsections.

Northern Portion

The northern 42-acre portion of the Artillery Firing Range MRS where UXO and MD were recovered, is located primarily within three land use zones: (1) Cadet Support; (2) Post Support; and (3) Recreational, Industrial, Field Training. This portion of the MRS is used for residential and military housing; academics, including the West Point Elementary School; and industrial uses, including Keller Army Community Hospital and a lumber yard. Small forested and undeveloped areas that may be used for recreational purposes are located throughout the northern portion of the MRS.

There are no plans to change the current land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the Artillery Firing Range MRS. Residential, academic, maintenance, and industrial activities in the northern portion of the Artillery Firing Range MRS may disturb subsurface soil, whereas recreational activities are typically limited to surface soil interaction. The undeveloped areas within the Artillery Firing Range MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

Southern Portion

The southern 123.4-acre portion of the Artillery Firing Range MRS where MD was recovered during the RI consistent with historical UXO discoveries, is located within all four land use zones: (1) Cadet Use; (2) Cadet Support; (3) Post Support; and (4) Recreational, Industrial, Field Training. This portion of the MRS is used for residential and military housing; academics including the USMAPS; recreational uses, including the West Point Golf Course, the USMAPS athletic field house, the Victor Constant Ski Slope and associated structures; and industrial uses, including the U.S. Treasury Depository, the laundry plant, maintenance shops, water tank, and the salt dome; and four closed solid waste landfills (the Motor Pool, Ski Lot, Motor Pool East, and the Organic Compost landfills). Small forested and undeveloped areas that may be used for recreational purposes are located throughout the southern portion of the MRS.

There are no plans to change the current land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the Artillery Firing Range MRS. Residential, cadet academics, maintenance, and industrial activities in the southern portion of the Artillery Firing Range MRS may disturb subsurface soil, whereas recreational activities are typically limited to surface soil interaction. The undeveloped areas within the Artillery Firing Range MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing in addition to the downhill skiing, golfing and cadet athletics. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

Firing Point Area

The 7-acre portion of the Artillery Firing Range MRS (the Sacred Heart Cemetery Range firing point) is located within the Recreational, Industrial, Field Training land use zone. No MEC or MD was recovered during the RI and only one MD item was previously located during the SI.

This portion of the MRS is partially wooded in the north and includes a portion of the Sacred Heart Cemetery in the south. Because of the proximity of the operational range area directly north of the 7-acre firing point parcel, general recreational activities (e.g., hiking, bird watching, cross-country skiing) are unlikely. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011). There are no plans to change the current land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the Artillery Firing Range MRS. Maintenance activities associated with the cemetery may disturb surface or subsurface soil.

5.8.1.1.3 Receptors

A receptor is an organism (human or ecological) that comes in physical contact with MEC. Potential human receptors that may be exposed to UXO in the northern and southern portions of the Artillery Firing Range MRS include West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel. In the 7-acre firing point area, human receptors are limited to West Point residents (adults and children), site visitors, installation personnel, maintenance workers, and contractor personnel.

Potential ecological receptors are presented in Section 5.1.1.6.5. The Artillery Firing Range MRS consists primarily of disturbed areas. The northern portion of the MRS is developed and includes roads, parking lots, various buildings, and some residential housing. It is unlikely that the majority of the ecological receptors would rely on the northern portion of the MRS for habitat. Vegetation within this portion is primarily the mowed lawn and trees that are characteristic of developed, landscaped areas.

It is likely that the southern portion of the Artillery Firing Range MRS and the Sacred Heart Cemetery Range firing point area provide habitat for some ecological receptors. Pockets of forested areas are located throughout the Artillery Firing Range MRS. Portions of the MRS that include sections of the golf course and the ski slopes contain spans of open, grassy space bordered by forested areas.

5.8.1.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to update the preliminary MEC CSM for the Artillery Firing Range MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS given current and anticipated future land users.

A statistical approach was taken for the characterization of the Artillery Firing Range MRS during the RI, and a portion of the MRS was investigated by geophysical surveys and intrusive investigations. No MEC was identified within the 6.4 acres of investigation coverage and intrusive investigation of anomalies during the RI field investigations. MD was identified at ground surface and in subsurface soils to a depth of 10 inches bgs. No munitions-related material was found within the 7-acre portion of the MRS that is the Sacred Heart Cemetery Range firing point.

5.8.1.2.1 Northern Portion

No MEC and only six MD items were recovered in the northern 42-acre portion of the Artillery Firing Range MRS. The MD included unidentifiable fragments and a 4.6-inch Parrott round. UXO items were found within this portion of the MRS during post-RI activities, and UXO items were found within the adjacent Fort Clinton West MRS near its border with the Artillery Firing Range MRS during the RI. The majority of these items are believed to be associated with an impact area for former targets on Crows Nest mountain, or imported in prior construction fill. Therefore, based on the results of the SI, RI field investigations, and the post-RI EOD reports available, a MEC source or explosive safety hazard is present in the northern portion of the Artillery Firing Range MRS. The MEC source might be related to historical range activities and the former targets on Crows Nest mountain, or be a result of transport to the Artillery Firing Range MRS in construction fill. Current receptor interactions, which are not anticipated to change, include residential, maintenance, and industrial activities. In the revised CSM for MEC, complete pathways are identified for surface and subsurface soils for all receptors having access to the northern portion of the Artillery Firing Range MRS (**Figure 5-10**).

5.8.1.2.2 Southern Portion

No MEC, but 52 MD items were recovered in the southern 123.4-acre portion of the Artillery Firing Range MRS. The MD found around the golf course and ski area included three slap flares, two MKII practice grenades (empty), one rifle grenade (illumination), one M69 practice grenade, and one M18A1 rifle grenade (illumination). The MD recovered from the central and southern portions of the Artillery Firing Range MRS was consistent with the MD removed during the 2009 TCRA and with the MEC and MD removed during the 2009-2010 USMAPS construction and MD observed during the SI. The MD found in the southern portion of the Artillery Firing Range MRS is consistent with the types of munitions used in an obstacle course scenario. All MD was found within the wooded area east of the golf course. No MD was found within the grids and transects closest to the golf course fairways. Therefore, based on the results of the SI and the RI field investigations, a MEC source or explosive safety hazard is present in the southern portion of the Artillery Firing Range MRS. This source could also be a result of historical range activities or the result of transport to the Artillery Firing Range MRS in prior construction fill. Current receptor interactions, which are not anticipated to change, include residential, maintenance, recreational, and industrial activities. Although MEC was identified only in the subsurface, MD was identified on the surface; therefore, the pathways for surface soils are considered complete. In the revised CSM for MEC, complete pathways for surface and subsurface soils are identified for all receptors having access to the southern portion of the Artillery Firing Range MRS (**Figure 5-11**).

5.8.1.2.3 Firing Point Area

No MEC or MD was found during the RI, and only one MD item was previously found during the SI in the 7-acre noncontiguous portion of the Artillery Firing Range MRS. According to historical documents, this portion of the MRS is the former Sacred Heart Cemetery Range firing point. Based on the results of the SI and the RI field investigations, it is not expected that a MEC source or explosive safety hazard is present in the firing point area related to historical range activities. Because no MEC source or explosive safety hazard has been identified, there are no current receptor interactions or anticipated interactions under future land use. The revised CSM for MEC identified incomplete pathways for surface and subsurface soils for all receptors having access to the Sacred Heart Cemetery Range firing point area of the Artillery Firing Range MRS (**Figure 5-12).**

5.8.2 Revised Munitions Constituent Conceptual Site Exposure Model

To supplement the historical data collected to evaluate MC during the SI and to assess MC based on the RI geophysical investigations, two sampling locations were selected to assess the potential MC contamination in soil at the Artillery Firing Range MRS. Sampling was conducted to investigate MC at the former Sacred Heart Cemetery Range and Silver Depository Range firing points that potentially contain MC. As depicted on **Figure 5-7**, two incremental samples and one duplicate/triplicate pair were collected at the firing points. The field replicates were collected for QC purposes. The incremental samples and the field replicates collected from the firing points were comprised of 30 increments collected over a 0.5-acre sampling unit area.

The MC sampling results are discussed in Section 5.5.2. The complete analytical results and the data validation reports are provided in **Appendix 5-J**. The analytical results were used to perform the HHRA and SLERA (see Section 5.6) and to update the preliminary CSM as needed.

5.8.2.1 Revised Munitions Constituents Exposure Pathway Analysis

The MC exposure pathway analyses for the Artillery Firing Range MRS are summarized in this section. As previously described in Section 5.2.1, each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. An exposure pathway for MC requires a source exposure medium (i.e., MC in soil), interaction (release mechanism and exposure route), and receptors. A pathway is considered complete when all components exist and imply potential risk. A pathway is considered potentially complete when data are required to determine whether the pathway is complete or incomplete. An incomplete pathway presents no associated risk and no further data are required.

5.8.2.1.1 Source

The investigation of anomalies detected during the RI without evidence of MEC or significant concentrations of MD with evidence of a release (e.g., soil staining) suggests that an MC source and the potential risk of encountering MC are not present in the Artillery Firing Range MRS due to UXO, DMM, or high densities of MD. MC sampling was not conducted based on the geophysical findings during the RI. A current MC source or significant MC related to MD was not identified during the SI, and further assessment was not recommended unless MEC was found. However, MC was assessed at the firing point to evaluate the potential for chemical release after firing and contamination of surface soil.

Northern Portion

No MEC sources were identified during the RI in the northern 42 acres of the Artillery Firing Range MRS, and MD that was found was consistent with previous investigation findings during the SI. Therefore, no samples were collected to assess MC in the northern portion of the Artillery Firing Range MRS. Based on the sample results and the risk screening conducted during the SI, the MD that has been delineated within this portion of the MRS is not providing a source of MC to the environment (TLI, 2007). However, because three UXO items were found after the RI field investigation and the MD characterized was found to be consistent with increased concentrations of MEC and MD found in the Crows Nest impact area, a MEC source to potentially release MC is present. MC was not specifically assessed in the northern portion of the Artillery Firing Range MRS during the RI based on the field investigation results and in accordance with the Final RI Work Plan (WESTON, 2011a). Sampling of surface soil was conducted within the delineated Crows Nest impact area (see Section 6.2.2 for additional information).

Southern Portion

UXO has been found historically during construction events in the southern 123.4-acre portion of the Artillery Firing Range MRS; however, no MEC sources were identified during the RI. The MD that was found was consistent with the SI findings. In accordance with the Final RI Work Plan, no samples were collected in the range area to assess MC associated with MD in the southern portion of the Artillery Firing Range MRS. Based on the sample results and the risk screening conducted during the SI, the MD characterized within this portion of the MRS and the MEC found historically are not providing a source of MC to the environment (TLI, 2007). During the RI, soil sampling for MC was performed at the Silver Depository Range firing point area, located within the southern portion of the Artillery Firing Range. Concentrations of explosive MC in soil indicative of a release were not identified. No explosives were positively detected in the primary sample collected. Elevated SQLs that exceeded the conservative screening levels used to evaluate risk during the RI were reported for two chemicals in one of the field replicates.

Firing Point Area

No potential MC sources are known to exist in the 7-acre firing point area near the Sacred Heart Cemetery. No MEC or significant densities of MD have been identified. During the RI soil sampling, concentrations of explosive MC in soil indicative of a release were not identified. No explosives were positively detected in the sample collected to characterize the Sacred Heart Cemetery Range firing point.

5.8.2.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes an exposure route with a release mechanism for impacted media. The Artillery Firing Range MRS is located within the four land use zones: (1) Cadet Use; (2) Cadet Support; (3) Post Support; and (4) Recreational, Industrial, Field Training. Once on the West Point installation, human and ecological receptors have unrestricted access to the MRS. A human or ecological receptor may encounter MC in soil through direct contact, including ingestion, inhalation, or dermal exposure routes.

Within the environment, fate and transport of MC in soil, if present, has the potential to be affected by secondary release processes such as wet/dry erosion, infiltration/leaching to groundwater, and food web interactions. These processes may result in the movement or transformation of MC within environmental media. Because a MC release in soil has not been identified associated with MEC or MD characterized at the MRS, no interactions are expected to exist at the Artillery Firing Range MRS that would expose receptors to MC contamination.

5.8.2.1.3 Receptors

Potential receptors for MC at the Artillery Firing Range MRS are the same as those presented in the revised MEC CSM in Section 5.8.1.1.3.

5.8.2.2 Munitions Constituents Exposure Pathway Conclusions

The analytical results from incremental samples collected and the risk assessment activities performed to support the RI were used to update the preliminary MC CSM for the Artillery Firing Range MRS. The updated CSM identifies complete, potentially complete, or incomplete source-receptor interactions for the MRS with regard to current and anticipated future land users.

5.8.2.2.1 Northern Portion

Biased soil sampling conducted during the SI, which assessed MC in the northern portion of the Artillery Firing Range MRS, did not indicate a release of MC associated with the MD (TLI, 2007). Sampling for MC during the RI was not specifically performed within the northern 42-acre portion of the Artillery Firing Range MRS (Crows Nest impact area) where MD was found during the SI and RI. MEC was found after the RI field activities. However, analytical sampling was performed during the RI in the portions of the Fort Clinton West MRS and the Siege Battery MRS where increased concentrations of MEC and MD were also found within the Crows Nest impact area (see Sections 2 and 3). Based on the analytical sampling results from the Crows Nest impact area, a release of MC in soil associated with increased concentrations of MEC and MD was not identified. The pathways for human and ecological receptors to contact MC are considered incomplete because no MC releases associated with the MEC and MD that has been characterized, and thus no potential MC exposure risks, are known to exist in the northern 42-acre portion of the Artillery Firing Range MRS (see **Figure 5-13**).

5.8.2.2.2 Southern Portion

Sampling for explosives only was conducted at the former Silver Depository Range firing point in the southern 123.4 acres of the Artillery Firing Range MRS during the RI because no MEC or visible evidence of a potential MC release was identified. Explosives were not detected in any of the soil samples, and the SQLs were determined to be protective of human health during the HHRA. The SQL for 2,6-DNT exceeded the project ESV, but not the NOAEL. The pathways for human and ecological receptors to contact MC are considered incomplete. There are no MC releases associated with the MD and historical MEC that have been characterized. Thus no potential MC exposure risks are known to exist in the southern 123.4-acre portion of the Artillery Firing Range MRS (see **Figure 5-14**).

5.8.2.2.3 Firing Point Area

Although no MEC or MD was found to be a potential source for MC within the 7-acre portion of the Artillery Firing Range MRS, sampling for explosive MC during the RI was conducted within the known firing point area. Explosives were not detected in the soil sample. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources or releases, and thus no potential MC exposure risks, are known to exist in the 7-acre firing point area for the Artillery Firing Range MRS (see **Figure 5-15**).

5.9 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT AND MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL

5.9.1 Munitions and Explosives of Concern Hazard Assessment

The CERCLA process for responding to releases or potential releases of hazardous substances includes the development of site-specific risk assessments appropriate to the requirements of a site. The results of the risk assessments are used to help site managers decide whether a response action is required and to support the risk management decisions that are made through the remedy evaluation, selection, and implementation process.

The CERCLA methodology for human health chemical risk assessment was not designed to address explosive safety hazards at MEC sites. In October 2008, the Technical Working Group for Hazard Assessment, which included representatives from DoD, Department of the Interior, EPA, and others, made available the technical reference document *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). The document was designed to be used as the CERCLA hazard assessment methodology for MRSs where an explosive hazard exists from the known or suspected presence of MEC.

As stated in Section 5.8.1, it was determined based on the RI results that the Artillery Firing Range MRS should be separated into three portions in accordance with the differences in the CSMs. The 7-acre firing point area, the 123.4-acre southern portion, and the 42-acre northern portions are identified as follows:

- The 7-acre firing point area is associated with the original MRS ID, Artillery Firing Range MRS (WSTPT-001-R-01).
- The 123.4-acre southern portion is associated with a new MRS ID, Artillery Firing Range South MRS (WSTPT-001-R-03).
- The remaining 42-acre northern portion is also associated with a new MRS ID, the 143.3-acre Artillery Firing Range North MRS (WSTPT-001-R-02).

Because the Artillery Firing Range North MRS includes acreage previously associated with adjacent MRSs, the MEC HA for the new MRS is discussed further in Section 6.6. The MEC HA, which was applied to the remaining portions, Artillery Firing Range MRS and Artillery Firing Range South MRS, as appropriate, is discussed below.

No MEC was identified at the Artillery Firing Range MRS during the RI field activities. As a result, the project team determined that the calculation of a MEC HA score was not warranted at the Artillery Firing Range MRS.

No MEC was identified at the Artillery Firing Range South MRS during the RI field activities; however, MEC items were identified during the 2009-2010 USMAPS construction. Therefore, a MEC HA score was calculated for the Artillery Firing Range South MRS.

The MEC HA is structured around three components of a potential explosive hazard incident:

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

Each of these components is assessed in the MEC HA by input factors for the Artillery Firing Range South MRS. The sum of the input factor scores falls within one of four defined ranges, called hazard levels. Each of the four levels reflects site attributes that describe groups of sites and site conditions ranging from the highest to the lowest hazards. The MEC HA hazard levels are as follows:

- Hazard Level 1 — Sites with the highest hazard potential. There might be instances where an imminent threat to human health exists from MEC.

- Hazard Level 2 — Sites with a high hazard potential. A site 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.

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

- Hazard Level 4 — Sites with a low hazard potential. A site compatible with current and reasonably anticipated future use. Level 4 sites typically have had a MEC cleanup performed.

The MEC HA fits into MMRP activities and the regulatory structure of CERCLA by addressing the NCP requirements to conduct site-specific risk assessments for threats to human health and the environment. The MEC HA does not directly address environmental or ecological concerns that might be associated with MEC (EPA, 2008).

The MEC HA guidance document (EPA, 2008) includes an automated workbook that develops site scoring through standardized input and formulas. As part of the RI, the automated workbook was used to provide a HA score. The following is a summary of the MEC HA scoring for the Artillery Firing Range South MRS:

Site ID: Artillery Firing Range South MRS	**Hazard Level**	**Category Score**
Current Use Activities	3	730

Source: EPA MEC HA Worksheet V.1.2, 2007.

The Artillery Firing Range South MRS has a Hazard Level Category of 3, which indicates the MRS has a moderate hazard potential. The presence of MEC at an MRS means that an explosive hazard may exist. Artillery Firing Range South MRS characteristics of a Hazard Level 3 MRS include the following:

- Intrusive activities that overlap with minimum depths of MEC located only in the subsurface.

- Former firing area.

Supporting MEC HA input information is provided in **Appendix 5-K.**

The UXO items that were reported after the RI field activities are included in the MEC HA developed for the Artillery Firing Range North MRS (see Section 6.6.1) because these items were found within the northern 42-acre portion of the Artillery Firing Range MRS delineated within the Crows Nest impact area.

5.9.2 Munitions Response Site Prioritization Protocol Scoring Update

The results from the RI were used to reapply the MRSPP to the MRS. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with CWM can be assigned to Priority 1 and no MRS with CWM can be assigned to Priority 8.

5.9.2.1 Northern 42-Acre Portion

Data and information relative to the northern 42-acre portion of the Artillery Firing Range MRS are included in application of the MRSPP to the Artillery Firing Range North MRS (see Section 6.6.2).

5.9.2.2 Southern 123.4-Acre Portion

Based on the MEC and MC characterization during the RI, the southern 123.4-acre portion of the Artillery Firing Range MRS is proposed to be designated as a new MRS within the Army Environmental Database – Restoration Module (Artillery Firing Range South MRS, WSTPT-001-R-03). MRSPP forms for the southern 123.4-acre portion of the Artillery Firing Range MRS not within the Crows Nest impact area are provided in **Appendix 5-L**. The MRS priority for the southern 123.4-acre portion is 4.

5.9.2.3 Firing Point Area

MRSPP forms for the 7-acre firing point area of the Artillery Firing Range MRS are provided in **Appendix 5-L**. The MRSPP for the 7-acre firing point indicates that there is no known or suspected hazard.

5.10 SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI activities conducted at the Artillery Firing Range MRS. The RI was conducted to determine the nature and extent of MEC and MC and to determine the potential hazards and risks posed to human health and the environment by MEC and MC. The RI also provided additional data to assist in determining what remedial alternatives, if any, are necessary. As a result of the characterization activities conducted at the Artillery Firing Range MRS, the objectives of the RI have been satisfied.

5.10.1 Summary of Remedial Investigation Activities

The preliminary CSM for the Artillery Firing Range MRS aided in developing data needs and DQOs as documented in the Final RI Work Plan (WESTON, 2011a). In general, the data needs and DQOs focused on characterizing the nature and extent of MEC and MC that may be present in the MRS because of activities at former artillery ranges. The characterization activities were used to gather information to evaluate whether there are unacceptable potential risks to human health and the environment associated with MEC and/or MC and to determine whether further action is required under the CERCLA process.

UXO Estimator was used to develop a statistically based characterization strategy. Geophysical surveys were performed at the Artillery Firing Range MRS between April and August 2011 to assess the nature and extent of MEC in the MRS. Both DGM (EM61-MK2) and mag and dig (White's all-metals detectors) surveys were performed as part of the RI field work. A total of 6.4 acres and a total of 202 anomalies were investigated as a result of geophysical surveys.

No MEC was observed in the Artillery Firing Range MRS during RI field activities. A total of 58 MD items were recovered at depths ranging between 0 inches and 10 inches bgs. No munitions-related material was observed within the 7-acre portion known as the firing point area, which is noncontiguous to the remaining acreage of the MRS. The MD items recovered included 49 fragments from unknown munitions, three slap flares, two MKII practice grenades (empty), one 4.6-inch Parrott round (empty), one rifle grenade (illumination), one M69 practice grenade, and one M18A1 rifle grenade (illumination).

The remaining non-MD related material included 144 items classified as cultural debris, two no contacts, and two quality control seeds. These items were recovered between depths ranging between 0 inches and 9 inches bgs. After the RI field activities, three UXO items (8-inch Butler projectile and two 8-inch Parrott shells) and one MD item (one 8-inch Butler projectile [concrete-filled]) were also recovered during construction projects within the northern portion of the Artillery Firing Range MRS. The discovery of these items was incorporated into the overall assessment of the MRS.

In accordance with the Final RI Work Plan (WESTON, 2011a), two sampling locations were selected to assess the potential MC contamination in soil through incremental sampling at the known firing point areas for the Artillery Firing Range MRS. Thirty increments were collected within 0.5-acre sampling units located at the Silver Depository Range and Sacred Heart Cemetery Range firing points. The samples were collected and analyzed to identify the presence of explosive MC (if any) and to fully characterize the nature and extent of MC. No explosives were detected in the samples. Elevated SQLs for one chemical (2,6-DNT) were further evaluated during the HHRA and SLERA.

5.10.2 Risk Assessment

The results of the HHRA showed that no MC was present that constituted a potential risk to human health, including current or future West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel. All explosives analytical results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs, and were observed below the project screening levels ultimately used to assess human health effects. Although the SQL reported for nitroglycerin was above the project screening level initially selected to assess a target HQ of 0.1, the lack of identified noncarcinogens allowed the screening level to be adjusted upwards to a assess a target HQ of 1.0. In the HHRA, it was determined that the nondetect SQLs reported by the laboratory were protective of human health.

There is little to no potential for adverse ecological impacts from explosives MC in surface soil at the Artillery Firing Range MRS because only the SQL for 2,6-DNT slightly exceeded the EPA conservative screening level. However, SQLs for 2,6-DNT were below the less conservative alternative screening value obtained to assess the NOAEL. When the SQL was considered at ½ of its reported value, the nondetect result did meet the ESV. Additionally, 2,6-DNT was not detected in any samples collected at the program-level at other West Point MRSs, and toxicological information indicates that this compound would not be likely to persist in surface soil. Therefore, the risk of exposure to COPECs for ecological receptors at the Artillery Firing Range MRS is considered to be minimal.

5.10.3 Revised Conceptual Site Model

The purpose of the CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and reasonably anticipated future land use activities at the MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, interaction (activity and access), and receptor. Based on the historical information reviewed and the data collected during the SI, the pathways for MEC exposure to all receptors were determined to be complete. Biased soil sampling conducted during the SI did not identify any releases of MC in soil that were attributable to the MD found within the MRS. The pathways for MC exposure for all receptors were determined to be incomplete.

The Artillery Firing Range MRS includes the Sacred Heart Cemetery Range and Silver Depository Range firing points, and portions of the overlapping artillery range fans from adjacent MRSs. Concentrations of MEC and MD were not anticipated within the MRS because the targets for the former range were on Crows Nest mountain and not included within the MRS boundaries, and the firing point area has been partially developed and reworked for the Sacred Heart Cemetery. Low concentrations of MEC were suspected in the form of UXO in the range fan area because of misfires or undershots toward the Crows Nest and DMM at the firing point areas.

It is possible that MEC and MD may have been transported in fill material and placed within the Artillery Firing Range MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal, and is mitigated by the installation-wide dig permitting program (pre-existing institutional control).

The information collected during the RI was used to update the CSM for both MEC and MC exposure at the Artillery Firing Range MRS.

5.10.3.1 Munitions and Explosives of Concern Exposure

A statistical approach was developed to assess the potential MEC density within the Artillery Firing Range MRS. UXO Estimator was used to develop the appropriate coverage necessary to make high confidence assessments. No MEC was found within the 6.4 acres where geophysical surveys and the subsequent intrusive investigation of anomalies were conducted. These results were then re-assessed in UXO Estimator. The statistical upper bound density of MEC was determined to be 0.458 MEC per acre based on the percentage of the area surveyed at the Artillery Firing Range MRS and the actual intrusive investigation results. This value was within the DQO target density of 0.5 MEC per acre, which means that the investigation was adequate to be 95% confident that there is less than 0.458 MEC per acre within the MRS. The UXO Estimator results indicated that a statistical potential for MEC may remain at the MRS. Therefore, further qualitative assessments regarding the presence/absence of a MEC source and explosive hazard were performed based on historical information and the spatial distribution of RI findings.

The MD characterized during the RI was found only on the larger of the two noncontiguous areas included within the boundary of the Artillery Firing Range MRS. After completion of RI field work across the MRSs at West Point, an increase in MEC and/or MD densities was observed laterally extending across several MRS with overlapping ranges, including Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. Based on the observed distribution of densities and the type of MEC and MD recovered, the source of increased clustering and densities is related to the former target area at Crows Nest in the northern extent of West Point. The impact area includes 42 acres of the Artillery Firing Range MRS in its northern extent where the MRS intersects the Fort Clinton West MRS and the Lusk Reservoir MRS, and abuts Crows Nest to the north. Only MD was found during the SI and RI in the northern portion of the Artillery Firing Range MRS. After the RI field activities, however, three UXO were found in the delineated impact area near the northern boundary of the MRS. Farther south within the main portion of the Artillery Firing Range MRS, only MD was found during the

RI. However, UXO was found in the southern portion of the Artillery Firing Range MRS during the USMAPS construction.

Separating the northern 42-acre portion of the MRS where MEC and MD have been confirmed and the southern 123.4-acre portion from the original boundary of the Artillery Firing Range MRS would reduce the total acreage to the noncontiguous 7 acres (the firing point area near Sacred Heart Cemetery). The revised CSM for the Artillery Firing Range MRS was subdivided to address each area separately.

5.10.3.1.1 Northern Portion

Based on the MD observed during the SI and RI, and the UXO findings in the MRS subsequent to RI field activities, a MEC source and thus an explosive hazard are present in the northern 42-acre portion of the Artillery Firing Range MRS (Crows Nest impact area). Finding MD in the northern portion is consistent with the MEC source identification in portions of the Fort Clinton West MRS, the Siege Battery MRS, and the Lusk Reservoir MRS delineated within the Crows Nest impact area. The southern boundary for the impact area traverses the Artillery Firing Range MRS south of the Keller Army Community Hospital and along Washington Street. In the revised CSM for MEC, complete pathways are identified for all receptors having access to the northern 42-acre portion of the Artillery Firing Range MRS delineated within the Crows Nest impact area.

5.10.3.1.2 Southern Portion

During the RI, 32 MD items were recovered in the southern 123.4-acre portion of the Artillery Firing Range MRS around the golf course and ski area. The MD included 24 fragments from unknown munitions, three slap flares, two MKII practice grenades (empty), one rifle grenade (illumination), one M69 practice grenade, and one M18A1 rifle grenade (illumination). An obstacle course located in the wooded area to the east of the golf course is on the operational range adjacent to the Artillery Firing Range MRS. All MD was found within the wooded area east of the golf course and is consistent with the types of munitions used in an obstacle course scenario. Therefore, based on the UXO found during the construction of USMAPS and the MD characterized throughout the southern portion of the Artillery Firing Range MRS during the SI and RI, a low probability of encountering a MEC source and thus an explosive hazard is present. Although MEC was identified only in the subsurface, MD was identified on the surface;

therefore, the pathways for surface soils are considered complete. In the revised CSM for MEC, complete pathways are identified for all receptors having access to the southern 123.4-acre portion of the Artillery Firing Range MRS.

5.10.3.1.3 Firing Point Area

Based on the one MD item observed during the SI in the 7-acre Sacred Heart Cemetery Range firing point area, and the lack of munitions-related material found during the RI, there is no MEC source and consequently no explosive hazard present at the firing point area. In the revised CSM for MEC, incomplete pathways are identified for all receptors having access to the 7-acre firing point area.

5.10.3.2 Munitions Constituents Exposure

In accordance with the Final RI Work Plan, MC assessment during the RI was limited to the firing point areas within the Artillery Firing Range MRS because no MEC indicative of a potential source for MC was observed during the geophysical surveys. No explosives were detected in soil samples collected from the firing points, and elevated SQLs reported for one chemical (2,6-DNT) above the ESV were found to be protective of ecological receptors during risk assessment. Consistent with the SI conclusions, the RI findings indicate that the MC exposure pathway is incomplete for current and future human and ecological receptors in all three portions of the Artillery Firing Range MRS.

5.10.4 Munitions and Explosives of Concern Hazard Assessment

An evaluation of the explosive hazard at the Artillery Firing Range MRS was to be prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). However, because no MEC was identified at the MRS during the RI field activities, the project team determined that the calculation of a MEC HA score was not warranted at the Artillery Firing Range MRS. No MEC was identified at the Artillery Firing Range South MRS during the RI field activities; however, MEC was identified during the 2009-2010 USMAPS construction. Therefore, a MEC HA score was calculated for the Artillery Firing Range South MRS. A score of 730 with a corresponding hazard level of 3 was calculated for the Artillery Firing Range South MRS.

The confirmed UXO discovered within the 42-acre northern portion of the Artillery Firing Range MRS subsequent to RI field activities is included in the Artillery Firing Range North MRS MEC HA provided in **Appendix 6-E**.

Despite the lack of MEC found during the RI surveys and anomaly investigations, qualitative assessment regarding a MEC source for the Artillery Firing Range MRS indicates that there is likely a source and an explosive hazard present in both the northern and southern portions of the MRS. Therefore, fate and transport dynamics pertaining to MEC are discussed as applicable to the Artillery Firing Range MRS.

5.10.4.1 MEC Fate and Transport

Potential routes of migration include those physical processes that might result in movement or relocation of MEC from its original placement. If not removed, the MEC will have the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement:

- Picking up or moving a potential MEC item by a person(s).
- Disturbance of potential MEC during construction, excavation, or other soil moving activities.
- Natural processes such as erosion/deposition or frost heave.

All human receptors with access to the Artillery Firing Range MRS may be at risk of contact with MEC at ground surface, and construction workers may encounter MEC while engaging in intrusive activities. Over time, the natural erosion of soil by the wind or by water (surface water or precipitation) that may result in the exposure of buried MEC is more likely to occur in the northern portion of the Artillery Firing Range MRS than in the southern portion. In the southern portion, a large percentage of the land is covered by thick vegetation. In the northern portion, significant development has occurred.

All soils in the Artillery Firing Range MRS are low to moderately susceptible to frost heave based on their capacity to retain moisture and on the seasonally cold temperatures typical for the regional location of West Point. The maximum frost penetration depth for the region is 1.00 to 1.25 meters (approximately 3.28 feet to 4 feet) below ground surface (National Oceanic and Atmospheric Administration [NOAA], 1978).

5.10.5 Uncertainties

The primary uncertainty for the RI is based on the statistical calculations performed using UXO Estimator. The survey coverage for the Artillery Firing Range MRS was determined by UXO Estimator so that at a 95% confidence level, a minimum MEC density of 0.5 MEC/acre was expected to be found at the survey area. Following the investigation, UXO Estimator was used to calculate the statistical upper bound density of MEC to be 0.458 MEC/acre at a 95% confidence level. The average MEC density within the Artillery Firing Range MRS was calculated to be 0.150 MEC/acre. Therefore, it is statistically possible that MEC may be present at the Artillery Firing Range MRS, especially within the 42 acres delineated within the Crows Nest impact area in the northern extent of the MRS and within the southern 123.4-acre portionwhere UXO was found during the pre-construction clearance for USMAPS. MEC may be present as a result of the Crows Nest impact area that was delineated (northern 42-acre portion only), misfires or undershots during former range use, or transport in fill material transferred to the Artillery Firing Range MRS from other portions of West Point.

Because the DQOs were met and no MEC was found during the RI field activities, the anticipated MEC density is low in the southern portion of the MRS. In the northern portion of the MRS, the anticipated MEC density is higher because of the UXO items found in the adjacent Fort Clinton West MRS during the RI and the UXO items reported in the Artillery Firing Range MRS and the Lusk Reservoir MRS after the RI field activities.

5.10.6 Conclusions and Recommendations

Based on the results of the RI field activities, the following conclusions were determined for the Artillery Firing Range MRS:

- A total of 6.4 acres were investigated at the MRS during the RI, exceeding the required spatial coverage needed to achieve a high statistical confidence to determine MEC density.
- MD was found in surface and subsurface soil to 10 inches bgs in the northern 42-acre portion of the MRS and in the southern 123.4-acre portion of the MRS. Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for these portions of the MRS.

- No MEC or MD was found and the DQOs for the project were met. An explosive safety hazard is not anticipated to exist in the 7-acre portion of the Artillery Firing Range MRS (the noncontiguous parcel of land that was a known firing point area). Incomplete MEC pathways were identified for surface and subsurface soils for all receptors having access to this portion of the MRS.

- MC pathways to potential receptors were determined to be incomplete.

The DQOs for the Artillery Firing Range MRS have been satisfied and the nature and extent of MEC and MC have been adequately characterized. It is recommended that the northern 42-acre portion of the Artillery Firing Range MRS that is associated with the Crows Nest impact area be transferred to the Artillery Firing Range North MRS (WSTPT-001-R-02). The Artillery Firing Range North MRS consolidates the areas of the Main Post that have increased concentrations of MEC and MD and are associated with the Crows Nest impact area. The recommendations, which are further documented in **Table 5-15** and **Figure 5-9,** are as follows:

- Revise the Artillery Firing Range MRS to the 7-acre Sacred Heart Cemetery Range firing point area.
- Transfer the northern 42-acre portion of the Artillery Firing Range MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS.
- Delineate as a separate MRS the remaining southern 123.4-acre portion of the Artillery Firing Range MRS where a complete MEC exposure pathway to potential receptors is present, but which is not within the Crows Nest impact area.

Table 5-15 Artillery Firing Range MRS Recommendations

Original Configuration		**Configuration Following Recommendations**	
MRS Name	**Area**	**MRS Name**	**Area**
Artillery Firing Range (WSTPT-001-R-01)	172.4	Artillery Firing Range (WSTPT-001-R-01)	7 acres
		Artillery Firing Range North (WSTPT-001-R-02)	143.3 acres (includes 42 acres from within the original boundaries of the Artillery Firing Range MRS)*
		Artillery Firing Range South (WSTPT-001-R-03)	123.4 acres

* The Artillery Firing Range North MRS acreage is a combination of areas from the Fort Clinton West MRS, the Lusk Reservoir MRS, the Siege Battery MRS, and the Artillery Firing Range MRS that have increased concentrations of MEC and MD associated with the Crows Nest impact area (see Section 6).

Adjusted Artillery Firing Range MRS (WSTPT-001-R-01)—Based on the conclusions, no further action under the MMRP is recommended for the remaining 7 acres of the Artillery Firing Range MRS (WSTPT-001-R-01). Future actions for the Artillery Firing Range MRS may include the preparation of a No Further Action Proposed Plan for public review followed by issuance of a Decision Document.

Artillery Firing Range North MRS (WSTPT-001-R-02)—The Artillery Firing Range North MRS is discussed in Section 6. It is recommended that the Crows Nest impact area be further evaluated for potential action in an FS to address hazards related to the presence of MEC. Sections 2 through 5 present details about the Crows Nest impact area that was identified within the original boundaries of the Lusk Reservoir, Fort Clinton West, Siege Battery, and Artillery Firing Range MRSs.

Artillery Firing Range South MRS (WSTPT-001-R-03)—Based on the MD found during the SI and the RI and the UXO found historically during a preconstruction clearance event for the USMAPS, an FS is recommended to further evaluate future response actions at the Artillery Firing Range South MRS.

SECTION 5
FIGURES

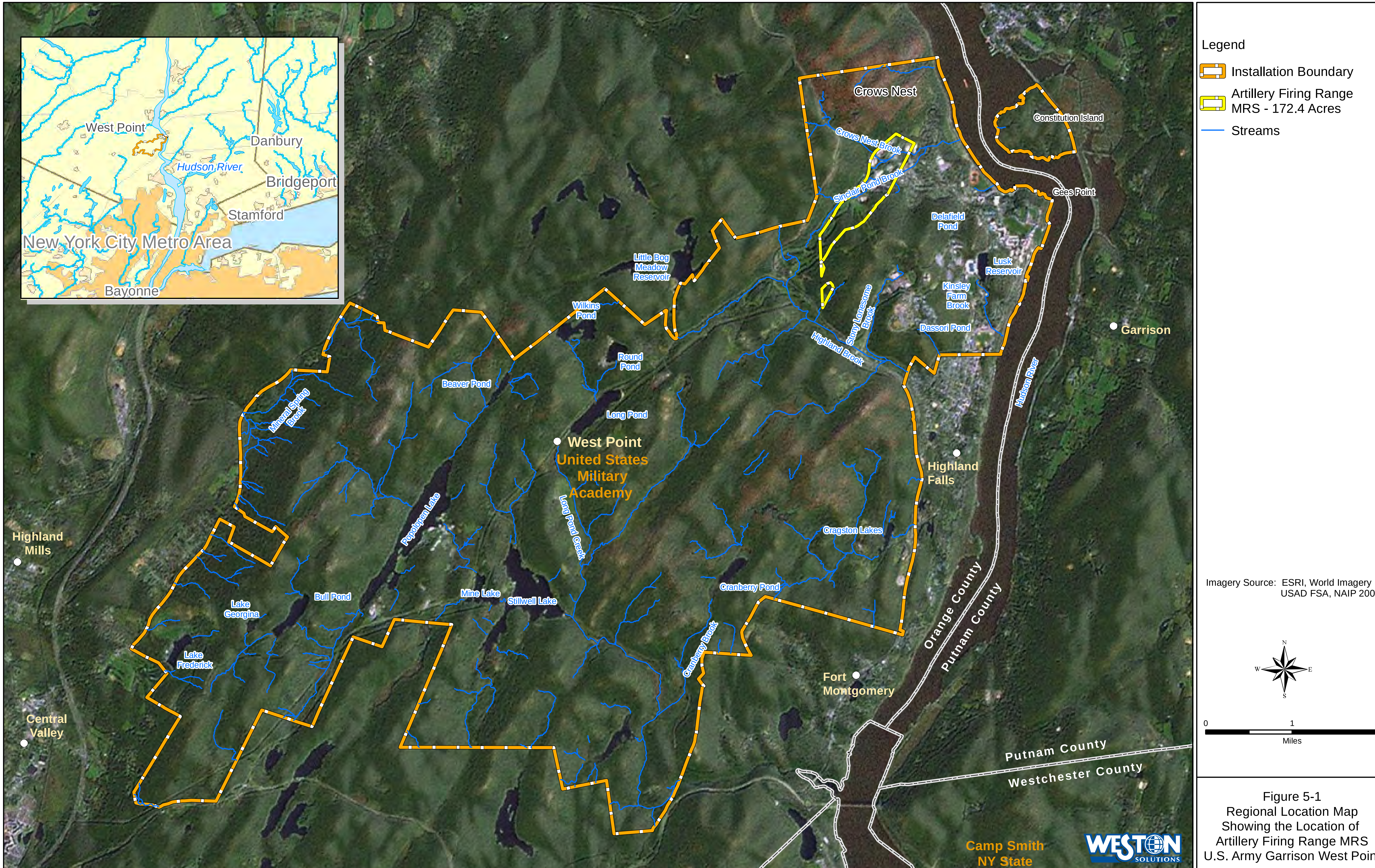
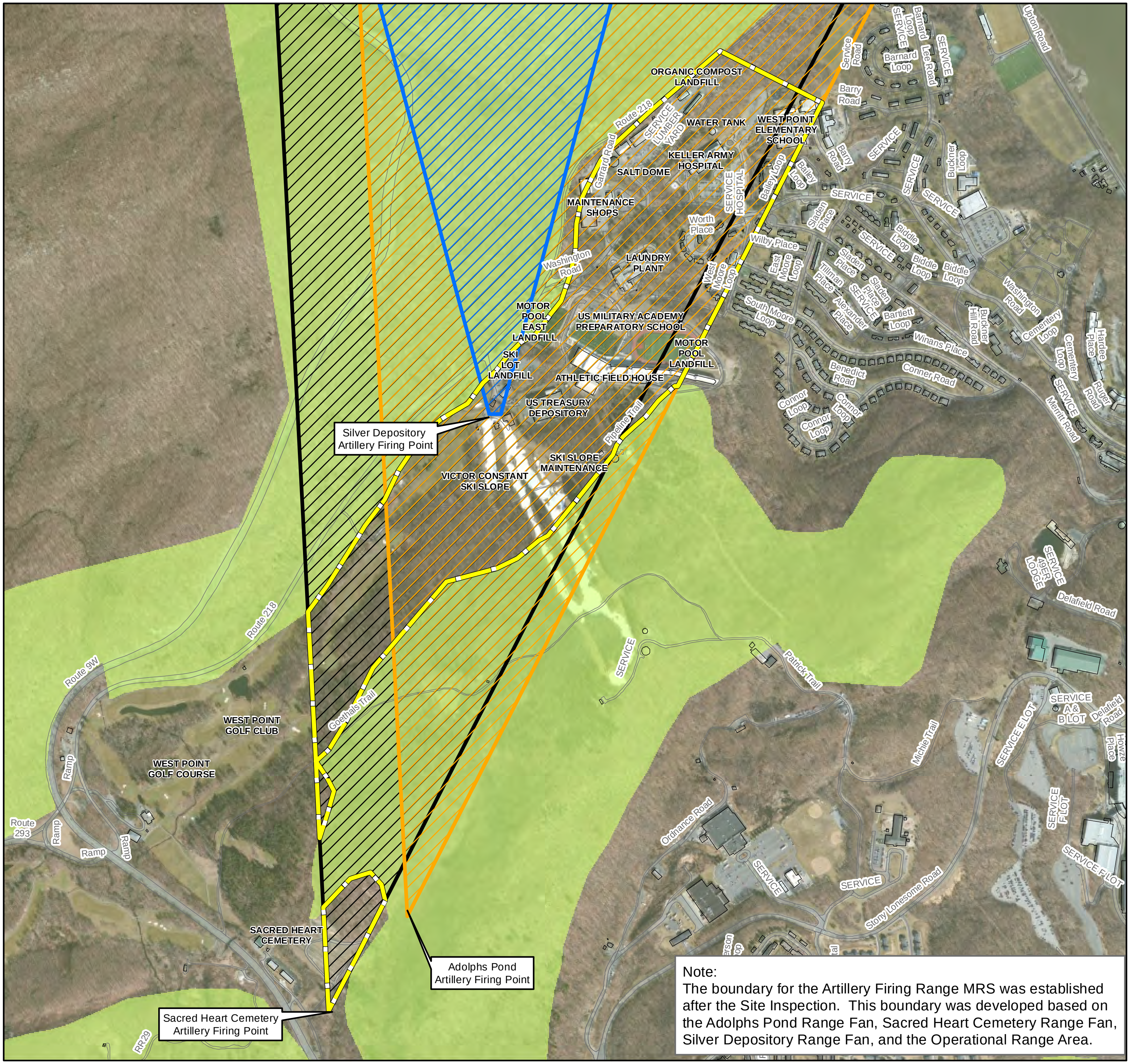


Figure 5-1
Regional Location Map
Showing the Location of
Artillery Firing Range MRS
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\Location Map.mxd, 2/28/2014 9:48:08 AM, johna



Legend

- Artillery Firing Range MRS - 172.4 Acres
- Adolphs Pond Range Fan
- Sacred Heart Cemetery Range Fan
- Silver Depository Range Fan
- Operational Range Area

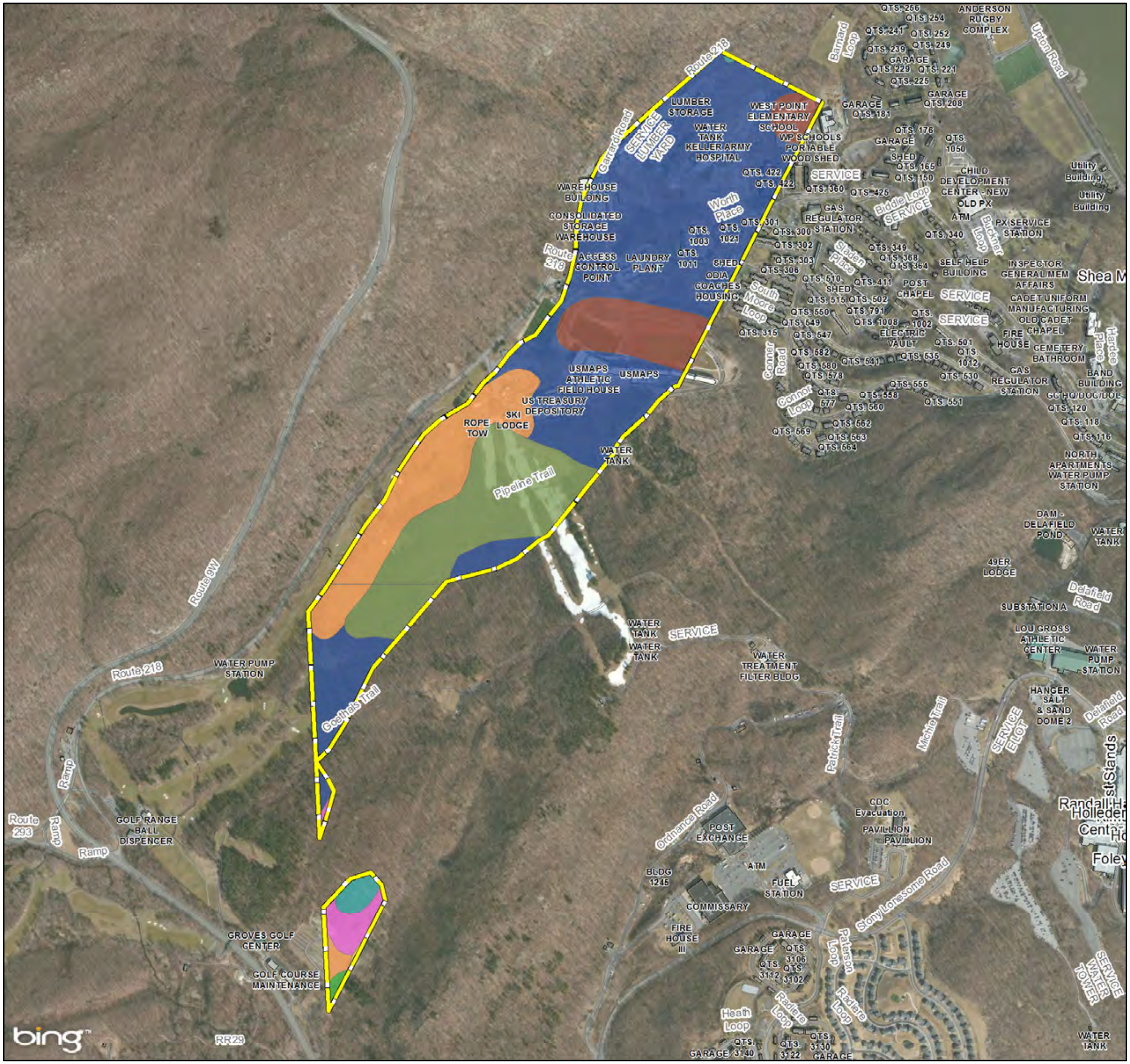
Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 550 1,100 Feet

Figure 5-2
Artillery Firing Range MRS
(WSTPT-001-R-01)
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\AFR.mxd, 11/3/2014 2:26:18 PM, ricksc

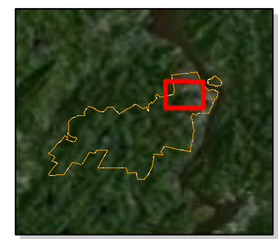


Legend

Artillery Firing Range MRS - 172.4 Acres

Artillery Firing Range Soil Series

- Charlton-Paxton complex, extremely stony, sloping
- Charlton fine sandy loam, 8 to 15 percent slopes
- Erie gravelly silt loam, 3 to 8 percent slopes
- Hollis soils, sloping
- Hollis soils, moderately steep
- Rock outcrop-Hollis complex, sloping
- Rock outcrop-Hollis complex, moderately steep
- Udorthents, smoothed



Imagery Source: ESRI, Bing Mapping Service. 2013

0 550 1,100 Feet

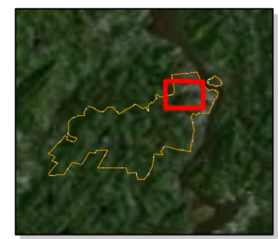
Figure 5-3
Artillery Firing Range MRS
(WSTPT-001-R-01)
Soil Series
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\AFR_soil.mxd, 12/17/2013 4:06:19 PM, ricksc

WESTON SOLUTIONS

Legend

- Artillery Firing Range MRS - 172.4 Acres
- MC Sampling Location
- Visual Survey
- Meandering Digital Geophysical Mapping Surveys



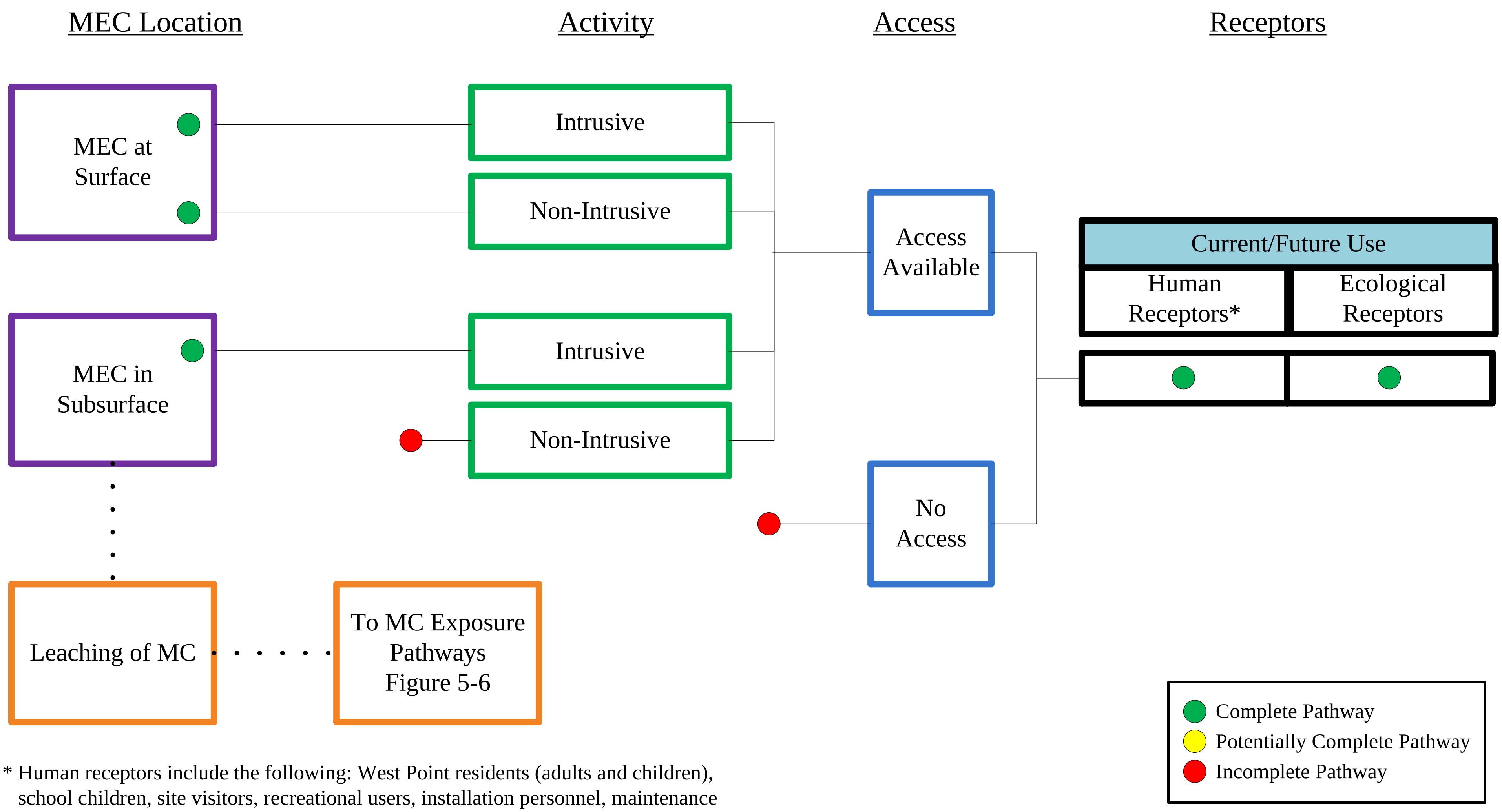
Imagery Source: ESRI, Bing Mapping Service. 2013

N E S W

0 550 1,100 Feet

Figure 5-4
Artillery Firing Range MRS
(WSTPT-001-R-01)
SI Results
U.S. Army Garrison West Point

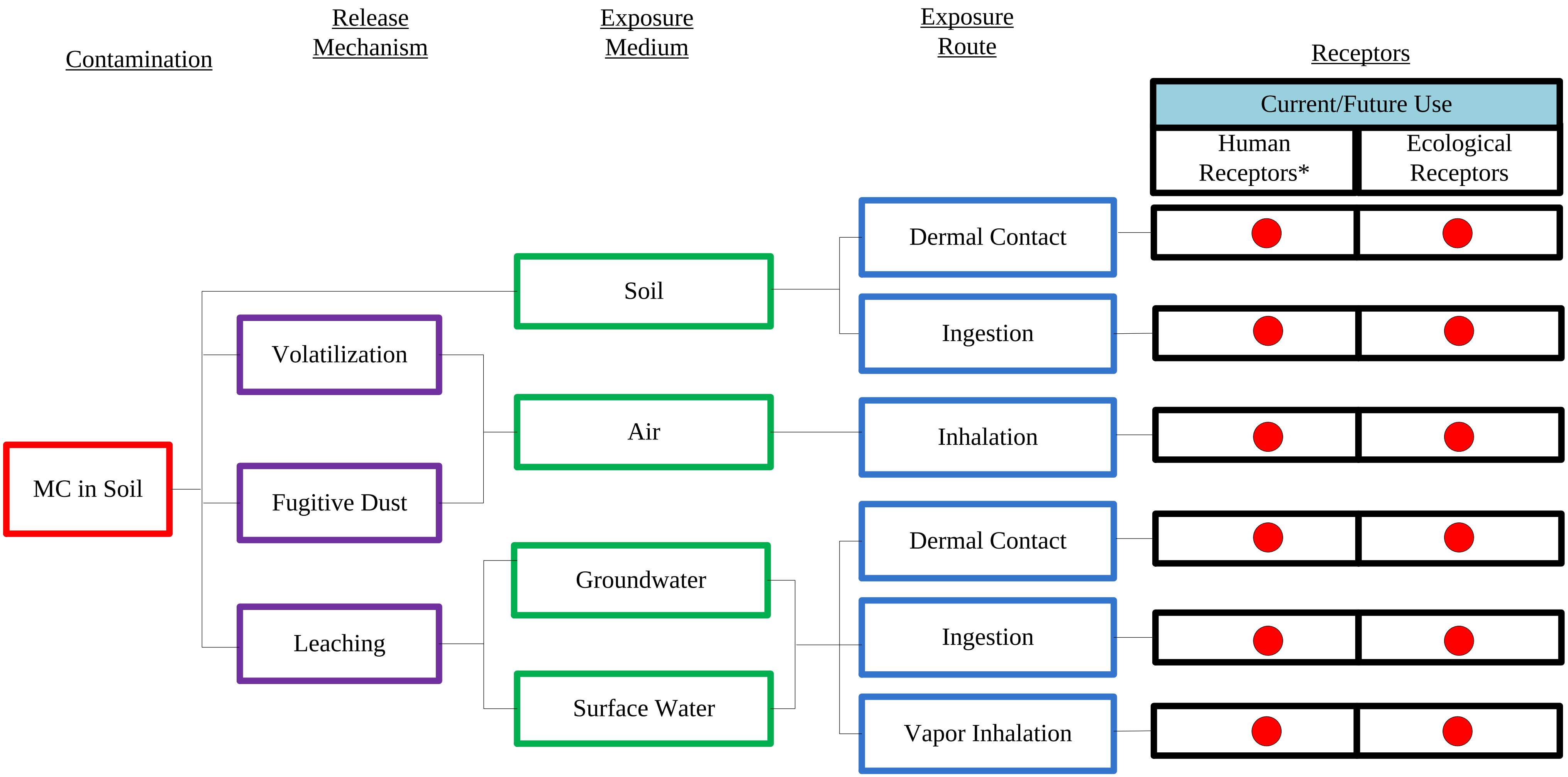
File: Y:\West_Point\mxd\RI\AFR_SI.mxd, 1/8/2014 5:07:07 PM, ricksc



* Human receptors include the following: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

Source: TLI Solutions, Inc., 2007.

Figure 5-5
SI Exposure Pathways for
Receptors to MEC, Artillery Firing Range MRS



* Human receptors include the following: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

Source: TLI Solutions, Inc., 2007.

- Complete Pathway
- Potentially Complete Pathway
- Incomplete Pathway

Figure 5-6
SI Exposure Pathways for
Receptors to MC, Artillery Firing Range MRS

Legend

Artillery Firing Range MRS - 172.4 Acres

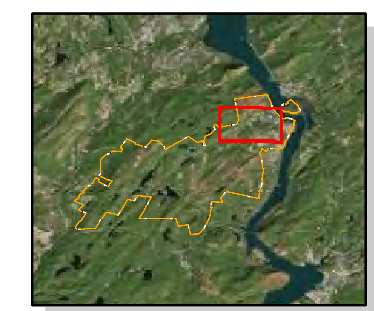
DGM Survey Area

Mag and Dig Survey Area

Sampling Unit

Mag and Dig Transects

DGM Transects



Imagery Source: ESRI, Bing Mapping Service. 2013

N S E W

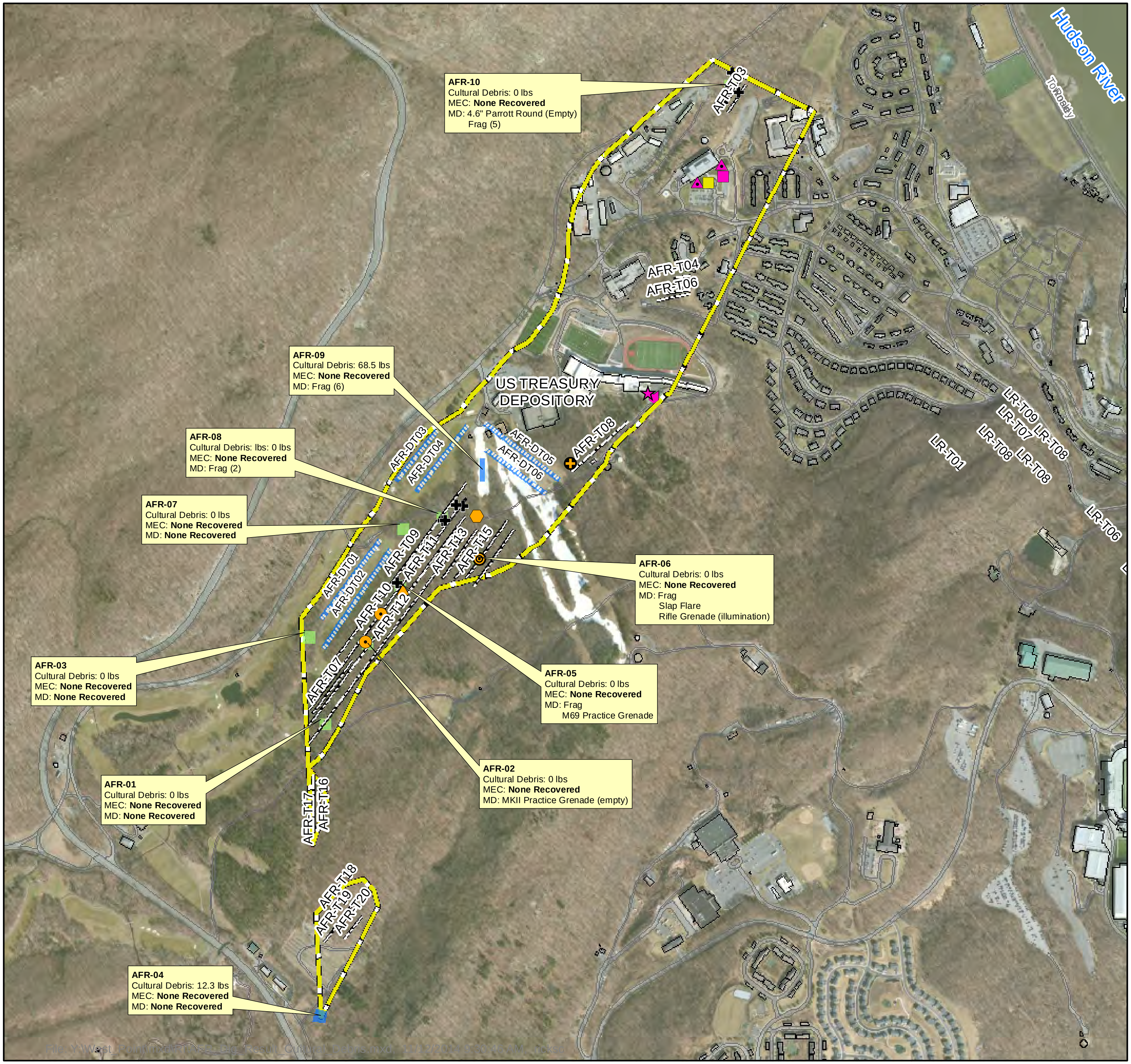
0 850

Feet

Figure 5-7
Artillery Firing Range MRS
(WSTPT-001-R-01)
Grid and Transect Locations
U.S. Army Garrison West Point

WESTON SOLUTIONS

Path: Y:\West_Point\mxd\RI\AFR_Grid_Transect_locs.mxd Author: ricksc 11/5/2014 2:20:19 PM



WESTON SOLUTIONS

Legend

- Artillery Firing Range - 172.4 Acres
- DGM Survey Area
- Mag and Dig Survey Area
- Mag and Dig Transects
- DGM Transects
- 4.6" Parrott Round (Empty)
- M18A1 Rifle Grenade (illumination)
- M69 Practice Grenade
- MD, MKII Practice Grenade (empty)
- Rifle Grenade (illumination)
- MD, Slap Flare
- Frag

Found During Construction Support

- 3" Stokes Mortar unfuzed
- 8" Projectile circa 1851
- 8" Butler Projectile
- 8" Parrott Shell (Unfuzed)
- MD, 8" Butler Projectile (Concrete Filled)

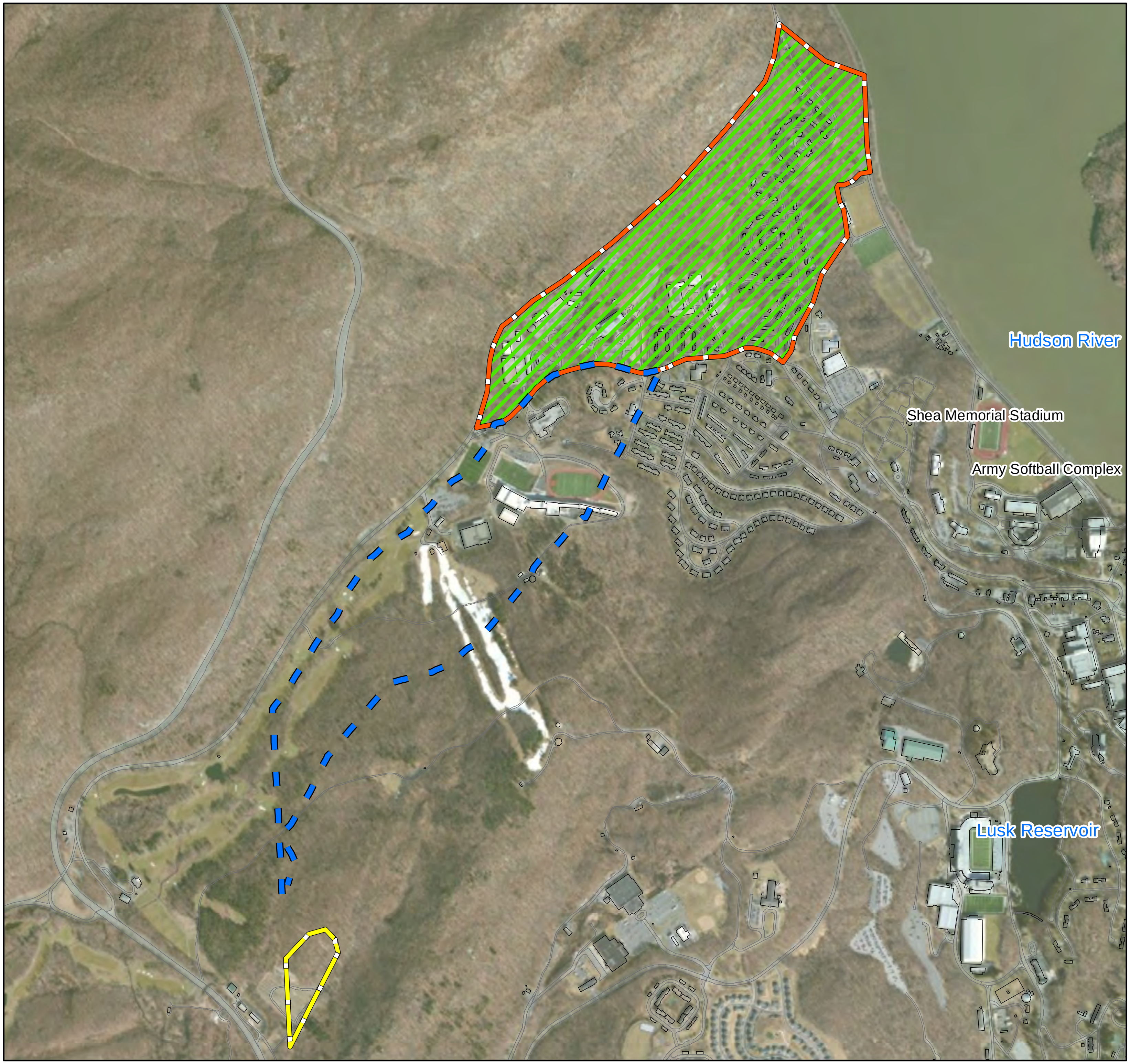
Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 1,100

Feet

Figure 5-8
Artillery Firing Range MRS
(WSTPT-001-R-01)
Original MRS Dig Results
U.S. Army Garrison West Point



WESTON SOLUTIONS

Legend

Artillery Firing Range (WSTPT-001-R-01) 7.0 Acres

Artillery Firing Range North (WSTPT-001-R-02) 143.3 Acres

Artillery Firing Range South (WSTPT-001-R-03) 123.4 Acres

Crows Nest Impact Area

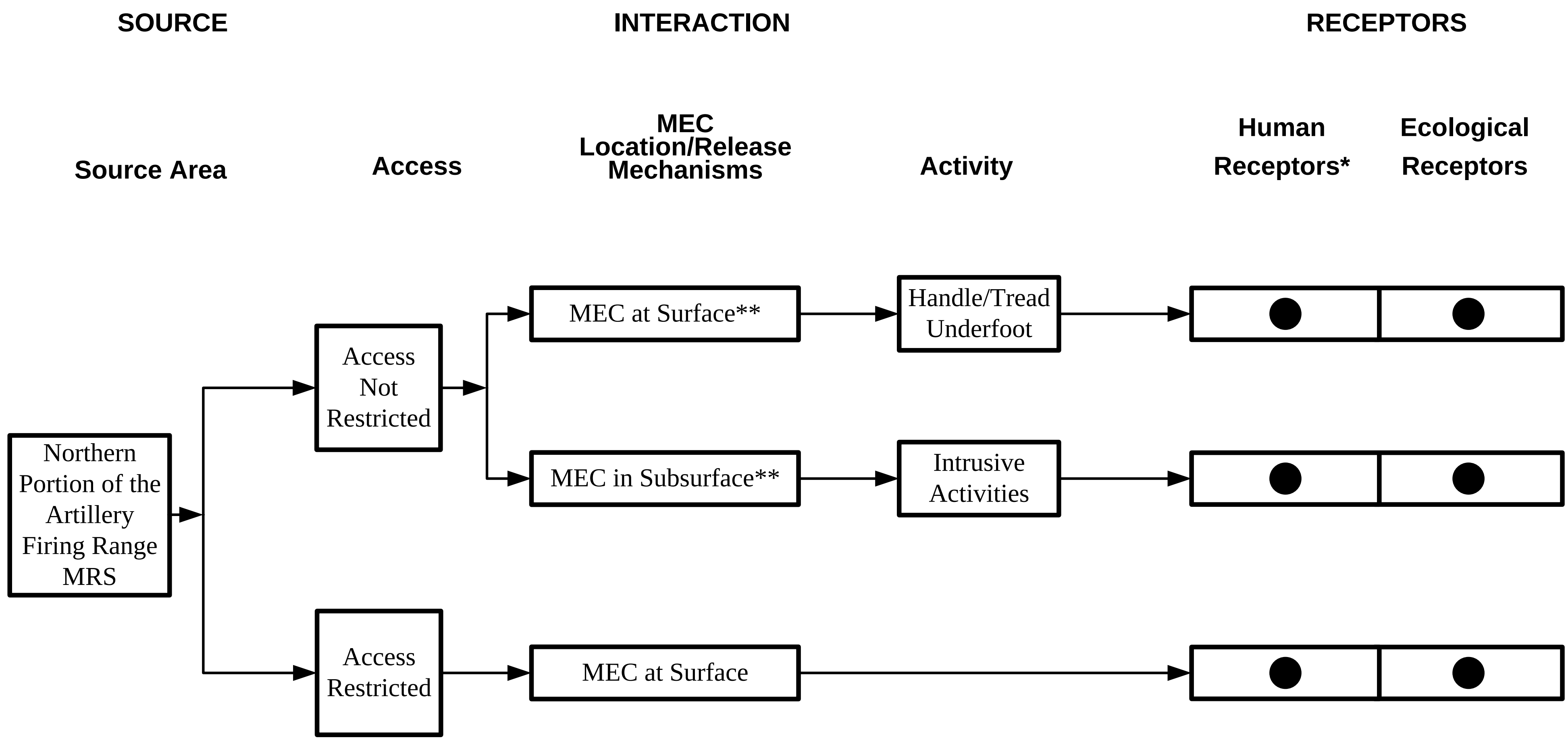
Imagery Source: ESRI, Bing Mapping Service. 2013

N
W E
S

0 650 1,300 Feet

Figure 5-9
Artillery Firing Range MRS
Revised Boundaries
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\AFR_Revised_MRS.mxd, 2/6/2015 10:51:37 AM, ricksc

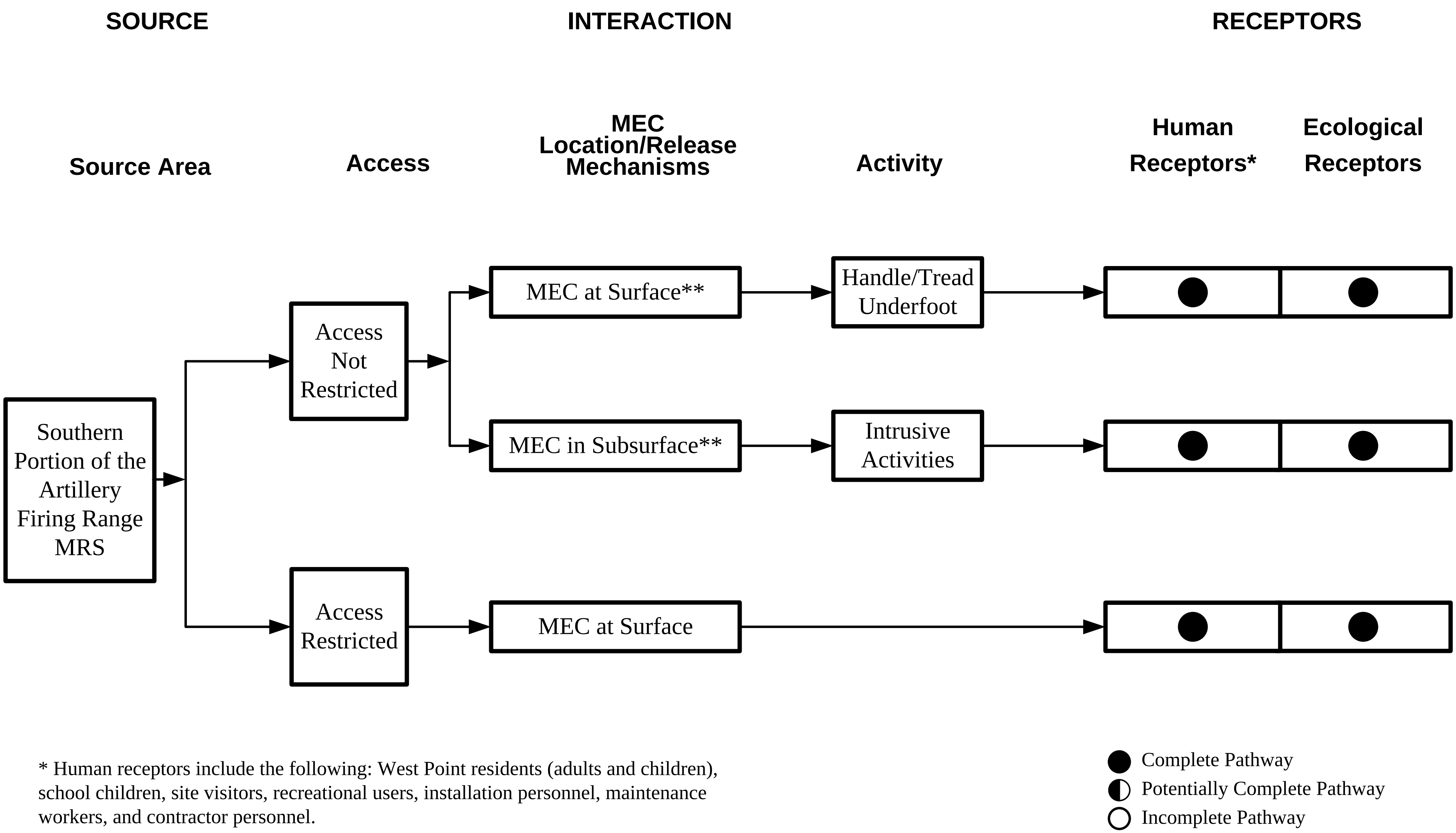


Complete Pathway
Potentially Complete Pathway
Incomplete Pathway

* Human receptors include the following: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

** No UXO was recovered during the RI. MD was recovered at ground surface and to 10 inches bgs. UXO was found after RI field activities during construction events.

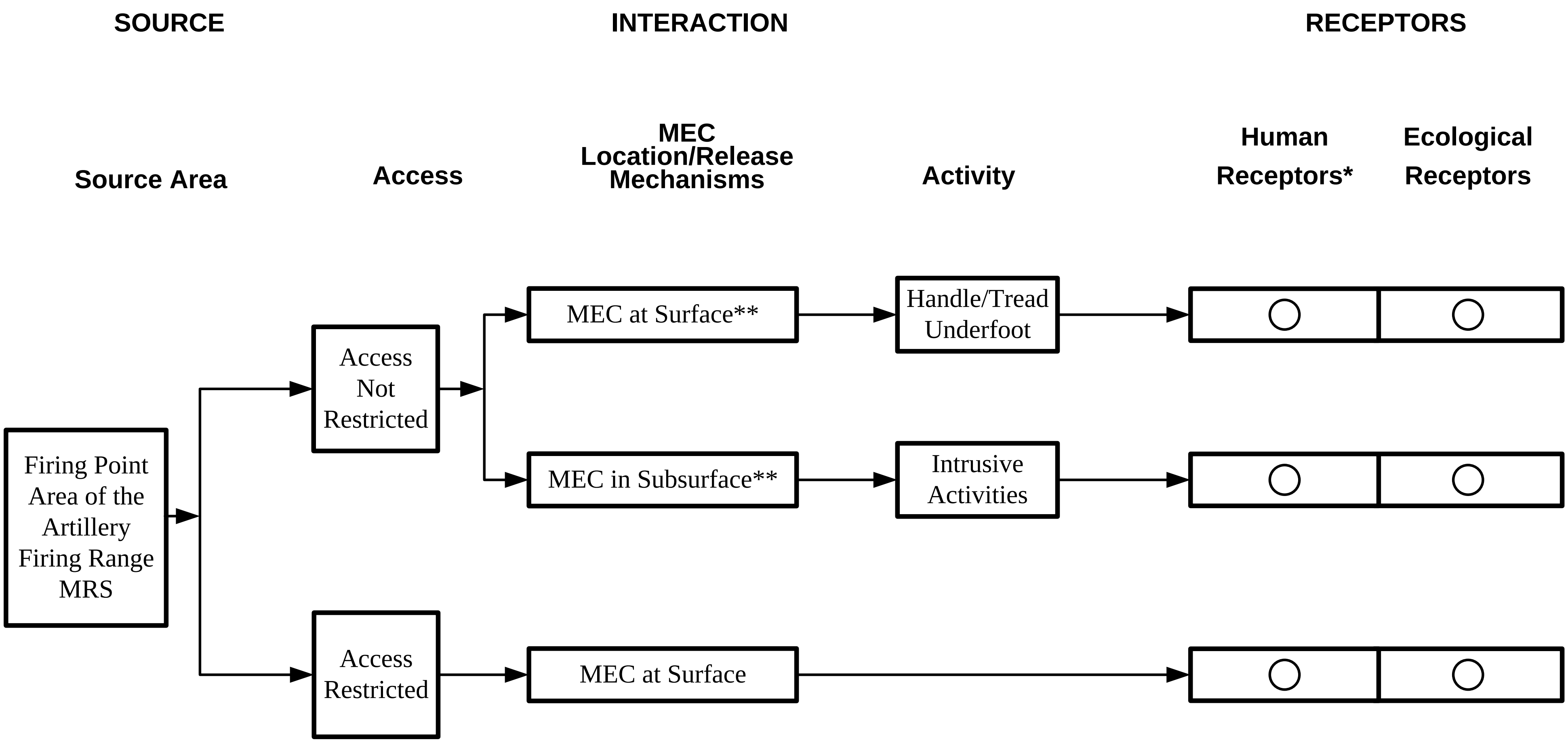
Figure 5-10
RI Exposure Pathways for Receptors to MEC in the Northern 42-Acre Portion (Crows Nest Impact Area) of the Artillery Firing Range MRS



* Human receptors include the following: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

** No UXO was recovered during the RI. MD was recovered at ground surface and to 10 inches bgs. UXO was recovered during historical pre-construction clearance for USMAPS.

Figure 5-11
RI Exposure Pathways for Receptors to MEC in the Southern 123.4-Acre Portion of the Artillery Firing Range MRS

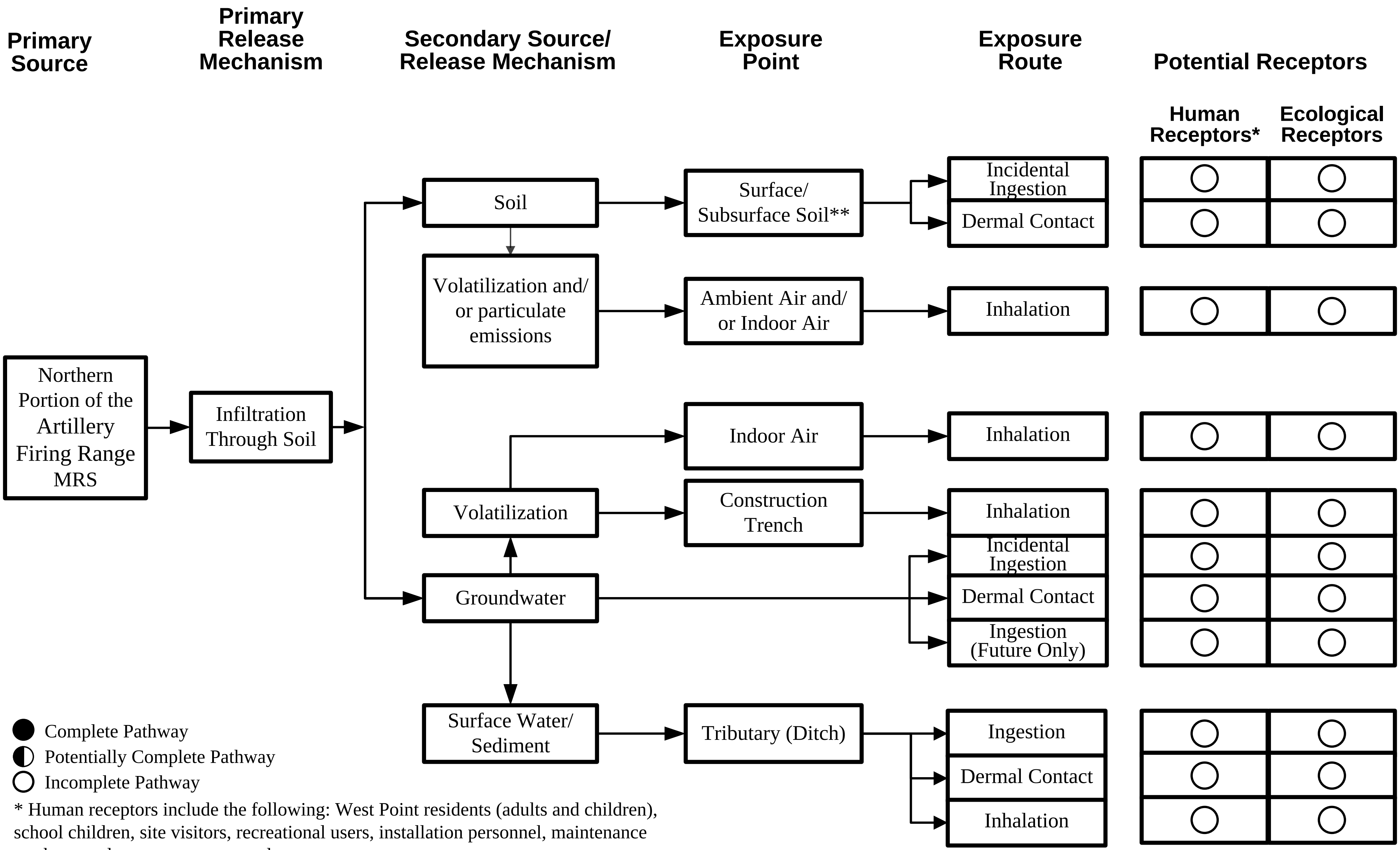


* Human receptors include the following: West Point residents (adults and children), site visitors, installation personnel, maintenance workers, and contractor personnel.

** No MEC or MD was recovered during the RI. One MD item was found during the SI at ground surface.

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

Figure 5-12
RI Exposure Pathways for Receptors to MEC in the Firing Point Area (7-Acre Portion) of the Artillery Firing Range MRS

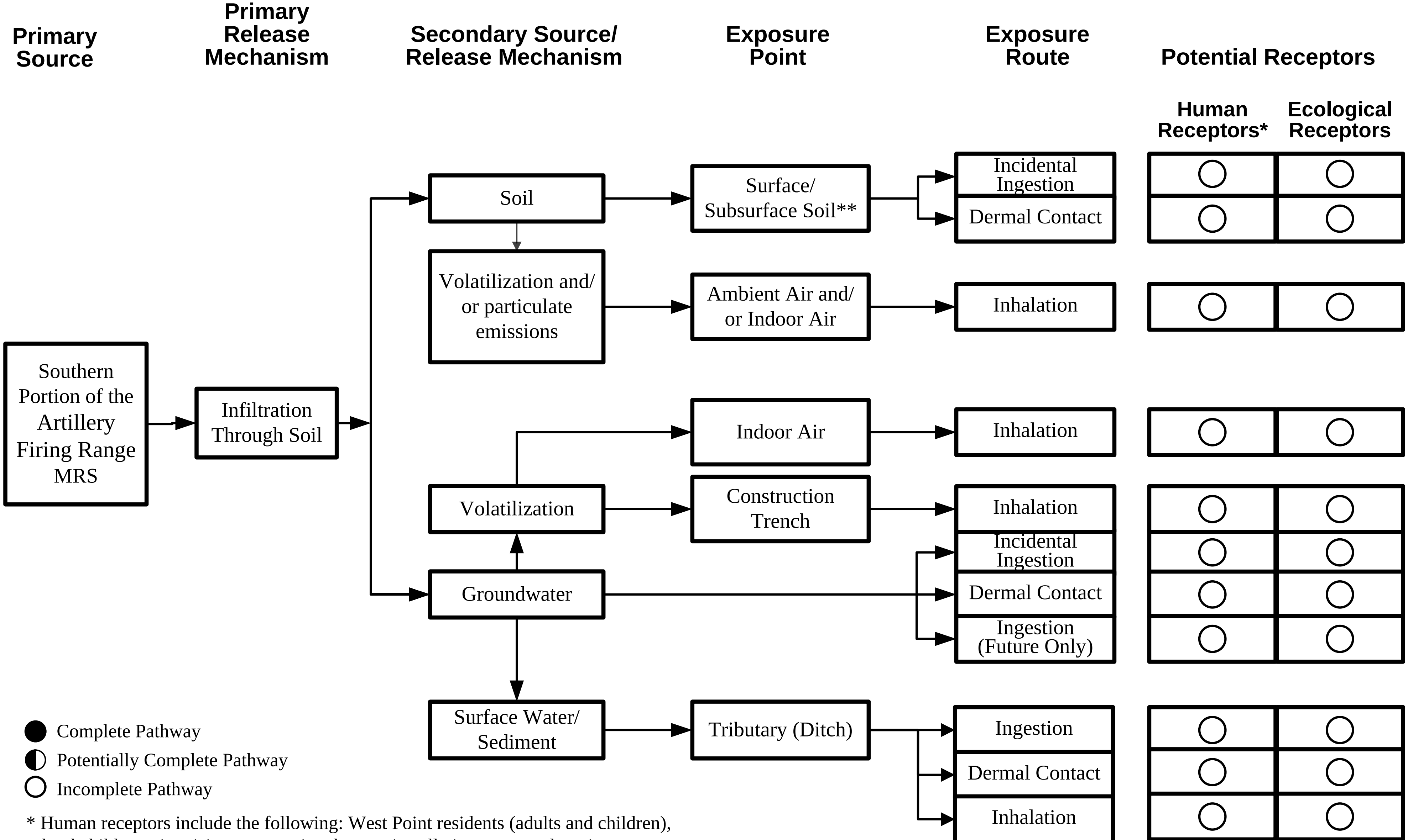


* Human receptors include the following: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

** No UXO was recovered during the RI. MD was recovered at ground surface and to 10 inches bgs. UXO was found after the RI field activities during construction events. MC assessment during the SI did not identify any releases in soil associated with the MD observed.

Figure 5-13

RI Exposure Pathways for Receptors to MC in the Northern 42-Acre Portion (Crows Nest Impact Area) of the Artillery Firing Range MRS



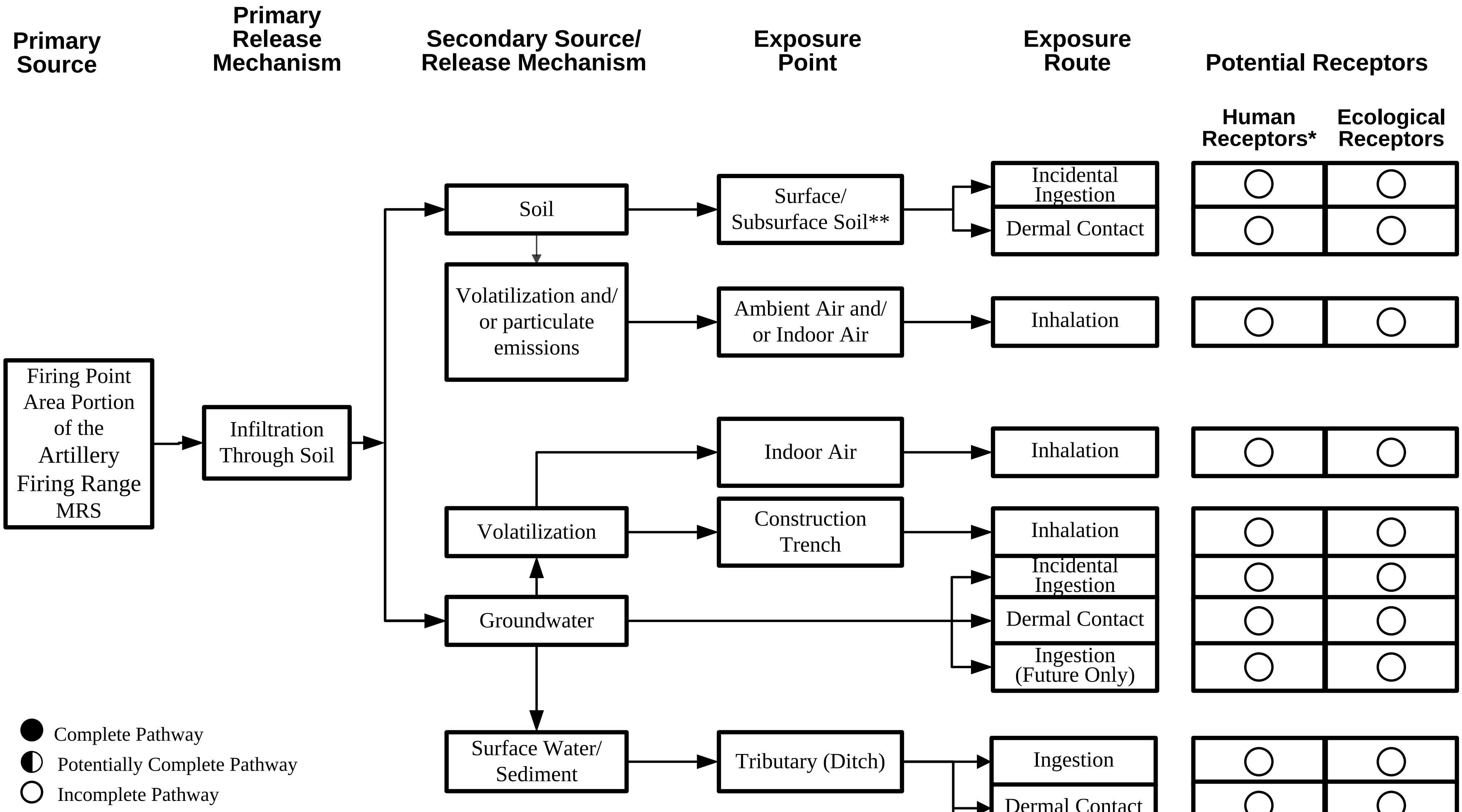
* Human receptors include the following: West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel.

** No UXO was recovered during the RI. MD was recovered at ground surface and to 10 inches bgs. UXO was recovered during historical pre-construction clearance for USMAPS. MC assessment during the SI did not identify any releases in soil associated with the MD observed.

Figure 5-14

RI Exposure Pathways for Receptors to MC in the Southern 123.4-Acre Portion of the Artillery Firing Range MRS

Fig 5-10 5-11 5-12 5-13 5-14 5-15 Artillery Firing Range Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), site visitors, installation personnel, maintenance workers, and contractor personnel.

** No UXO was recovered during the RI. MD recovered at ground surface and to 10 inches bgs. UXO was recovered during historical pre-construction MC assessment during the SI. The RI did not identify any releases in soil associated with the MD observed at a known firing point.

Figure 5-15
RI Exposure Pathways for Receptors to MC in the Firing Point Area (7-Acre Portion) of the Artillery Firing Range MRS

6. ARTILLERY FIRING RANGE NORTH MRS

6.1 INTRODUCTION

Based on the remedial investigation (RI) results and the conclusions detailed in Sections 2.10, 3.10, 4.10, and 5.10, it was determined that a new Artillery Firing Range North munitions response site (MRS) (WSTPT-001-R-02) should be created to aid in the characterization of the Crows Nest impact area. The new MRS includes 143.3 acres recommended for transfer from the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, and the Artillery Firing Range MRS because results indicative of a common conceptual site model (CSM) were observed across the boundaries of these four MRSs. Sections 2 through 5 present details about the Crows Nest impact area that was identified within the original boundaries of the Lusk Reservoir, Fort Clinton West, Siege Battery, and Artillery Firing Range MRSs.

Section 6 focuses on characterizing the nature and extent of hazards that are specific to the Artillery Firing Range North MRS. The results presented in Section 6 are a compilation of the results that were originally developed for the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs and that are relevant to the area of the new Artillery Firing Range North MRS.

6.1.1 Site Description

The Artillery Firing Range North MRS (WSTPT-001-R-02) encompasses 143.3 acres in the northern portion of the West Point installation south of the Crows Nest (see **Figure 6-1**). The West Point installation's northern boundary for West Point includes the southern slope of Crows Nest mountain (summit elevation approximately 1,400 ft above mean sea level [amsl]). Former targets were located on Crows Nest and used for training purposes from multiple firing points within West Point and from the West Point Foundry (located upstream of West Point along the Hudson River in Cold Spring, New York, and also referred to as the Cold Spring Foundry). The northwestern boundary of the impact area delineated as the Artillery Firing Range North MRS coincides with the Storm King Highway (State Highway 218) at the toe of the slope to the Crows Nest and the operational range area to the north (**Figure 6-1**). The southeastern boundary of the Artillery Firing Range North MRS traverses the Main Post.

The portions of the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs that are included in the Crows Nest impact area are presented in **Table 6-1**. Former ranges identified in historical documents associated with each of the MRSs are also described in **Table 6-1.** As presented in historical documents regarding munitions use at West Point, firing towards targets located on Crows Nest mountain was conducted at these former ranges. Approximately 70 structures are located in the Artillery Firing Range North MRS, including the West Point Elementary School and Middle School, Keller Army Community Hospital, and residential housing (**Figure 6-2**).

Table 6-1 Crows Nest Impact Area Delineation Summary

Original Configuration MRS Identifier	Artillery Firing Range North MRS Configuration (Crows Nest Impact Area Delineation)	Former Range Descriptions
Fort Clinton West (WSTPT-008-R-01)	12.7 acres	Northwestern portion of artillery range associated with Fort Clinton firing activities towards targets located on Crows Nest mountain.
Siege Battery (WSTPT-015-R-01)	66.3 acres	Northwestern (Main Post) portion of artillery range associated with Siege Battery firing activities towards targets located on Crows Nest mountain.
Lusk Reservoir (WSTPT-019-R 01)	8.8 acres	Northern portion of artillery range associated with firing from east of the Lusk Reservoir towards targets located on Crows Nest mountain.
Artillery Firing Range (WSTPT-001-R-01)	42 acres	Northeastern portions of three artillery ranges (Sacred Heart Cemetery Range, Adolphs Pond Range, and Lusk Reservoir Range) with firing activities towards targets located on Crows Nest mountain.
Area previously not included within an established MRS boundary	13.5	Area falls between Lusk Reservoir MRS and Fort Clinton West MRS, or adjacent to the Siege Battery MRS.
Total Area:	**143.3 acres**	

6.1.1.1 Climate

The climate of the region that includes West Point is characterized as a humid, continental climate. Summers are warm and have periods of high humidity. For more specific details regarding the climate of the West Point region, refer to Sections 2.1.1.1, 3.1.1.1, 4.1.1.1, or 5.1.1.1

6.1.1.2 Geology

West Point lies in the Hudson Highlands, a low, rugged mountain range, that forms a zone of folded and faulted metamorphic and igneous rocks subjected to extensive weathering and erosion. Precambrian-age granite, diorite, gneiss, and schist compose the majority of the crystalline bedrock underlying West Point. Granite, the most prevalent rock type in the bedrock, is typically medium-grained and composed of quartz, feldspar, and mica. Granite and pegmatite are igneous rocks that occur as dikes and sills within the gneiss. Igneous rocks on the West Point installation consist of plagioclase feldspar, hornblende, pyroxene, and biotite mica and quartz (Tetra Tech, Inc., 2011). For more specific details regarding the geology at West Point, refer to Sections 2.1.1.2, 3.1.1.2, 4.1.1.2, or 5.1.1.2.

Site-specific geologic investigations were not conducted for the Artillery Firing Range North MRS, and information regarding site-specific geology is not available for the MRS**.** Regional geologic maps (Cadwell, 1989; Fisher et al., 1970) indicate that the bedrock geology of the Artillery Firing Range North MRS consists of the following:

- Leucogranitic gneiss.
- Quartz plagioclase gneiss; may contain pyroxenes, hornblende, biotite; locally interlayered with amphibolite; subordinate biotite mesoperthite gneiss.

6.1.1.3 Topography

The topography of West Point is described as having moderately steep hills and numerous escarpments. The elevation ranges between 0 feet (0 meters) and approximately 410 feet (125 meters) above mean sea level (amsl). The developed areas of the Artillery Firing Range North MRS have relatively level terrain, but the land is steeply sloped on the southwestern edge behind the Keller Army Community Hospital and along the northwestern boundary. Northwest of the MRS boundary, the ground elevation rises towards the summit of Crows Nest mountain in the northern extent of West Point.

6.1.1.4 Soils

Seven soil types exist within the Artillery Firing Range North MRS based on the soils mapped within West Point (Tetra Tech Inc., 2011). Sloping Hollis soils are dominant within the MRS, followed by moderately steep and sloping Rock outcrop-Hollis soils. The remaining soils include steep Otisville and Hoosic soils, smoothed Udorthents, Chenango gravelly silt loam (0 to 3 percent slopes), and Swartswood gravelly loam (3 to 8% slopes). The soil types in the Artillery Firing Range North MRS range from moderately well drained to excessively drained. **Figure 6-3** presents the locations of the specific soil types within the MRS.

6.1.1.5 Hydrology

6.1.1.5.1 Surface Water

Sinclair Pond Brook and Crows Nest Brook are located in the Artillery Firing Range North MRS and drain towards the Hudson River. The following surface water bodies are located within a 3-mile radius of the MRS: the Hudson River, Delafield Pond, Lusk Reservoir, Kinsley Farm Brook, Stony Lonesome Brook, Highland Brook, Dassori Pond, Round Pond, Wilkins Pond, Cragston Lakes, Long Pond, Popolopen Lake, and Stillwell Lake.

6.1.1.5.2 Groundwater

Groundwater on West Point occurs in an unconsolidated aquifer consisting of alluvial deposits and a consolidated bedrock aquifer. However, based on the geology, an unconsolidated aquifer does not exist within the Artillery Firing Range North MRS. Site-specific groundwater investigations were not conducted for the Artillery Firing Range North MRS. For more specific details regarding the groundwater at West Point, refer to Sections 2.1.1.5.2, 3.1.1.5.2, 4.1.1.5.2, or 5.1.1.5.2.

6.1.1.6 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 in that five physiographic provinces—the Appalachian Plateaus, Folded Appalachians (Valley and Ridge), New England, Piedmont, and Coastal Plain—converge within a 35-mile radius of the West Point installation. West Point is located in the New England Province in an area known as the Hudson Highlands (Tetra Tech, Inc., 2011).

6.1.1.6.1 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 West Point installation. None of the 12 specially managed sites exists within the Artillery Firing Range North MRS.

6.1.1.6.2 Wetlands

Approximately 1,010 acres of wetlands are located throughout West Point in association with streams, ponds, depressions, and seeps (Tetra Tech, Inc., 2011). No wetlands are located in the Artillery Firing Range North MRS.

6.1.1.6.3 Flora

The Artillery Firing Range North MRS consists primarily of disturbed areas. Approximately 75% is developed and includes roads, parking lots, various buildings, and some residential housing. Vegetation within the developed area of the MRS is primarily the mowed lawn and trees that are characteristic of developed, landscaped areas. Pockets of forested areas are located throughout the Artillery Firing Range North MRS.

6.1.1.6.4 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 species of fish and invertebrate species (Tetra Tech, Inc., 2011). It is unlikely that the majority of these species are present in the developed areas of the Artillery Firing Range North MRS. The forested areas may provide habitat for some of these species.

6.1.1.6.5 Ecological Receptors

Potential ecological receptors are presented in the overall conceptual site model (CSM) for West Point. The ecological receptors included in the overall CSM for West Point are detailed in Sections 2.1.1.6.5, 3.1.1.6.5, 4.1.1.6.5, and 5.1.1.6.5.

6.1.1.7 Sensitive Environmental Resources within the MRS

Weston Solutions, Inc. (WESTON®) submitted a request for review by the New York Natural Heritage Program (NYNHP) to determine whether there are records of any known rare, threatened, and endangered species or species of special concern located within or near the West Point MRSs. In response, the 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 the 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 species listed above have the potential to occur within the Artillery Firing Range North MRS. Because a large component of the Artillery Firing Range North MRS is developed, it is unlikely that these species would rely on the area for habitat. The open grassy areas and forested parts of the MRS may provide potential habitat for these species; however, the NYNHP did not identify any federally threatened or endangered plant species within any of the West Point MRSs.

6.1.1.8 Cultural and Archaeological Resources

Because West Point is one of the older training grounds in the United States that is still intact, it contains numerous cultural, archaeological, and historical sites (TLI, 2007; WESTON, 2011a). There are no known cultural, archaeological, or historical sites present within the Artillery Firing Range North MRS.

6.1.1.9 Demographics

The Artillery Firing Range North MRS is easily accessible to West Point residents (adults and children), school children, site visitors, recreational users, installation personnel, maintenance workers, and contractor personnel. The Artillery Firing Range North MRS is located inside the West Point installation fence, and access to the area is unrestricted.

6.1.1.10 Current and Projected Land Use

Most of the lands on the Main Post are highly developed or are considered undevelopable because of steep slopes. West Point lands have been divided into four land use zones based on the functional categories that reflect the West Point missions (Tetra Tech, Inc., 2011):

- Cadet Use: Academic, intramural athletic, billeting, and parading.
- Cadet Support: Intercollegiate athletic fields and some cadet support facilities.
- Post Support: Housing, commercial, and service support to staff and faculty, non-West Point military personnel, and military retirees.
- Recreational, Industrial, Field Training: Building and storage area support for industrial operation, field training areas, recreation areas, and open space.

The Artillery Firing Range North MRS is located within three land use zones: (1) Cadet Support; (2) Post Support; and (3) Recreational, Industrial, Field Training. The Lee Housing Area and undeveloped, heavily wooded terrain are located in the northeastern portion of the MRS. In addition to residential and military housing, structures within the MRS include West Point Elementary and Middle Schools, a solid waste landfill (Post School Landfill), water pump station, the Keller Army Community Hospital, and a lumber yard. Interspersed areas of forest that are undeveloped may be used for recreational purposes within the MRS. The Crows Nest lies to the north of the MRS (see **Figure 6-2**). There are no plans to change the current land use.

6.1.2 Previous Investigations

6.1.2.1 Historical Information

The Artillery Firing Range North MRS is an impact area associated with former targets located on Crows Nest mountain at West Point. Prior to completing the RI, previous investigations specific to this MRS were not completed because the area was included within the original boundaries of the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. The Artillery Firing Range North MRS boundary encompasses portions of five former artillery ranges associated with firing activities from the former Fort Clinton and Siege Battery, the firing point east of the Lusk Reservoir, the Sacred Heart Cemetery Range, and the Adolphs Pond Range. Historical information about the individual ranges and MRSs is provided in Section 2 through Section 5.

6.1.2.1.1 Crows Nest

The Storm King Highway (now referred to as the Old Storm King Highway or Route 218) was constructed along the northern boundary of West Point between 1919 and 1922. Although the highway made the Crows Nest area unsuitable for field artillery practice because firing occurred over the highway, artillery practice in the area continued into the early 1930s. When firing occurred, traffic on the highway was suspended. To eliminate the problem of interfering with highway traffic, West Point acquired approximately 15,000 acres of additional property to the south and west, and target practice toward Crows Nest mountain was discontinued by the mid-1930s. The “New Storm King Highway” was built in 1940 after artillery practice activities ceased; therefore, interference with the highway, currently referred to as Highway 9W, was not an issue (TLI, 2006).

Additionally, the West Point Foundry (located upstream of West Point along the Hudson River in Cold Spring, New York, and also referred to as the Cold Spring Foundry) documented use of the cliffs across the Hudson as the target for ordnance testing (Hillery, 1961).

Several unexploded ordnance (UXO) investigations and removals have been conducted in relation to the Storm King site, located due north of West Point within what is currently Storm King State Park. In addition to the UXO associated with the West Point Foundry, the UXO identified at the Storm King site could have been fired from several locations within West Point at targets on Crows Nest, resulting in overshots that landed in the Storm King area (ATI, 2006). Historical documentation indicates that former munitions training at West Point included firing in the direction of Crows Nest from the Fort Clinton West, Siege Battery, Lusk Reservoir, Artillery Firing Range, and Redoubt No. 2 MRSs (TLI, 2006 and 2007). Therefore, the type of UXO identified at the Storm King site and the Crows Nest may also be present in these MRSs.

In a 1994 survey of Crows Nest and the surrounding area, several types of UXO, including fuzed and fired ordnance, were identified. These UXO included a 2.25-inch projectile, a 15-inch mortar shell from the Civil War era, and 75mm projectiles (TLI, 2006).

Following a fire in the Storm King State Park in August 1999, the area was closed to the public because of concerns about the presence of UXO. A Time Critical Removal Action was conducted from June through October 2000 at the park to clear trails, trailheads, firebreaks, and highway shoulders. During the removal, 23 UXO items were destroyed on-site. The items identified included 75mm ejection rounds, 75mm high explosive (HE) rounds, and 1907M Powder Train Time Fuzes (PTTF) (EHSII, 2000).

In April 2001, a geophysical survey was conducted in an area near the West Point Lee Road entrance gate, which is located at the intersection of Lee Road and Highway 218. The survey area extended from the intersection of Highway 218 and Lee Road at the north to the West Point Elementary School and Keller Army Community Hospital at the southwest. The area is bounded on the northwest by Highway 218 and on the southeast by the Lee Family Housing Area. The survey area included portions of the Artillery Firing Range MRS, the Fort Clinton West MRS, and the Siege Battery MRS. The survey identified 1,539 anomalies within the study area; however, no anomalies were intrusively investigated. The U.S. Army Engineering and Support Center in Huntsville, Alabama, evaluated the geophysical survey data and recommended that West Point conduct sampling in the area to determine whether the anomalies were ordnance related. No documents were located to indicate that the sampling was conducted (TLI, 2006).

A July 2002 Engineering Evaluation/Cost Analysis (EE/CA) for the Storm King site included additional information about the types of munitions used at the Artillery Firing Range. The scope of the EE/CA was to characterize the type, location, and distribution of ordnance and explosives and UXO present within the park to the north and west of the Crows Nest. The EE/CA summarized the findings from other munitions and explosives of concern (MEC) studies conducted at the Storm King site and surrounding areas. During the EE/CA, a geophysical survey identified 7,165 anomalies that were investigated at the Storm King site. Of these anomalies, 9 were 75mm projectiles (HE and shrapnel), 1 was a 6-inch MK 34 projectile, and 476 were ordnance-related scrap (TLI, 2006).

Between August 16 and October 7, 2004, a removal action was performed in the Storm King area that removed 316 UXO items, including the following: 37mm booster (BD fuze), 75mm HE M2 (no fuze/M48 series/PD), M48 series booster/fuzes, HE discs, and 1907M fuzes. A total of 239 pieces of 75mm MK1 shrapnel (no fuze) were also recovered (ATI, 2006).

6.1.2.2 Site Inspection Report and Results

No site inspection (SI) field activities were conducted specifically for the Artillery Firing Range North MRS because it had not been identified at the time of the SI. Sections 2.1.2, 3.1.2, 4.1.2, and 5.1.2 present discussions of the SI field activities relative to the original boundaries of the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. No MEC was found during the SI within the area currently delineated as the Artillery Firing Range North MRS. Munitions debris (MD) was observed at several locations in all four MRSs included in the delineation of the Crows Nest impact area. Samples collected from environmental media to assess munitions constituents (MC) did not identify any significant risks to potential receptors. All explosives were below laboratory reporting limits and/or the project screening levels. Several metals were detected, but were either below the project screening levels or within expected background concentrations.

Based on the results of the visual survey and the geophysical surveys conducted during the SI field work, and a review of historical documentation for each MRS, recommendations to perform further investigations for MEC and associated MC were made for the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs (TLI, 2007).

6.2 REMEDIAL INVESTIGATION RESULTS

This section presents the results of the RI MEC characterization and MC characterization for the 143.3-acre Artillery Firing Range North MRS and includes results previously discussed for the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs (Sections 2 through 5). A preliminary identification of the potential applicable or relevant and appropriate requirements (ARARs) (Section 6.3.3) is also presented for the Artillery Firing Range North MRS.

6.2.1 Results for Munitions and Explosives of Concern Characterization

The characterization performed that led to delineation of the Artillery Firing Range North MRS involved the following tasks:

- Mag and dig grid and transect surveys.
- DGM data collection.
- Digital data processing, analysis and anomaly selection.
- Anomaly reacquisition.
- Intrusive investigation of detected anomalies.

6.2.1.1 Geophysical Survey Results

This section provides a summary of the items found during the RI field investigations, which were identified in the Crows Nest impact area identified as the Artillery Firing Range North MRS. **Figure 6-4** presents the grid and transect locations for the Artillery Firing Range North MRS. Based on the distribution of the geophysical survey coverage in each of the original MRSs included in the RI planning, a total of 7.97 acres of mag and dig transects and grids and DGM grids were investigated within the delineated Crows Nest impact area.

Figure 6-5 shows the locations of the UXO and MD items found in the Artillery Firing Range North MRS (Crows Nest impact area). Three UXO items, including two MKII hand grenades (unfuzed) and one 8-inch Butler projectile, were recovered from within the Crows Nest impact area. A total of 827 MD items were also recovered and included four MKII hand grenades (empty), one 4.6-inch Parrott round (empty), two 8-inch Butler projectiles (empty), one 5.3-inch Parrott type II bottle top, one 10-inch Parrott type II bottle top, one 3.5-inch cannonball (solid shot), one 6-inch cannonball (solid shot), and 816 fragments from unknown munitions. All materials were recovered between the surface and 15 inches below ground surface (bgs). The UXO items were disposed by being blown in place. Numerous MD items recovered within the impact area were transferred to the West Point Museum. **Appendix 6-A** shows the locations of the items recovered, and **Table 6-2** provides a summary of the recovered UXO from the Artillery Firing Range North MRS. The complete dig list is provided in **Appendix 6-B**. A record of the disposal of these items is provided in **Appendix 6-C**.

6.2.1.2 Additional Findings

After completion of the RI field investigations, four UXO and one MD item were encountered during construction projects (**Figure 6-5**). Each of these items was found within the Artillery Firing Range North MRS boundary delineated based on the RI field investigation results (see **Table 6-2)**. These findings, which are included in the overall qualitative assessment of the MRS, are reported below:

- In January 2012, a construction crew working behind the West Point Middle School encountered a 90mm armor-piercing capped tracer (APC-T) in fill material.
- In February 2012, a construction crew working near the Keller Army Community Hospital encountered an MD item, an 8-inch Butler projectile (concrete filled).
- In May 2012, a UXO item, an 8-inch Butler projectile, was encountered by the operator of a front-end loader working near the Keller Army Community Hospital.
- On June 21, 2012, a second UXO item, an unfuzed 8-inch Parrott shell, was encountered by a construction crew working near the Keller Army Community Hospital.
- On June 26, 2012, a third UXO item, an unfuzed 8-inch Parrott shell, was encountered by a construction crew working near the Keller Army Community Hospital.

Table 6-2 UXO Summary at the Artillery Firing Range North MRS (Crows Nest Impact Area)

Target ID No.	Item Type	Item Description	Investigation Type	Dig Date	Depth (inches)	Weight (lb)	Quantity
FCW-02-133	UXO	MKII hand grenade (unfuzed)	DGM	7/27/2011	3.0	2.0	1.0
FCW-02-139	UXO	MKII hand grenade (unfuzed)	DGM	7/27/2011	3.0	1.5	1.0
FCW-05	UXO	8-inch Butler projectile	Mag and Dig	6/23/2011	8.0	187.0	1.0
N/A*	UXO	8-inch Butler projectile	N/A	5/9/2012	Unknown	Unknown	1.0
N/A*	UXO	90mm APC-T	N/A	1/3/2012	Unknown	Unknown	1.0
N/A*	UXO	Unfuzed 8-inch Parrott shell	N/A	6/21/2012	Unknown	Unknown	1.0
N/A*	UXO	Unfuzed 8-inch Parrott shell	N/A	6/26/2012	Unknown	Unknown	1.0

Notes:
* Item was encountered by a construction crew after the completion of the RI.
FCW = Fort Clinton West MRS

6.2.2 Results for Munitions Constituents Characterization

Because a UXO and MD impact area was identified, indicating that a confirmed source for MC was present, sampling was conducted in accordance with the *Final Work Plan, Military Munitions Response Program, Remedial Investigations, U.S. Army Garrison West Point, West Point, NY* (Final RI Work Plan) (WESTON, 2011a), the Uniform Federal Policy Quality Assurance Project Plan (UFP-QAPP) (WESTON, 2011b) and the MC Sampling Methodology Memorandum for Fort Clinton West and Siege Battery (see **Appendix 2-H**). The samples were collected based on the pre-RI demarcation of the MRS boundaries and the findings within each individual MRS. Thus, these results are presented in Sections 2.5.2 and 3.5.2 relative to the Fort Clinton West MRS and the Siege Battery MRS, respectively, and are also discussed in this section to support the characterization of the Artillery Firing Range North MRS.

Eight incremental sample locations were assessed within the Artillery Firing Range North MRS boundary. As depicted on **Figure 6-4**, two incremental samples (plus one field duplicate and one duplicate/triplicate pair) were collected from the impacted portion of the original boundary of the Fort Clinton West MRS (WPR03-SS26, WPR03-SS27 [field duplicate], WPR03-SS28, WPR03-SS29 [duplicate] and WPR03-SS30 [triplicate]). Six incremental samples were collected from the impacted portion of the original boundary of the Siege Battery MRS (WPR16-SS31,

WPR16-SS32, WPR16-SS33, WPR16-SS34, WPR16-SS35, and WPR16-SS36). Samples WPR03-SS26 and WPR03-SS27 (field duplicate) were collected from a sampling unit placed along the original boundary between the Fort Clinton West MRS and the Siege Battery MRS.

The field duplicates (split) and replicates were collected for QC purposes. Each incremental sample and replicates collected from the Artillery Firing Range North MRS were comprised of 50 increments distributed over a 0.8-acre sampling unit area. The incremental samples were collected and analyzed to identify the presence of MC (if any) and to characterize the nature and extent of MC. The incremental samples were collected using new, clean, dedicated, and disposable equipment; therefore, no investigation derived waste (IDW) (solid or liquid) was generated. Analytical results for the Artillery Firing Range North MRS are provided in **Table 6-3**.

6.2.2.1 Explosives

No detections of explosives were reported for the samples collected from the Artillery Firing Range North MRS. Analytical results for nitroglycerin and 2,6-DNT were reported with UJ qualifiers, which indicates that the analytes were not detected above the reported sample quantitation limits (SQLs). The reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analytes in the sample. The analytical results for the remainder of the explosives included U qualifiers for each reported value, indicating that the explosive was analyzed for, but was not detected, above the reported SQL (**Table 6-3**). Data qualifiers are discussed in more detail in Section 6.2.2.3.2.

Section 6.3 presents the analytical results in comparison to the human health and ecological screening values used to establish baseline risks to potential human and ecological receptors.

Table 6-3 Analytical Results for Soil Sampling for MC Artillery Firing Range North MRS, U.S. Army Garrison West Point, MMRP Remedial Investigation

Sample ID:	WPR03-SS26		WPR03-SS27		WPR03-SS28		WPR03-SS29		WPR03-SS30		WPR16-SS31		WPR16-SS32		WPR16-SS33		WPR16-SS34		WPR16-SS35		WPR16-SS36	
Lab Sample ID:	200-6475-1		200-6475-2		200-6491-3		200-6491-1		200-6491-2		200-6513-1		200-6513-2		200-6513-3		200-6513-4		200-6513-5		200-6513-6	
Sample Type:	Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil		Soil	
Date Sampled:	8/8/2011		8/8/2011		8/9/2011		8/9/2011		8/9/2011		8/10/2011		8/10/2011		8/10/2011		8/11/2011		8/11/2011		8/11/2011	
Munitions Response Site:	Fort Clinton West/Siege Battery		Fort Clinton West/ Siege Battery		Fort Clinton West		Fort Clinton West		Fort Clinton West		Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery		Siege Battery	
Comments:			Field Duplicate QC Sample of SS26				Duplicate QC Sample of SS28		Triplicate QC Sample of SS28													
EXPLOSIVES in µg/kg	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**	**Result**	**Qual.**
2,4,6-Trinitrotoluene	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U	14	U
4-Amino-2,6-dinitrotoluene	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U
2-Amino-4,6-dinitrotoluene	23	U	23	U	23	U	60	U	23	U	23	U	23	U	23	U	23	U	23	U	23	U
2,6-Dinitrotoluene	14	U	14	U	95	UJ	63	U	96	UJ	46	U	14	U	68	U	14	U	14	U	14	U
2,4-Dinitrotoluene	28	U	28	U	28	U	28	U	28	U	28	U	28	U	28	U	29	U	28	U	29	U
PETN	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U	1700	U
Nitroglycerin	1300	UJ	550	U	540	U	1600	UJ	550	U	550	U	540	U	580	U	550	U	540	U	550	U
METALS in mg/kg																						
Lead, Total	150	J	130		68	J	120	J	93	J	45		96		91		140		100		79	
Mercury, Total	0.24	J	0.20	J	0.16	J	0.19	J	0.17	J	0.064	J	0.15	J	0.12	J	0.18	J	0.23	J	0.12	J

Notes:

J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).

U = The analyte was analyzed for, but was not detected above the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).

UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis via photodiode array confirmed that the analyte was not present (poor spectral match observed).

QC = quality control

µg/kg = micrograms per kilogram

mg/kg = milligrams per kilogram

6.2.2.2 Metals

Lead and mercury were the only metals suspected to be MC associated with the recovered UXO and MD. Both analytes were positively detected by the laboratory in all samples (see **Table 6-3**):

- Lead ranged from 45 milligrams per kilogram (mg/kg) to 150 mg/kg. Approximately half of the results were J qualified, indicating the results were estimated quantities.
- Mercury ranged from 0.064 mg/kg to 0.24 mg/kg. All results were J qualified, indicating the results were estimated quantities.

Data qualifiers are discussed in more detail in Section 6.2.2.3.2. Section 6.3 presents the analytical results in comparison to the human health and ecological screening values used to establish baseline risks from MC to potential human health and ecological receptors.

6.2.2.3 MC Data Quality

An assessment of data quality for MC sampling was conducted in accordance with the Final RI Work Plan (WESTON, 2011a) and the UFP-QAPP (WESTON, 2011b). Field QC samples were collected and analyzed to assess the quality of the data resulting from the field sampling program at a program-wide level for the MMRP RI at West Point. As discussed in Section 6.2.2.3, 100% of the MC data results were validated by an independent third party, MEC^{x}, LP.

Field QC samples specified in the UFP-QAPP include rinsate, field blanks, field duplicates, and triplicates. Field duplicates, which consist of one soil sample split into two parts with each aliquot analyzed by the laboratory for the identical parameters, are collected to estimate sampling and laboratory analysis precision, including sample homogeneity. Precision is measured using routine and duplicate sampling results and is expressed as the relative percent difference (RPD). Calculation of the RPD is described in the UFP-QAPP.

The incremental duplicate/triplicate (also referred to as replicates) involves the collection of three individual samples from within the same sampling unit (routine sample, duplicate, and triplicate). Each sample is comprised of the appropriate number of unique increments. The collection of random increments from within the sampling unit is performed three separate times to create the routine, duplicate, and triplicate samples. This collection approach allows the comparison of relative standard deviation (RSD) between the three incremental sample results for the same sampling unit to evaluate whether the sampling procedure was accurate. The RPD can also be calculated for the incremental duplicate sample.

Matrix spike/matrix spike duplicate (MS/MSD) samples are the introduction of a known concentration of a compound into a sample to provide information about the effect of the sample matrix on the extraction and/or measurement methodology. MS/MSDs are reviewed as part of the data validation process and are discussed in the data validation narrative in **Appendix 6-D**.

6.2.2.3.1 Field QC Samples and Sampling QC

Field QC samples were collected and assessed for sampling QC during the MMRP RI at West Point at a program-level based on the sample delivery groups submitted to the laboratory for analysis and because of similarities in past munitions use, soil types, and land use. Some MRSs had one or very few soil samples, and samples were batched together where possible. As a result, QC sample results and sampling assessments related to samples collected to characterize the Crows Nest impact area are provided in Section 2.5.2.2.1 for the Fort Clinton West MRS and Section 3.5.2.2.1 for the Siege Battery MRS. High-quality MC data were collected at the Artillery Firing Range North MRS based on an assessment of data usability employing the following parameters: precision, accuracy, representativeness, completeness, and comparability. These parameters were assessed as part of the MC sampling section in Fort Clinton West MRS (Section 2.5.2.3.1) and Siege MRS (Section 3.5.2.3.1). The high quality data collected met the data quality objectives of the RI established for the individual MRSs (see Section 2.2.4 and 3.2.4) and are sufficient to support the risk assessment and the evaluation of alternatives for the Artillery Firing Range North MRS.

6.2.2.3.2 Data Validation Results

The data validation guidelines are presented in Sections 2.4, 3.4, 4.4, and 5.4. The data validation package for the Artillery Firing Range North MRS, including validation report narratives for the MRS analytical results and a glossary of quality assurance/quality control (QA/QC) terms and data qualifier codes, is provided in **Appendix 6-D**. The data validation guidelines ensure that all data meet uniform requirements for accuracy and the validity of the data. If the data quality parameters for the MRS-specific analyses did not meet the criteria of the EPA and DoD Quality Systems Manual (QSM) Version 4.2 (DoD, 2010) or the laboratory standard operating procedure

(SOP), a discussion of the implications regarding the guidelines was included in the data validation narrative.

No major issues were identified during data validation. The results for some incremental samples from the Artillery Firing Range North MRS showed nondetects with elevated SQLs. These values were qualified as UJ due to poor photodiode array spectral match, which is a method routinely used for further identification of any detect above the limit of quantitation. A validation note consisting of an "H8" code was added to the UJ qualifier, verifying that the analyte was not confirmed on a second dissimilar column or that the diode array spectrums did not match the library. These UJ values are considered estimated, but still usable data, which met all remaining acceptance criteria. A number of sample results were below the detection limit and had an elevated intercolumn RPD; as a result, they were qualified with a nondetect, U. Several results were qualified with a J due to detections reported between the detection limit and the SQL, or confirmed results with a relatively high intercolumn RPD, or low detections in the method blank. These J values are considered estimated values but are still usable data. Using J values for risk assessment is consistent with the allowable use of J qualified data as discussed in the *Guidance for Data Useability for Risk Assessment (Part A)* (EPA, 1992).

Overall, the data validation showed that the data received from the laboratory were valid and usable for assessing the environmental conditions related to MC. Sufficient usable data were available for the newly delineated Artillery Firing Range North MRS to meet the objectives of the RI and to complete the risk assessment.

6.3 RISK ASSESSMENT FOR MUNITIONS CONSTITUENTS

6.3.1 Human Health Risk Assessment

A human health risk assessment (HHRA) was performed for the Artillery Firing Range North MRS (relative to the samples collected within the boundary established to represent the Crows Nest impact area). Based on the CSM (see Section 6.5), the potential human receptors include West Point residents (adults and children), contractor personnel, installation personnel, school children, recreational users, and site visitors.

6.3.1.1 Data Evaluation

Sampling performed within the Artillery Firing Range North MRS consisted of eight incremental samples, plus one field duplicate and one duplicate/triplicate pair (also known as field replicates), collected from areas within the impact area delineated based on the concentrations of UXO and MD observed during the RI characterization. Six incremental samples were collected within the original boundary of the Siege Battery MRS, one incremental sample (plus one field duplicate) was collected at the original border between the Siege Battery MRS and the Fort Clinton West MRS, and one incremental sample (plus one field duplicate and one duplicate/triplicate pair) was collected within the original boundary of the Fort Clinton West MRS. Each of these samples consisted of a 0.8-acre sampling unit from which 50 increments were collected and analyzed for explosives and metals. **Table 6-4** presents the analytical results for the Artillery Firing Range North MRS surface soil incremental samples. No explosives were positively identified; however, lead and mercury were detected.

A discussion of the results in relation to the human health screening levels and the rural background levels (for metals) is provided in the following subsections.

6.3.1.2 Selection of Chemicals of Potential Concern

Typically, soil chemicals of potential concern (COPCs) are identified by comparing the maximum detected concentration of each chemical with the recommended human health screening value. All samples collected from the Artillery Firing Range North MRS were analyzed for explosives and metals. All explosives in the surface soil incremental samples at Artillery Firing Range North MRS were reported as U and UJ values, indicating the analytes were not detected above their reported SQLs. The laboratory would have reported detects below the screening level, even if they were estimated values (J), and none were reported.

Both mercury and lead were positively detected; therefore, a screening was performed on lead and mercury and on the SQLs for the other chemicals. **Table 6-4** presents the results of the screening for the samples collected from the Artillery Firing Range North MRS.

Analyte	ORNL Residential RSL[a]	NYSDEC Residential SCO[b]	NYSDEC Unrestricted Use SCO[b]	Recommended Human Health Screening Value[c]	WPR03-SS26 200-6475-1 8/8/2011 Fort Clinton West/ Siege Battery	WPR03-SS27 (Duplicate of SS26) 200-6475-2 8/8/2011 Fort Clinton West/ Siege Battery	WPR16-SS31 200-6513-1 8/10/2011 Siege Battery	WPR16-SS32 2006513-2 8/10/2011 Siege Battery	WPR16-SS33 200-6513-3 8/10/2011 Siege Battery	WPR16-SS34 200-6513-4 8/11/2011 Siege Battery	WPR16-SS35 200-6513-5 8/11/2011 Siege Battery	WPR16-SS36 200-6513-6 8/11/2011 Siege Battery	WPR03-SS28 200-6491-3 8/9/2011 Fort Clinton West	WPR03-SS29 (Duplicate of SS28) 200-6491-1 8/9/2011 Fort Clinton West	WPR03-SS30 (Triplicate of SS28) 200-6491-2 8/9/2011 Fort Clinton West	HH COPC?
Explosives (µg/kg)																
2,4,6-Trinitrotoluene	3,600 n	NBA	NBA	3,600 n	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	14 U	No
4-Amino-2,6-Dinitrotoluene	15,000 n	NBA	NBA	15,000 n	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	No
2-Amino-4,6-Dinitrotoluene	15,000 n	NBA	NBA	15,000 n	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	23 U	60 U	23 U	No
2,6-Dinitrotoluene	6,100 n	NBA	1,030	1,030	14 U	14 U	46 U	14 U	68 U	14 U	14 U	14 U	95 UJ	63 U	96 UJ	No
2,4-Dinitrotoluene	1,600 c	NBA	NBA	1,600 c	28 U	28 U	28 U	28 U	28 U	29 U	28 U	29 U	28 U	28 U	28 U	No
PETN	12,000 n	NBA	NBA	12,000 n	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1700 U	1,700 U	1,700 U	1,700 U	No
Nitroglycerin	610 n	NBA	NBA	610 n	1300 UJ	550 U	550 U	540 U	580 U	550 U	540 U	550 U	540 U	1,600 UJ	550 U	No [d]
METALS (mg/kg)																
Lead, Total	400	400	63.00	63	150 [f] J	130 [f]	45	96 [e]	91 [e]	140 [f]	100 [e]	79 [e]	68 [e] J	120 [f] J	93 [e] J	No
Mercury, Total	1.00 n	0.81	0.18	0.18	0.24 [e] J	0.20 [e] J	0.064 J	0.15 J	0.12 J	0.18 [e] J	0.23 [e] J	0.12 J	0.16 J	0.19 [e] J	0.17 J	No

[a] Residential Screening Levels were obtained from ORNL Regional Screening Levels for Chemical Contaminants at Superfund Sites Table (May 2012). The RSLs are shown at a target risk (TR) of 1.0E-6 or a target hazard quotient (THQ) of 0.1.

[b] NYSDEC. 2006. Remedial Program Soil Cleanup Objectives - http://www.dec.ny.gov/regs/15507.html

[c] The primary source for the Recommended Screening Value is the NYSDEC value. If a NYSDEC value was not available, the ORNL Benchmark was used.

[d] When using the ORNL RSL values, noncarcinogens were reduced by an order of magnitude to yield a risk-based screening level with a THQ of 0.1 to address the additivity of noncancer effects when there is exposure to multiple chemicals. However, because no other chemicals were detected, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg.

[e] Exceeded recommended human health screening value but were within the rural background range of concentrations obtained from New York Department of Environmental Conservation. 2005. Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D. August 2005.

[f] The lead arithmetic mean for the Artillery Firing Range North MRS is 101.1 mg/kg, which is below the rural maximum concentration of 112 mg/kg.

c = Cancer effects at a target risk of 1.0E-06.
µg/kg = Micrograms per kilogram.
n = Noncancer effects, at a target hazard quotient of 0.1.
NBA = No benchmark available.
RSL = Regional screening level.
SCO = Soil cleanup objectives.
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).
U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis using photo diode array confirmed that the analyte was not present.

Highlighting indicates that the detected result is equal to or exceeds the Recommended Human Health Screening Value.

As presented in **Table 6-4,** the recommended human health screening value is the lowest human health New York State Department of Environmental Conservation (NYSDEC) value (NYSDEC, 2006). If an NYSDEC value was not available, the Oak Ridge National Laboratory (ORNL) residential regional screening level (RSL) (EPA, 2012) was used. For COPC screening purposes, noncarcinogenic RSLs were adjusted to correspond to a target hazard quotient (THQ) of 0.1 rather than 1. Thus chemicals with additive effects were not prematurely eliminated during screening. If RSLs were available for carcinogenic and noncarcinogenic endpoints and both ingestion and inhalation exposure routes, the lower (i.e., more stringent) value was used for the screening comparison.

The results shown in **Table 6-4** indicate that no explosives had SQLs above the recommended human health screening level. The nitroglycerin SQL exceeded its benchmark when using the risk-based screening level at a THQ of 0.1 (610 micrograms per kilogram [µg/kg]). No other chemicals with additive effects (i.e., noncarcinogens with similar target organ effects) exceeded their respective benchmarks. Therefore, the THQ can be adjusted upward to 1.0, yielding a site-specific screening level of 6,100 µg/kg, which is greater than the maximum SQL for nitroglycerin (1,600 µg/kg).

For metals detected at the Artillery Firing Range North MRS, lead was detected at concentrations greater than the recommended human health screening level (i.e., NYSDEC Unrestricted Use soil cleanup objective [SCO], 63 mg/kg). However, as presented in **Table 6-4**, the value was less than the ORNL residential soil RSL and the NYSDEC residential SCO value of 400 mg/kg. The difference between the two NYSDEC values is that the Unrestricted Use screening is for the protection of public health and ecological resources due to the presence of contaminants in the soil. Therefore, the NYSDEC residential SCO value is appropriate to use as an alternative screening number for the human health risk evaluation and supports the future use of the Artillery Firing Range North MRS. Furthermore, the lead arithmetic mean (101.1 mg/kg) and the majority of the samples (7 of 11) were less than the rural maximum concentration background level of 112 mg/kg reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D,* Table D1, August 2005 (NYSDEC, 2005).

Mercury was detected at concentrations greater than the recommended human health screening level (i.e., NYSDEC Unrestricted Use SCO, 0.18 mg/kg) in 4 out of 11 samples as presented in **Table 6-4.** However, the value was less than the maximum background level of 0.30 mg/kg established for soils (NYSDEC, 2005). In addition, mercury concentrations were less than the ORNL residential soil RSL and the NYSDEC residential SCO value of 1.0 mg/kg and 0.81 mg/kg, respectively. Although lead and mercury were detected in samples collected in the Artillery Firing Range North MRS, the analytes were not detected at levels that would pose a potential risk to human health.

6.3.1.3 Human Health Risk Assessment Summary and Conclusions

MD and UXO were found in the Artillery Firing Range North MRS. The sample results for explosives were qualified as U or UJ, indicating the chemicals were not detected above their reported SQLs. Lead and mercury were detected in samples from the Artillery Firing Range North MRS. Based on the HHRA results, the surface soil incremental samples did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), contractor personnel, installation personnel, school children, recreational users, and site visitors.

6.3.2 Ecological Risk Assessment

A focused Screening Level Ecological Risk Assessment (SLERA) was completed to assess the potential adverse impacts on current and future ecological receptors exposed to MC in surface soil at the Artillery Firing Range North MRS. The assessment endpoint for the SLERA is the protection of local populations and communities of biota from exposure to chemicals of potential ecological concern (COPECs) in soil. The CSM for the Artillery Firing Range North MRS is presented in Section 6.5.

6.3.2.1 Ecological Screening

Average concentrations of chemicals detected in soil at the Artillery Firing Range North MRS (based on incremental sampling) were compared to conservative ecological screening values (ESVs). All chemicals detected in soil at concentrations greater than the ESV were considered to potentially adversely impact ecological receptors and were identified as COPECs. The ecological screening values are presented in **Table 6-5**.

Table 6-5 Screening Level Ecological Risk Assessment Results for Soil

Analyte	Recommended Ecological Screening Value	MEC Release Area Sample Number	Maximum Detected Incremental Sample Value at the MEC Release Area[h]	Maximum Background Screening Value[i]	Chemical of Potential Ecological Concern (COPEC)?
Explosives (µg/kg)					
2-Amino-4,6-dinitrotoluene	9,000[a,b]	WPR03-SS29	60 U	N/A	N
4-Amino-2,6-dinitrotoluene	9,000[a,b]	all samples	23 U	N/A	N
2,4-Dinitrotoluene	1,280[c]	multiple samples	29 U	N/A	N
2,6-Dinitrotoluene	32.8[c]	WPR03-SS30	96 UJ (48)	N/A	Y
Nitroglycerin	3,000[a,d]	WPR03-SS29	1,600 U	N/A	N
PETN	170,000[a,e]	all samples	1,700	N/A	N
RDX	21,000[f]	---	---	N/A	N
2,4,6-Tinitrotoluene	70[a,g]	all samples	14 U	N/A	N
Metals (mg/kg)					
Lead, Total	63[g]	WPR03-SS26	150 J	112	Y
Mercury, Total	0.18[g]	WPR03-SS26	0.24 J	0.3	Y

Notes:
µg/kg = micrograms per kilogram
[a]µg/kg/d = micrograms per kilogram per day, no observed adverse effect level (NOAEL).
[c]EPA, 2003.
[d] U.S. Army Center for Health Promotion and Preventative Medicine (USACHPPM), 2000.
[e]USACHPPM, 2001a.
[f]Kuperman et al., 2006.
[g]USACHPPM, 2001b.
[h]Second value is half of the detection limit.
[i]NYSDEC, 2005.
J = The analyte was positively identified; the associated numerical value is the approximate concentration of the analyte in the sample (organics). The associated value is an estimated quantity (inorganics).
U = The analyte was analyzed for, but was not detected above, the reported sample quantitation limit (i.e., limit of detection in accordance with QSM Version 4.2).
UJ = The analyte was not detected above the reported sample quantitation limit. However, the reported quantitation limit is approximate and may or may not represent the actual limit of quantitation necessary to accurately and precisely measure the analyte in the sample. Secondary spectral analysis using photo diode array confirmed that the analyte was not present.

The ESVs used for comparison to chemicals detected in soil samples were obtained from the NYSDEC Remedial Program SCOs, EPA EcoSSLs, EPA Region 5 Resource Conservation and Recovery Act (RCRA) ESLs, information obtained from select ORNL guidance, and additional appropriate guidance, as necessary. The primary source for the recommended screening value was the NYSDEC value. If a NYSDEC value was not available, ecological screening values were selected in accordance with the hierarchy listed above.

If no value was established within the hierarchy presented in the Final RI Work Plan, additional research was conducted to identify ESVs during the development of the SLERA. ESVs were obtained for the following analytes: 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene, nitroglycerin, PETN, hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX), and 2,4,6-trinitrotoluene (**Table 6-5**).

6.3.2.2 Habitat and Receptors

The Artillery Firing Range North MRS is 143.3 acres and is located south of the Crows Nest in the northern extent of the West Point installation. The Artillery Firing Range North MRS includes part of the Siege Battery, Fort Clinton, and Lusk Reservoir range fans in addition to the Sacred Heart Cemetery and Adolphs Pond range fans. Access is unrestricted once on-post. Approximately 70% of the Artillery Firing Range North MRS has been disturbed by development.

Ecological receptors that could potentially be exposed to MC at the Artillery Firing Range North MRS include terrestrial plants; terrestrial invertebrates; and terrestrial avian and mammalian species, including herbivores, omnivores, and carnivores. Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Artillery Firing Range North MRS.

6.3.2.3 Screening of Chemicals of Potential Ecological Concern

The maximum detected values for incremental soil samples at the Artillery Firing Range North MRS were compared to appropriate ESVs. Sampling consisted of six incremental samples collected within the original boundary of the Siege Battery MRS, one incremental sample (plus one field duplicate) collected at the original border between the Siege Battery MRS and the Fort Clinton West MRS, and one incremental sample (plus one field duplicate and one duplicate/triplicate pair) collected from within the original boundary of the Fort Clinton West MRS where UXO and/or MD had been identified.

Explosives were not detected in the samples from the Artillery Firing Range North MRS. The compound 2,6-dinitrotolutene was reported as nondetected in all the Artillery Firing Range North MRS samples, with SQLs ranging from 14 µg/kg to 96 µg/kg. Of the 11 samples, 5 samples had SQLs greater than the ESV (32.8 µg/kg). Because all samples collected from the West Point MRSs during the MMRP RI had results for 2,6-DNT that were qualified as nondetects, half of the reported sample result was used for comparison to the ESV of 32.8 µg/kg (Region 5 RCRA Ecological Screening Levels [EPA, 2003]). The SQLs for the samples still exceeded the ESV. However, all results were less than the alternative no observed adverse effect level (NOAEL) value for 2,6-DNT of 700 µg/kg for ingestion exposure for mammals (U.S. Army Center for Health Promotion and Preventative Medicine [USACHPPM], 2006). Because 2,6-DNT was not positively detected in any of the MC samples collected from the MRSs included in the MMRP RI at West Point, it is highly unlikely that 2,6-DNT is present related to historical activities at the Artillery Firing Range North MRS. Furthermore, even if a release to surface soil at the MRS had occurred, 2,6-DNT is unlikely to persist in the environment because the compound readily breaks down in the presence of oxygen and sunlight, and is highly water soluble (Agency for Toxic Substances and Disease Registry [ATSDR], 1998).

Lead was detected in all Artillery Firing Range North MRS samples at concentrations ranging from 45 mg/kg and 150 mg/kg, which exceed the screening level of 63 mg/kg (NYSDEC Unrestricted Use SCO) (**Table 6-4**). Results for 4 of the 11 samples were J qualified, indicating that the associated value is an estimated quantity. The presence of lead does not present an unacceptable risk to the environment, because all concentrations of lead detected at the Artillery Firing Range North MRS were less than the alternative ORNL benchmark of 500 mg/kg. Additionally, the arithmetic mean concentration of lead in all samples was consistent with the rural maximum concentration of 112 mg/kg as reported in *Concentrations of Selected Analytes in Rural New*

York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey, Appendix D, Table D1, August 2005 (NYSDEC, 2005).

Mercury was detected in all Artillery Firing Range North MRS samples at concentrations ranging from 0.064J mg/kg to 0.24J mg/kg, which exceeds the screening level of 0.18 mg/kg (NYSDEC Unrestricted Use SCO) (**Table 6-4**). All of the 11 mercury results were J qualified, which indicates that mercury was positively identified, and the associated value is an estimated quantity. However, the presence of mercury does not present an unacceptable risk to the environment because the results are within the rural background range of concentrations. The range for the rural background mercury concentrations is 0.01 to 0.30 mg/kg, as reported in *Concentrations of Selected Analytes in Rural New York State Surface Soils: A Summary Report on the Statewide Rural Surface Soil Survey*, Appendix D, Table D1, August 2005 (NYSDEC, 2005).

6.3.2.4 Uncertainty Assessment

The 2,6-DNT concentration is listed as a nondetect/estimated value (UJ), but the SQL exceeds the established conservative ESV. Therefore, it was unclear whether 2,6-DNT is present and poses a quantifiable risk of exposure to ecological receptors within the Artillery Firing Range North MRS. Based on the secondary spectral analysis performed by the laboratory, which confirmed that no explosives were present, and on the screening-level evaluation results presented above, the uncertainty associated with the elevated SQLs is considered minimal.

6.3.2.5 Summary of Ecological Risk

Habitat is present at West Point that could support threatened and endangered species, such as the timber rattlesnake, which is a New York State threatened species. The shortnose sturgeon is a federally listed endangered species that is known to exist in the Hudson River; however, habitat for the sturgeon is not present in the Artillery Firing Range MRS. The ecological habitat within the MRS is not considered to be of high quality because of the development in the area. It is expected that potential ecological receptors would use other habitats within the surrounding areas.

There is little to no potential for adverse ecological impacts from MC in surface soil at the Artillery Firing Range North MRS based on the following reasons. Although UXO and/or MD were found in the MRS, explosives were not detected in the samples collected from the MRS. The SQL for 2,6-DNT was greater than the conservative ESVs; however, the SQL value is less than the alternative NOAEL value. In addition, 2,6-DNT was not positively detected in any of the program-level MC samples collected at West Point to support the RIs, and the toxicological information indicates that 2,6-DNT would not be likely to persist in surface soil. The uncertainty associated with the estimated SQLs observed using Method 8330B analysis was minimized by obtaining secondary confirmation by spectral analysis that 2,6-DNT was not present. Even though lead and mercury were detected in all samples, concentrations were less than alternative ESVs or within the range of background concentrations published for the area. Therefore, the risk of exposure to COPECs for ecological receptors at the Artillery Firing Range North MRS is considered to be minimal.

6.3.3 Preliminary Identification of Applicable or Relevant and Appropriate Requirements

A preliminary identification of potential ARARs is conducted during the RI characterization. The ARARs are used as a "starting point" in determining the remedial action objectives and the protectiveness of a remedy to be assessed in a feasibility study (FS). The results of the ARAR selection process for the Artillery Firing Range North MRS are provided in **Table 6-6**. For additional details regarding ARARs and the selection process, refer to Sections 2.6.3, 3.6.3, 4.6.3, or 5.6.3.

Table 6-6 Applicable or Relevant and Appropriate Requirements

Standard, Requirement, Criteria, or Limitation	Citation	Description of Requirement	Comments (Applicable or Relevant and Appropriate)
Action-Specific			
Military Munitions Rule	40 CFR Part 266, Subpart M	Regulates unused munitions, munitions used for intended purposes, and used or fired munitions.	*Applicable* Identify when military munitions become a solid waste; and, if these wastes are also hazardous under this subpart or 40 CFR Part 261, identify the management standards that apply to these wastes.
NY Division of Water - Classes and Standards of Quality and Purity and EPA National Pollutant Discharge Elimination System	6 NYCRR §750-1.5 and 40 CFR Part 122.26	Establishes water quality standards, including classifications of New York waters and water quality criteria to protect the ground and surface water resources; and controls stormwater and effluent discharges, including toxic substances, into state waters.	*Relevant and Appropriate* For remedial alternatives where soil excavation activities are performed and require stormwater management. Construction activities disturbing one or more acres of soil must be authorized under the NY General Permit for Stormwater Discharges from Construction Activities.
Hazardous Waste Manifest System and Related Standards For Generators, Transporters and Facilities	6 NYCRR Part 372	Establishes standards for generators and transporters of hazardous waste and standards for generators, transporters, and treatment, storage or disposal facilities relating to the use of the manifest system and its record keeping requirements.	*Applicable* in the event that hazardous waste is generated as part of a remedial alternative; for example, if MEC were removed and would need to be shipped (by a party other than the Army) as hazardous waste.
Waste Transporter Permits	6 NYCRR Part 364	Protects the environment from mishandling and mismanagement of regulated waste transported from the site of generation to the site of ultimate treatment, storage or disposal.	*Applicable* to any off-site transport and disposal of classified hazardous wastes, if generated as part of remedial alternative.
Air Quality Classifications and Standards	6 NYCRR Part 257-1.3 and 257-1.4	Designed to provide protection from the adverse health effects of air contamination; intended to protect and conserve the natural resources and environment.	*Relevant and Appropriate* in the event that a remedial alternative, such as soil excavation/grading, could impact ambient air quality for an extended period of time. The state regulation has 12-month average standards for dust levels from a specific source.

Notes:
CFR Code of Federal Regulations
NYCRR New York Codes, Rules and Regulations

The preliminary ARARs are summarized in **Table 6-6.** Based on the findings of the RI, it is anticipated that the remedial alternatives will not include on-site treatment, on-site storage (greater than 90 days), or on-site disposal of hazardous waste; therefore, potential action-specific ARARs related to these activities were not considered applicable at this time.

Location-specific ARARs were not identified for the Artillery Firing Range North MRS. Location-specific ARARs generally are restrictions placed on the concentration of hazardous substances or the conduct of activities to prevent damage to unique or sensitive areas, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats. The Artillery Firing Range North does not contain sensitive or unique areas.

Chemical-specific ARARs are health-based or risk-based numerical values that establish the acceptable amount or concentration of a chemical that may remain in, or be discharged to, the ambient environment. Chemical-specific ARARs are used to provide benchmarks with which to compare environmental sampling results for metals and explosives. Residential SCO values published in NYSDEC regulations (NYSDEC, 2006) would be considered chemical-specific ARARs for MC concentrations at the MRS. However, MC was not found at levels of concern (i.e., not detected or detected below risk-based screening values and/or background levels) at the Artillery Firing Range North MRS. Therefore, chemical-specific ARARs did not need to be carried forward based on the information available at the time of the RI. For additional details regarding TBCs that were identified for the entire project at West Point during the RI, refer to Sections 2.4.4, 3.4.4, 4.4.4, or 5.4.4.

NYSDEC participated in TPP 1 (General Project Introduction and Approach) and TPP 2 (Presentation of RI Field Work Approach). Discussions at TPP 1 and TPP 2 generally consisted of establishing which NYSDEC and EPA standards for MC would apply to the whole project (WESTON, 2011a). The RI reports will be presented at the TPP 3 meeting.

The ARARs will be further refined during future phases of work (e.g., the FS) at the Artillery Firing Range North MRS as needed.

6.4 CONTAMINANT FATE AND TRANSPORT

The intent of this section is to describe the fate of contaminants in the environment and the potential transport mechanisms for MEC and MC identified at the Artillery Firing Range North MRS. Contaminant fate refers to the expected final state that an element, compound, or group of compounds will achieve following release to the environment. Contaminant transport refers to the migration mechanisms away from the source area. Because UXO was characterized at the Artillery Firing Range North MRS during the RI, an explosive hazard has been identified and a discussion of MEC fate and transport relevant to the MRS is provided in Section 6.4.1.

Based on the analytical data evaluation and the subsequent risk assessment, an MC risk is not present within the Artillery Firing Range North MRS. Therefore, further analysis of MC fate and transport dynamics was not warranted.

6.4.1 MEC Fate and Transport

Potential routes of migration include those physical processes that might result in movement or relocation of MEC from its original placement. If not removed, the MEC will have the potential to pose an explosive hazard to human and ecological health. The following physical processes can result in the transport of MEC from its original placement:

- Potential MEC being picked up or moved by a person(s).
- Disturbance of potential MEC during construction, excavation, or other soil moving activities.
- Natural processes such as erosion/deposition or frost heave.

Over time, natural erosion of soil by the wind or by water (surface water or precipitation) can result in the exposure of buried MEC by the removal of the overlying soil. In some cases, if soil is unstable and the erosive force is sufficient to act on the size of MEC item(s) present, the process can also result in the movement of MEC from its original position to another location (typically somewhere downstream of the wash).

In addition to erosion, buried objects have been known to move or migrate toward the surface during freezing and thawing cycles. Movement occurs when cold penetrates the ground, and the water below the buried objects freezes and expands, gradually pushing the objects upward. The phenomenon is often referred to as "frost heave" and is most likely to affect items buried above the frost line. The soil type influences the occurrence of frost heave. Gravel, sand, and clay are not typically susceptible to frost heave, whereas silty soil is susceptible. All soils in the Artillery Firing Range North MRS are low to moderately susceptible to frost heave based on their capacity to retain moisture (see Section 6.1.1.4) and on the seasonally cold temperatures typical for the regional location of West Point. The maximum frost penetration depth for the region is 1.00 to 1.25 meters (approximately 3.28 feet to 4 feet) below ground surface (National Oceanic and Atmospheric Administration [NOAA], 1978).

Surface interactions, such as wet/dry erosion, are likely to impact source material, whereas frost heave is unlikely (low potential) in the Fort Clinton West portion of the Artillery Firing Range North MRS. For the Siege Battery portion of the MRS, surface interactions, such as wet/dry erosion and frost heave, are likely to impact source material. The Lusk portion of the MRS has the potential for surface interactions, such as wet/dry erosion, to impact source material, whereas frost heave is unlikely. For the Artillery Firing Range portion of the MRS, surface interactions, such as wet/dry erosion, have the potential to impact source material, whereas frost heave is unlikely. Refer to Sections 2.7.1, 3.7.1, 4.7.1, and 5.7.1 for more details. In summary, the entire Artillery Firing Range North MRS is susceptible to wet/dry erosion, whereas frost heave is unlikely except in the northeast. Burrowing biota might come in contact with residual MEC and MD because of the shallow depth of MEC observed during and after the RI, which was identified within the zone of biological activity.

6.5 CONCEPTUAL SITE MODEL

A CSM for the Artillery Firing Range North MRS was not developed prior to the RI because the land area was previously addressed under the original boundaries of the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. The following sections describe the CSM developed based on the RI results for the area now identified as the Artillery Firing Range North MRS.

The CSM is used as a planning tool to integrate MRS information from a variety of sources, to evaluate the information with respect to project objectives and data needs, and to respond through an iterative process of further data collection or action. The CSM development should be viewed as a process that reflects the progress of activities at an MRS from initial assessment through closeout. The CSM is divided into three primary components: potential sources, interactions, and receptors for MEC and/or MC, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. Each component is described below:

- Sources — Sources are those areas where MEC or MC has entered (or may enter) the physical system. An objective of the RI is to detect and delineate sources using geophysical surveys and intrusive investigations.
- Interactions — The hazard from MEC and the risk from MC are a result of direct human contact through an activity. Interactions describe ways that receptors come into contact with a MEC and/or MC source. For MC, interactions can include physical transport of the contaminant and transfer from one media to another through various processes so that media other than the source area can become contaminated. Interactions also include exposure routes (ingestion, inhalation, and dermal contact) for each receptor. For MEC, movement is not typically significant, and interaction will occur only at the source area, limited by access and activity. There can be movement of MEC through natural processes such as frost heave and soil erosion.
- Receptors — A receptor is an organism (human or ecological) that contacts a chemical or physical agent. The pathway evaluation must consider both current and reasonably anticipated future land use because receptors are determined on that basis. Receptors include human receptors, such as West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors, and ecological receptors.

6.5.1 Munitions and Explosives of Concern Conceptual Site Model

After completion of the RI field work, an increase in MEC and/or MD densities was observed laterally extending across several MRSs, including the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. Based on the observed density distribution and the type of MEC and MD recovered, the source of the increased clustering and densities is related to the former target area at the Crows Nest in the northern extent of West Point. The Crows Nest impact area includes 143.3 acres of land within the northern portion of West Point. The Artillery Firing Range North MRS boundary includes portions of five former range fans that were historically used for firing in the direction of targets located on Crows Nest.

6.5.1.1 Munitions and Explosives of Concern Exposure Pathway Analysis

Each pathway includes a source, interaction, and receptor, with complete, potentially complete, or incomplete exposure pathways identified for each receptor. A pathway is considered complete when a source (MEC) is known to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered potentially complete when a source (MEC) has not been confirmed, but is suspected to exist and when receptors have access to the MRS while engaging in an activity that results in contact with the source. A pathway is considered incomplete if any one of the three components (source, interaction, or receptors) is not present at an MRS.

6.5.1.1.1 Source

A MEC source is the location where MEC is situated or is expected to be found. High concentrations of MEC and MD were not anticipated during the RI planning for the original Fort Clinton West, Siege Battery, Lusk Reservoir, or Artillery Firing Range MRSs because the target area for the former ranges was located on Crows Nest and not included within the MRS boundaries. However, during the RI and subsequent construction projects, seven UXO items were recovered, including two MKII hand grenades (unfuzed), two 8-inch Butler projectiles, one 90mm APC-T, and two 8-inch Parrott shells. In addition, 828 MD were recovered, including four MKII hand grenades (empty), one 4.6-inch Parrott round (empty), two 8-inch Butler projectiles (empty), one 5.3-inch Parrott type II bottle top, one 10-inch Parrott type II bottle top, one 3.5-inch cannonball (solid shot), one 6-inch cannonball (solid shot), one 8-inch Butler projectile (concrete filled), and 816 fragments from unknown munitions. During the RI, all items were recovered at ground surface or within 15 inches of ground surface. The depth of UXO and MD encountered during construction events is unknown.

Based on the results of the RI, MEC, in particular UXO, may be found within the Artillery Firing Range North MRS as a result of misfires or undershots toward the former targets. It is possible that MEC and MD may have been transported in fill material and placed within the Artillery Firing Range North MRS during historical construction activities. The development of West Point over time has expanded outward from a core cantonment area with operational ranges located on the fringes. To support outward expansion, former operational range land was converted (excavation/fill) to enlarge the cantonment area, and material that originated at former operational ranges may have been used during construction. Although the fill material from former operational ranges was likely reused at current operational ranges as a matter of best practice, it is possible that it was placed elsewhere on the West Point installation. Any residual risk associated with the historical excavation and/or fill placement activities whereby MEC and MD may be present in the portions of the MRS not directly investigated during the RI is minimal and is mitigated by the installation-wide dig permitting program (pre-existing institutional control). The RI findings confirm the presence of a MEC source, and thus an explosive hazard, in the Artillery Firing Range North MRS.

6.5.1.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes both access and activity considerations. Access describes the degree to which a MEC source or an environment containing MEC is available to potential receptors. Activity describes the action by which receptors come in contact with a source. Typically, a receptor may contact MEC, if present, on the ground surface simply by walking. A receptor may contact MEC in the subsurface, if present, by performing intrusive activities.

The Artillery Firing Range North MRS is located within three land use zones: (1) Cadet Support; (2) Post Support; and (3) Recreational, Industrial, Field Training. The Lee Housing Area and undeveloped, heavily wooded terrain are located in the northeastern portion of the MRS. In addition to residential and military housing, structures within the Artillery Firing Range North MRS include West Point Elementary School and Middle School, a solid waste landfill (Post School Landfill), a water pump station, the Keller Army Community Hospital, and a lumber yard. Interspersed areas of forest that are undeveloped may be used for recreational purposes within the MRS. The Crows Nest lies to the north of the MRS (**Figure 6-2**).

There are no current plans to change the land use. Once on the West Point installation, human and ecological receptors have unrestricted access to the Artillery Firing Range North MRS. A receptor may contact UXO that is on the ground surface simply by walking. A receptor may contact UXO in the subsurface by performing intrusive activities. Residential, maintenance, and recreational activities in the MRS may disturb surface and subsurface soils. The undeveloped areas in the Artillery Firing Range North MRS may be used recreationally for activities such as hiking, bird watching, and cross country skiing. Hunting and trapping are not permitted within or near the MRS (Tetra Tech, Inc., 2011).

6.5.1.1.3 Receptors

A receptor is an organism (human or ecological) that comes in physical contact with MEC. Human receptors identified for the Artillery Firing Range North MRS include West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

Approximately 70% of the Artillery Firing Range North MRS has been disturbed by development, and it is unlikely that ecological receptors would rely on the developed area for habitat. The northwestern extent of the MRS has areas that are undisturbed and consist of heavily forested areas and some steep terrain. Potential ecological receptors that may be present are described in the overall CSM for West Point detailed in Sections 2.1.1.6.5, 3.1.1.6.5, 4.1.1.6.5, and 5.1.1.6.5.

6.5.1.2 Munitions and Explosives of Concern Exposure Conclusions

The information collected during the RI was used to develop a MEC CSM for the Artillery Firing Range North MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS given current and anticipated future land users. Based on the results of the RI, including historical data reviews, geophysical data collection, intrusive anomaly investigations, and recent Explosive Ordnance Disposal (EOD) responses (post-RI), UXO and MD are present in the Artillery Firing Range North MRS. Based on the qualitative assessment of the seven UXO items and the 828 MD items found within the MRS, a MEC source and thus an explosive hazard are present in the Artillery Firing Range North MRS. Because access to the MRS is unrestricted once within the West Point installation boundary and receptors have been identified with the potential to encounter UXO, the pathways for MEC exposure are complete for the Artillery Firing Range North MRS. Although MEC was identified only in the subsurface, MD was identified on the surface; therefore, the pathways for surface soils are considered complete. A MEC CSM diagram for the Artillery Firing Range North MRS is provided in **Figure 6-6**.

6.5.2 Munitions Constituents Conceptual Site Exposure Model

Eight sampling locations were selected to assess the potential MC contamination in soil at the Artillery Firing Range North MRS associated with MEC and MD identified during the RI.

Eleven incremental samples (includes eight primary samples, a field duplicate, and a field duplicate/triplicate pair), comprised of 50 increments, were collected within 0.8-acre sampling units, strategically placed within the MRS in locations where UXO was found during the geophysical investigations.

The MC sampling results are discussed in Section 6.2.2. The complete analytical results and data validation reports are provided in **Appendix 6-D**. The analytical results were used to perform the HHRA and SLERA (see Section 6.3) and to develop the CSM.

6.5.2.1 Munitions Constituents Exposure Pathway Analysis

Each pathway includes a source, interaction, and receptor, with complete, potentially complete, and incomplete exposure pathways identified for each receptor. An exposure pathway for MC requires a source exposure medium (i.e., MC in soil), interaction (release mechanism and exposure route), and receptors. A pathway is considered complete when all components exist and imply potential risk. A pathway is considered potentially complete when data are required to determine whether the pathway is complete or incomplete. An incomplete pathway presents no associated risk and no further data are required.

6.5.2.1.1 Source

Both UXO and MD were identified throughout the Artillery Firing Range North MRS. The UXO and MD represent an impact area associated with firing toward the former targets on Crows Nest. Although no soil staining was observed, MC sampling was conducted based on the confirmed UXO and MD to investigate whether an MC release occurred and whether further delineation was warranted. Data evaluation and the HHRA did not identify any COPCs or potential risks to human receptors because no explosives were detected in any of the samples and because detections of lead and mercury were below alternative screening levels and within published background levels. The risk from the one COPEC identified during the SLERA, due to an SQL that did not meet the selected ESV, was determined to be minimal. The data indicate that UXO, when present, is not a significant source of MC within the MRS and that the potential for encountering an MC risk is not present within the Artillery Firing Range North MRS.

6.5.2.1.2 Interaction

Interaction describes the ways that receptors come in contact with a source and includes an exposure route with a release mechanism for impacted media. The Artillery Firing Range North MRS is located primarily within three land use zones: (1) Cadet Support; (2) Post Support; and (3) Recreational, Industrial, Field Training. Once on the West Point installation, human and ecological receptors have unrestricted access to the MRS. A human or ecological receptor may encounter MC in soil through direct contact, including the ingestion, inhalation, or dermal exposure routes.

Within the environment, the fate and transport of MC in soil, if present, has the potential to be affected by secondary release processes such as wet/dry erosion, infiltration/leaching to groundwater, and food web interactions. These processes may result in the movement or transformation of MC within environmental media.

6.5.2.1.3 Receptors

Potential receptors for MC at the Artillery Firing Range North MRS are the same as those presented in the MEC CSM in Section 6.5.1.1.3.

6.5.2.2 Munitions Constituents Exposure Pathway Conclusions

The analytical results from the incremental samples and the risk assessment activities performed to support the RI were used to develop an MC CSM for the Artillery Firing Range North MRS and to identify complete, potentially complete, or incomplete source-receptor interactions for the MRS for current and anticipated future land users. Sampling for MC was conducted within the Artillery Firing Range North MRS where UXO and MD have been confirmed. Explosives were not detected in any of the soil samples. The SQL for 2,6-DNT exceeded the project ESV, but not the NOAEL. Although detected, neither lead nor mercury was found in concentrations above alternative screening levels and/or the published background concentrations.

Because an MC release has not been identified in any environmental media, no interactions are expected to exist at the Artillery Firing Range North MRS that would expose receptors to MC contamination. The pathways for human and ecological receptors to contact MC are considered incomplete because no potential MC sources, and thus no potential risk, are known to exist in the

Artillery Firing Range North MRS. An MC CSM diagram for the Artillery Firing Range North MRS is provided in **Figure 6-7.**

6.6 MUNITIONS AND EXPLOSIVES OF CONCERN HAZARD ASSESSMENT AND MUNITIONS RESPONSE SITE PRIORITIZATION PROTOCOL

6.6.1 Munitions and Explosives of Concern Hazard Assessment

The CERCLA process for responding to releases or potential releases of hazardous substances includes the development of site-specific risk assessments appropriate to the requirements of a site. The results of the risk assessments are used to help site managers decide whether a response action is required and to support the risk management decisions that are made through the remedy evaluation, selection, and implementation process.

The CERCLA methodology for human health chemical risk assessment was not designed to address explosive safety hazards at MEC sites. In October 2008, the Technical Working Group for Hazard Assessment, which included representatives from DoD, Department of the Interior, EPA, and others, made available the technical reference document Interim Munitions and Explosives of Concern Hazard Assessment Methodology (MEC HA) (EPA, 2008). For additional details regarding MEC HAs, refer to Sections 2.9, 3.9, 4.9, or 5.9.

The MEC HA guidance document (EPA, 2008) includes an automated workbook that develops site scoring through standardized input and formulas. As part of the RI, the automated workbook was used to provide a HA score.

A summary of the MEC HA scoring for the Artillery Firing Range North MRS is presented as follows:

Site ID: Artillery Firing Range North MRS	Hazard Level	Category Score
Current Use Activities	1	860

Source: EPA MEC HA Worksheet V.1.2, 2007.

The Artillery Firing Range North MRS has a Hazard Level Category of 1, which indicates the MRS has a high hazard potential. The presence of MEC at an MRS means that an explosive hazard may exist. Artillery Firing Range North MRS characteristics of a Hazard Level 1 MRS include the following:

- High-explosive-filled UXO.
- A former target area.
- An MRS with full accessibility.
- Subsurface MEC with intrusive activities to the depth of subsurface MEC.
- An MRS that has not undergone a cleanup.

Supporting MEC HA input information is provided in **Appendix 6-E.**

6.6.2 Munitions Response Site Prioritization Protocol Scoring

Results from the RI were used to apply the MRSPP to the newly delineated MRS. Priority 1 indicates the highest potential hazard and Priority 8 the lowest potential hazard. Under the MRSPP, only MRSs with chemical warfare materiel (CWM) can be assigned to Priority 1 and no MRS with CWM can be assigned to Priority 8. The MRS priority for the Artillery Firing Range North MRS was determined to be 3. The MRSPP forms are provided in **Appendix 6-F**.

6.7 SUMMARY AND CONCLUSIONS

This section summarizes the results and conclusions of the RI activities conducted at the Artillery Firing Range North MRS. The RI was conducted to determine the nature and extent of MEC and MC and to determine the potential hazards and risks posed to human health and the environment by MEC and MC. The RI also provided additional data to assist in determining what remedial alternatives, if any, are necessary. As a result of the characterization activities conducted at the Artillery Firing Range North MRS, the objectives of the RI have been satisfied.

6.7.1 Summary of Remedial Investigation Activities

During RI field investigations, three UXO items, including two MKII hand grenades (unfuzed) and one 8-inch Butler projectile, were recovered from the Crows Nest impact area delineated as the Artillery Firing Range North MRS. A total of 827 MD items were also recovered and included four MKII hand grenades (empty), one 4.6-inch Parrott round (empty), two 8-inch Butler projectiles (empty), one 5.3-inch Parrott type II bottle top, one 10-inch Parrott type II bottle top, one 3.5-inch cannonball (solid shot), one 6-inch cannonball (solid shot), and 816 fragments from unknown munitions. All materials were recovered between the surface and 15 inches bgs.

After the RI field activities, four UXO items (90mm APC-T, 8-inch Butler projectile, and two 8-inch Parrott shells) and one MD item (an 8-inch Butler projectile [concrete-filled]) were also recovered during construction projects that occurred within the northern portion of the Artillery Firing Range MRS and the northern portion of the Lusk Reservoir MRS. Because of the locations where these items were found, the discoveries were incorporated into the overall assessment of the area delineated as the Artillery Firing Range North MRS.

Eight sampling locations were assessed within the delineated impact area for potential MC contamination in soil by conducting incremental sampling where increased densities of UXO and MD were observed. No other signs of an MC release (e.g., soil staining, broken/leaking munition) were observed during the RI. Eleven samples were analyzed, including eight primary incremental samples, one field duplicate, and one field duplicate/field triplicate pair. Each incremental sample was comprised of 50 increments collected from 0.8-acre sampling units. The samples were collected and analyzed to identify the presence of MC (if any) and to fully characterize the nature and extent of MC. No explosives were detected in the samples; however, elevated SQLs for several explosive chemicals were further evaluated during the HHRA and SLERA. The HHRA and SLERA also addressed concentrations of lead and mercury that were observed.

6.7.2 Risk Assessment

The results of the HHRA showed that no MC was present that constituted a potential risk to human health. All explosives analytical results were qualified as U or UJ, indicating the analytes were not detected above their reported SQLs and were observed below the project screening levels selected to assess human health effects. Both lead and mercury were positively detected, but based on results of the HHRA, the surface soil incremental sample did not contain MC concentrations greater than the screening levels that would pose a potential risk to current or future West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

There is little to no potential for adverse ecological impacts from explosives MC in surface soil at the Artillery Firing Range MRS because only the SQL for 2,6-DNT slightly exceeded the EPA conservative screening criterion. However, SQLs for 2,6-DNT were below the less conservative alternative screening value obtained to assess the NOAEL. Additionally, 2,6-DNT was not detected in any samples collected at the program-level at other West Point MRSs, and toxicological information indicates that this compound would not be likely to persist in surface soil. Although both mercury and lead were positively detected at concentrations above the conservative project ESVs initially used for the point-by-point comparison, the concentrations were found to be below alternative ESVs that were available and/or within published background levels. Therefore, the risk of exposure to COPECs for ecological receptors at the Artillery Firing Range North MRS is considered to be minimal.

6.7.3 Conceptual Site Model

The information collected during the RI was used to develop the CSM (Section 6.5). The purpose of the CSM is to identify all complete, potentially complete, or incomplete source-receptor interactions for current and reasonably anticipated future land use activities at the Artillery Firing Range North MRS. An exposure pathway is the course a MEC item or MC takes from a source to a receptor. Each pathway includes a source, interaction (activity and access), and receptor.

During the MMRP RI at the 11 West Point MRSs, consistent results indicative of a common CSM were observed across the original boundaries of several MRSs, including the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs. These MRSs consist of overlapping ranges that are located south or southeast of Crows Nest at West Point. The Crows Nest, which demarcates the northern extent of the West Point installation boundary, is a topographic high point above the remainder of West Point. Crows Nest was the target area used for several ranges within West Point and for weapons testing from the West Point Foundry (also called the Cold Springs Foundry) situated on the east side of the Hudson River. During the RI and during subsequent construction activities, concentrations of MEC and MD were identified in the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs, which represent the southern extent of a MEC impact area related to the Crows Nest. The impact area has been identified as the Artillery Firing Range North MRS, with a 143.3-acre boundary delineated based on the RI characterization.

Concentrations of UXO and MD were observed throughout the Artillery Firing Range North MRS. The UXO and MD are primarily attributed to historical firing at targets located on Crows Nest mountain. MEC and MD transported in fill material used for construction projects is another potential MEC source based on historical documentation. The Crows Nest impact area represents a 143.3-acre portion of West Point that includes acreage formerly associated with the Fort Clinton West, Siege Battery, Lusk Reservoir, and the Artillery Firing Range MRSs.

The southwestern boundary for the Crows Nest impact area that was delineated during the RI extends into the Main Post south of the Keller Army Community Hospital and the West Point Elementary School and Middle School to approximately Washington Road and traverses northeasterly south of Bailey Loop and north of Buckner Loop, and south of the Lee Housing Area. The RI findings confirm the presence of a MEC source and thus an explosive hazard in the Artillery Firing Range North MRS. Although MEC was identified only in the subsurface, MD was identified on the surface; therefore, the pathways for surface soils are considered complete. The pathways for MEC exposure to potential receptors are considered complete based on MEC and MD findings in the Artillery Firing Range North MRS.

Media sampling was performed within the impact area to investigate whether a potential MC release might have occurred based on the presence of UXO and MD. No MC was detected in soil associated with the discovered UXO and MD that would pose risks to human or ecological receptors. Therefore, the pathways for human and ecological receptors to contact MC are considered incomplete based on the results of the RI.

6.7.4 Munitions and Explosives of Concern Hazard Assessment

An evaluation of the explosive hazard at the Artillery Firing Range North MRS was prepared in accordance with the *Interim Munitions and Explosives of Concern Hazard Assessment Methodology* (MEC HA) (EPA, 2008). A score of 860 with a corresponding hazard level of 1 was calculated for the Artillery Firing Range North MRS.

6.7.5 Conclusions and Recommendations

Based on the results of the RI field activities, the following conclusions were determined for the Artillery Firing Range North MRS:

- MEC, in the form of UXO, and MD were found in surface and subsurface soil to 15 inches bgs within the MRS, which represents the delineated Crows Nest impact area situated in the northern extent of West Point. MEC and MD in construction fill are also potentially present based on the available records reviewed to date.

- Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for the MRS.
- MC pathways to potential receptors were determined to be incomplete.

The nature and extent of MEC and MC have been adequately characterized. It is recommended that the Crows Nest impact area, comprised primarily of acreage formerly associated with the Fort Clinton West, Siege Battery, Lusk Reservoir, and Artillery Firing Range MRSs, be consolidated into the newly assigned Artillery Firing Range North MRS under tracking number WSTPT-001-R-02.

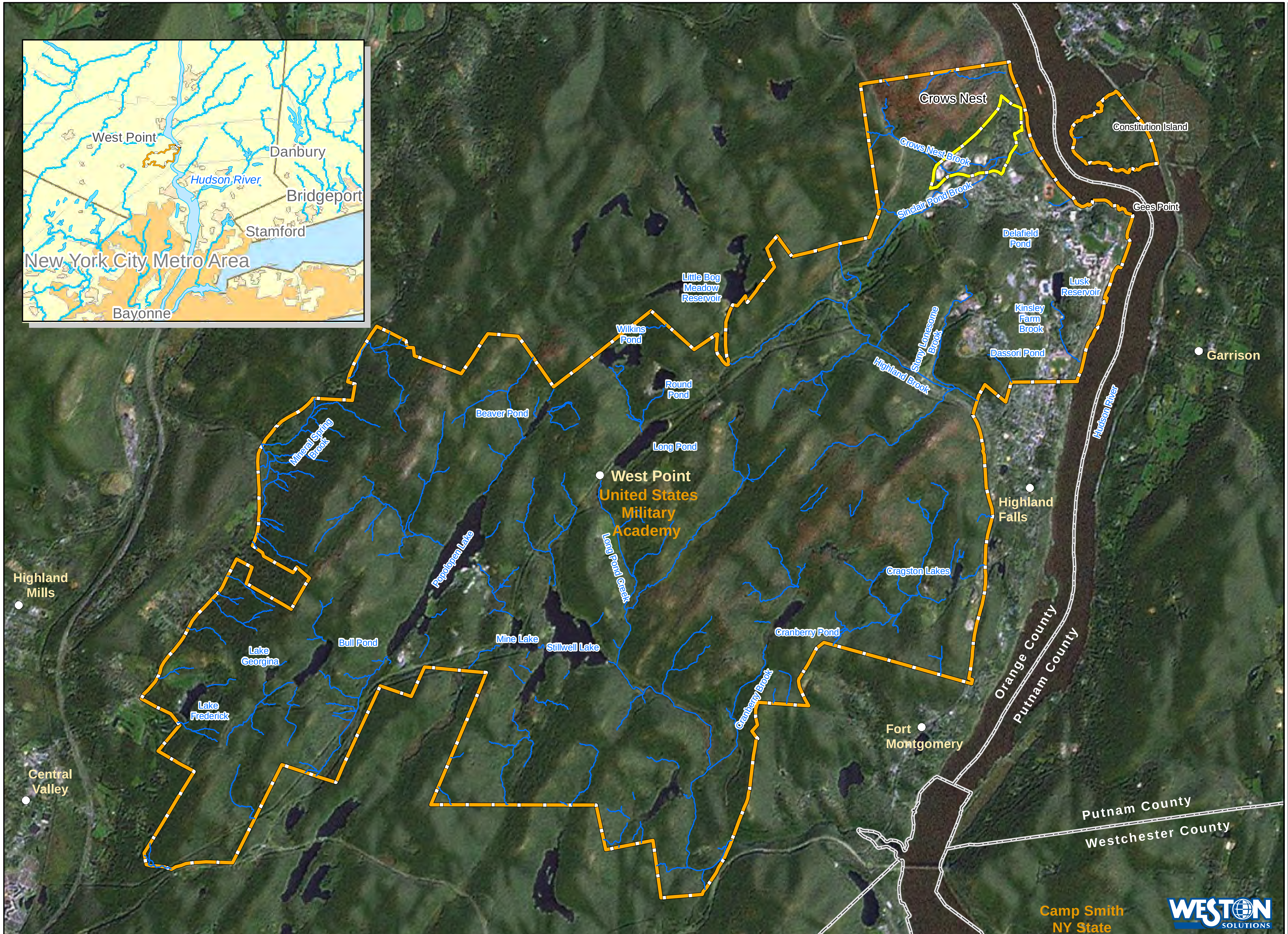
A summary of the area delineated within the Crows Nest impact area is presented in **Table 6-7**.

Table 6-7 Artillery Firing Range North MRS Delineation

Original MRS Identifier	**Area (acres) Recommended for Inclusion in Artillery Firing Range North**
Fort Clinton West (WSTPT-008-R-01)	12.7
Siege Battery (WSTPT-015-R-01)	66.3
Lusk Reservoir (WSTPT-019-R 01)	8.8
Artillery Firing Range (WSTPT-001-R-01)	42
Area previously not included within an MRS boundary at West Point	13.5
Artillery Firing Range North MRS total area:	143.3

Artillery Firing Range North MRS (WSTPT-001-R-02)—It is recommended that the Artillery Firing Range North MRS be further evaluated for potential action in an FS to address hazards related to the presence of MEC.

SECTION 6
FIGURES



Legend
- Installation Boundary
- Artillery Firing Range North MRS - 143.3 Acres
- Streams

Imagery Source: ESRI, World Imagery
USAD FSA, NAIP 2009

N W E S

0 1 2
Miles

Figure 6-1
Regional Location Map
Showing the Location of
Artillery Firing Range North MRS
U.S. Army Garrison West Point

WESTON SOLUTIONS

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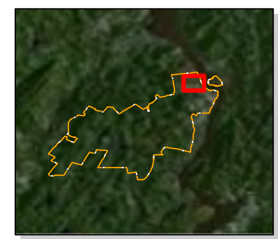
WESTON SOLUTIONS

Legend

Artillery Firing Range North MRS - 143.3 Acres

Boundaries of other MRSs



Imagery Source: ESRI, Bing Mapping Service. 2013

N W E S

0 300 600 Feet

Figure 6-2
Artillery Firing Range North MRS
(WSTPT-001-R-02)
U.S. Army Garrison West Point

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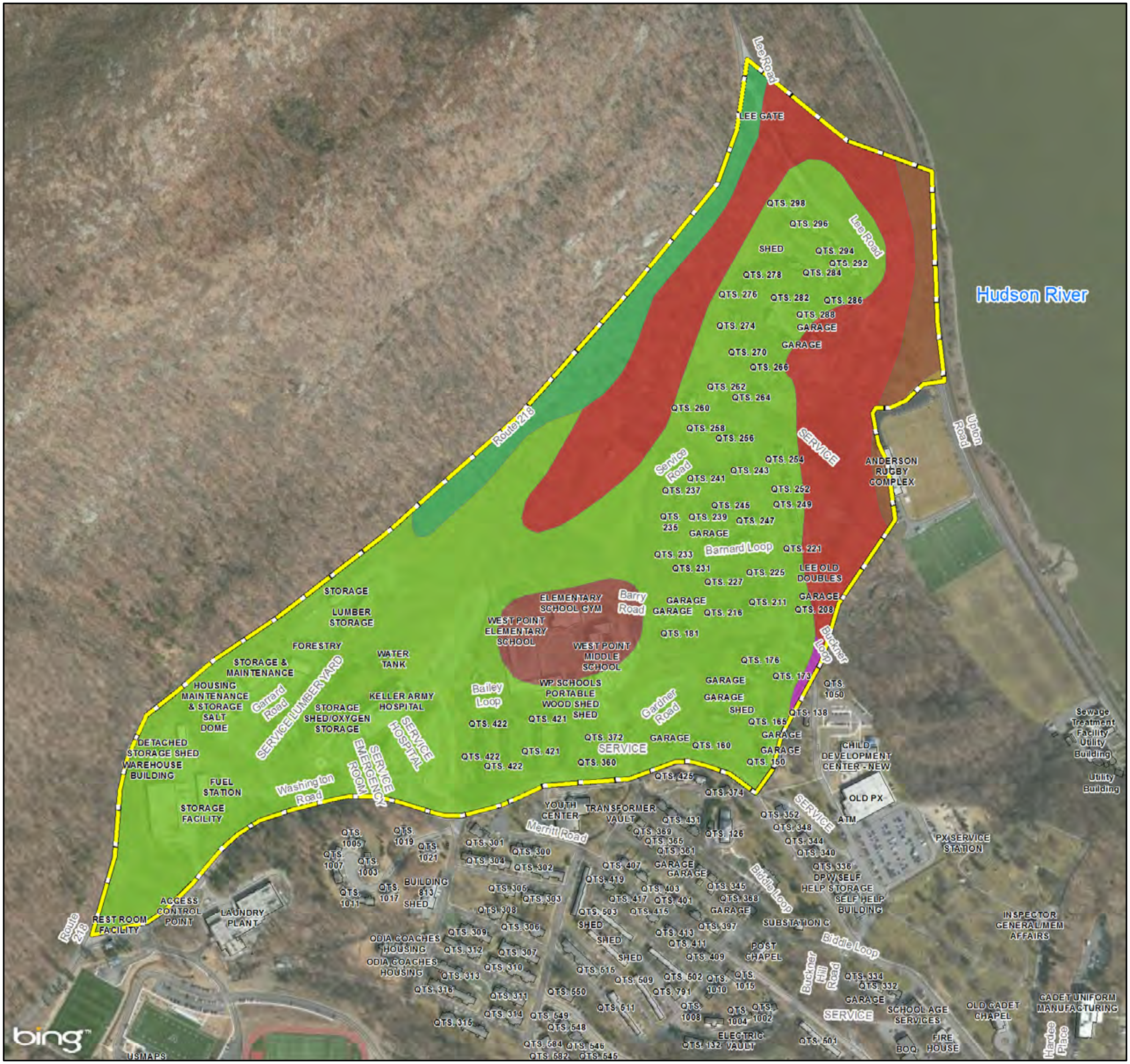

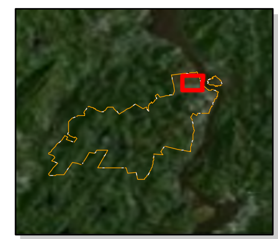

Legend

- Artillery Firing Range North - 143.3 Acres
- Chenango gravelly silt loam, 0 to 3 percent slopes
- Hollis soils, sloping
- Otisville and Hoosic soils, steep
- Rock outcrop-Hollis complex, sloping
- Rock outcrop-Hollis complex, moderately steep
- Swartswood gravelly loam, 3 to 8 percent slopes
- Udorthents, smoothed

Imagery Source: ESRI, Bing Mapping Service. 2013

Figure 6-3
Artillery Firing Range North MRS
(WSTPT-001-R-02)
Soil Series
U.S. Army Garrison West Point

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Figure 6-4
Artillery Firing Range North MRS
(WSTPT-001-R-02)
Grid and Transect Locations
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\AFR_North_Grid_Transect_locs_Revised_MRS_tabloid.mxd, 1/14/2014 1:34:16 PM, ricksc

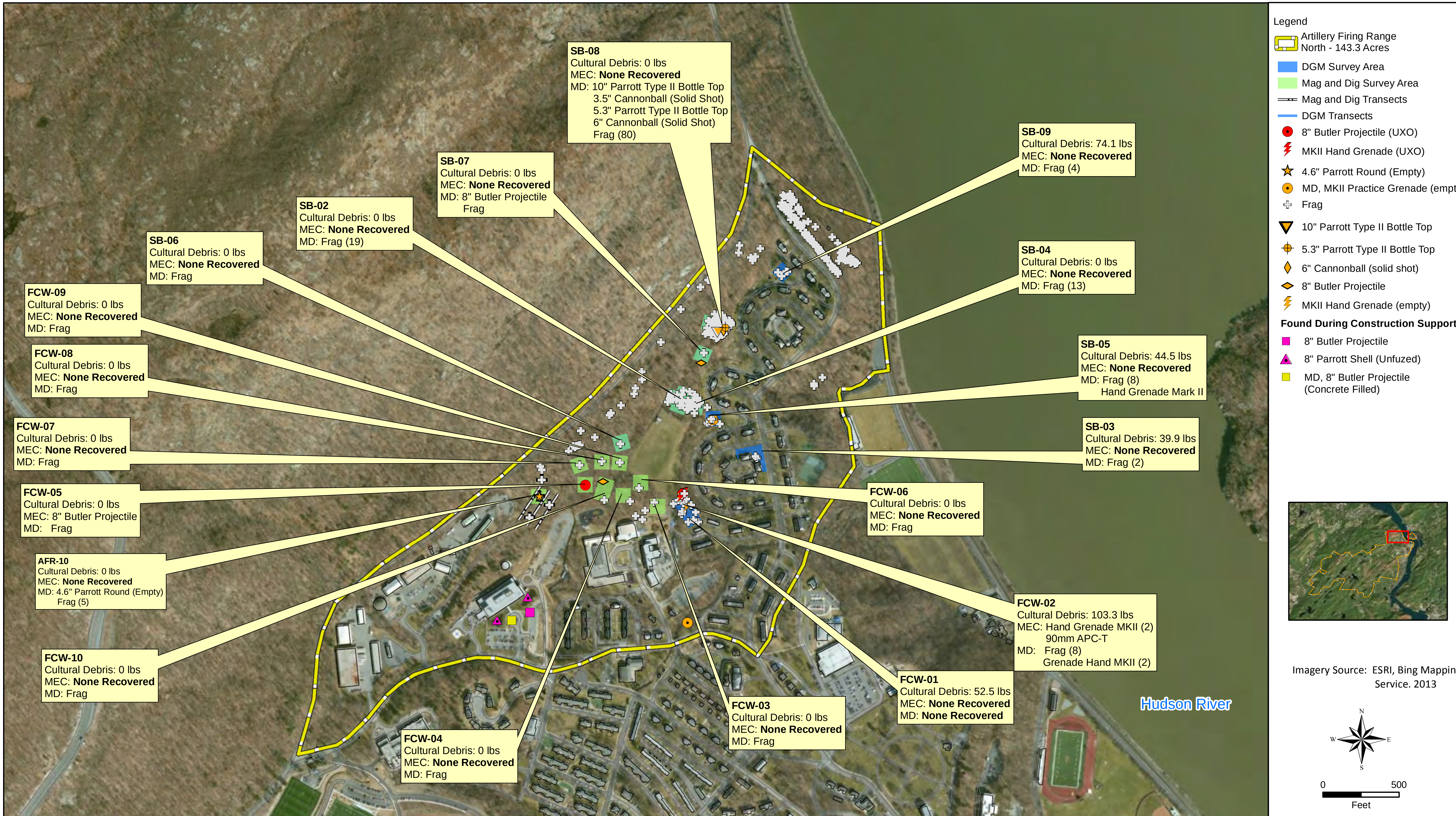
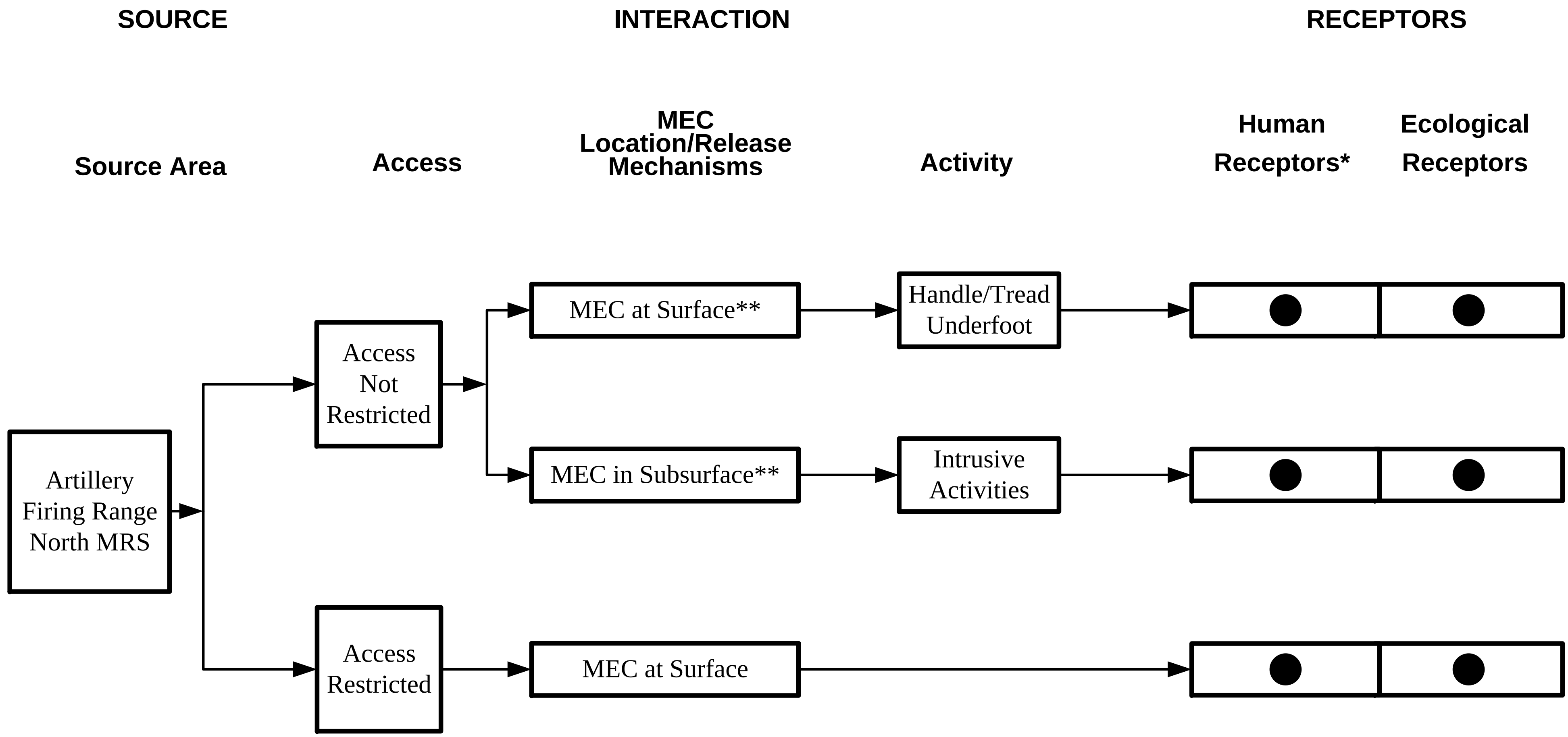


Figure 6-5
Artillery Firing Range North MRS
(WSTPT-001-R-02)
Dig Results
U.S. Army Garrison West Point

File: Y:\West_Point\mxd\RI\AFR_North_Dig_Result_Cultural_Debris_MRS.mxd, 12/18/2014 11:55:24 AM, johna



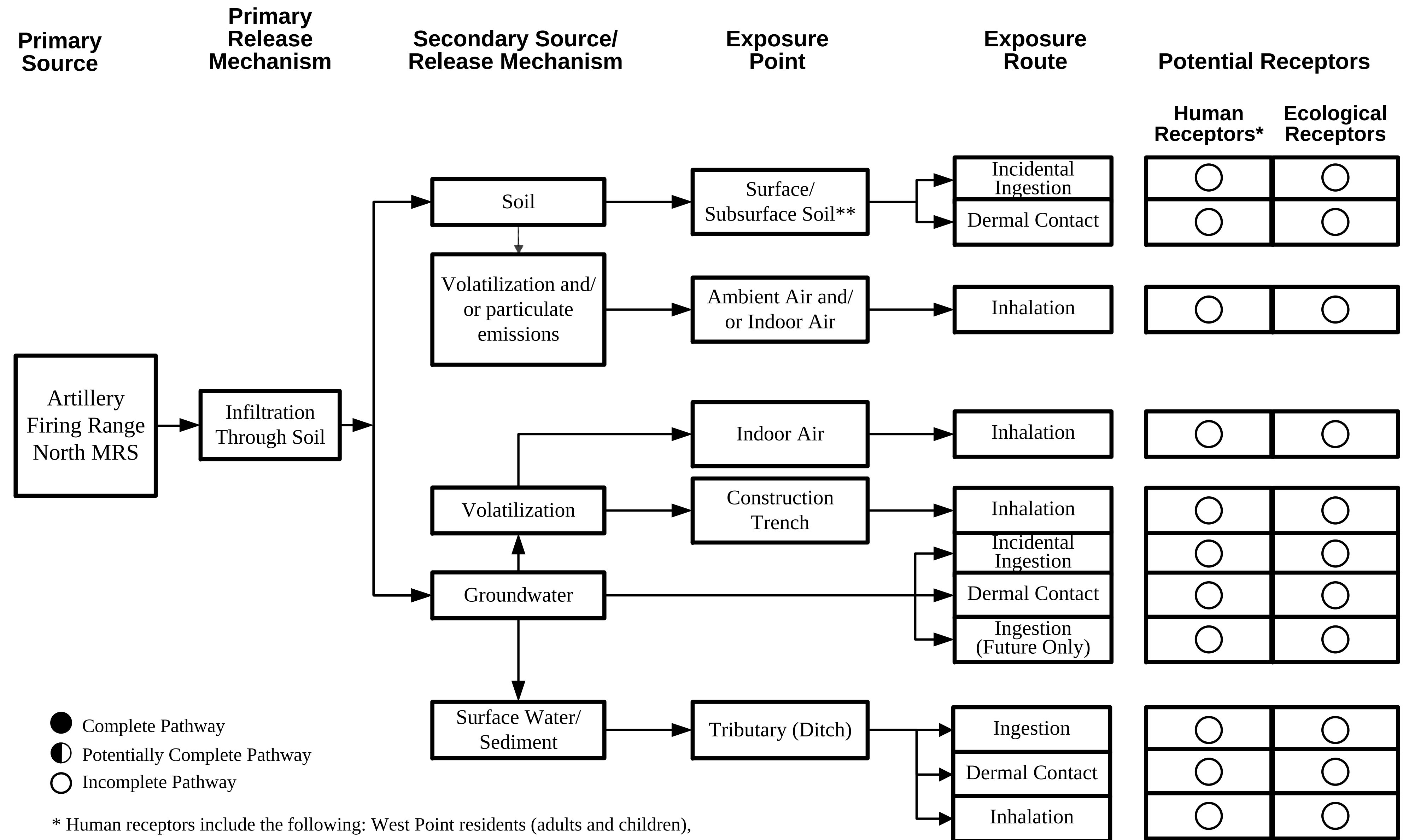
* Human receptors include the following: West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

** UXO and MD were recovered at ground surface and to 15 inches bgs. UXO was found after RI field work during construction activities.

● Complete Pathway
◐ Potentially Complete Pathway
○ Incomplete Pathway

Figure 6-6
RI Exposure Pathways for Receptors to MEC in the Artillery Firing Range North MRS (Crows Nest Impact Area)

Fig 6-6_6-7_AFR North_RI Exposure Pathways for MEC and MC.vsd



* Human receptors include the following: West Point residents (adults and children), school children, contractor personnel, installation personnel, recreational users, and site visitors.

** UXO and MD were recovered during the RI at ground surface and to 15 inches bgs. UXO was found after RI field work during construction activities. During the RI MC assessment, no releases in soil associated with the UXO or MD were observed.

Figure 6-7

RI Exposure Pathways for Receptors to MC in the Artillery Firing Range North MRS (Crows Nest Impact Area)

Fig 6-6_6-7_AFR North_RI Exposure Pathways for MEC and MC.vsd

7. SUMMARY AND CONCLUSIONS

This section summarizes the individual MRS conclusions. The recommendations for future activities are also provided based on the characterization completed during the MMRP RI at West Point for the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and the newly delineated Artillery Firing Range North MRS. Based on the investigation results, the DQOs for these MRSs have been satisfied and the nature and extent of MEC and MC have been adequately characterized.

7.1 SUMMARY OF MRS CONCLUSIONS

7.1.1 Fort Clinton West MRS

Based on the results of the RI field activities, the following conclusions were determined for the Fort Clinton West MRS:

- A total of 4.05 acres were investigated at the MRS during the RI.
- Three subsurface UXO and 32 MD items were recovered on the ground surface and subsurface soil to 12 inches bgs in the northwestern 12.7-acre portion of the MRS delineated within the Crows Nest impact area. Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for the northwestern portion of the MRS.
- Because no MEC or MD was found in the southeastern 1.7-acre portion of the Fort Clinton West MRS and the DQOs for the project were met, an explosive safety hazard is not anticipated to exist in this portion of the MRS. Incomplete MEC pathways were identified for surface and subsurface soils for all receptors having access to the southeastern 1.7-acre portion of the MRS.
- MC pathways to potential receptors were determined to be incomplete.

The recommendations for the Fort Clinton West MRS are as follows:

- Revise the Fort Clinton West MRS from 14.4 acres to 1.7 acres and maintain tracking under WSTPT-008-R-01. No further action under the MMRP is recommended for the adjusted Fort Clinton West MRS (WSTPT-008-R-01). Future phases of work for the Fort Clinton West MRS may include the preparation of a No Further Action Proposed Plan for public review followed by the issuance of a Decision Document.
- Transfer the northwestern 12.7-acre portion of the Fort Clinton West MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02). This newly defined MRS consolidates the impact area acreage identified in several MRSs associated with the former targets at the Crows Nest.

7.1.2 Siege Battery MRS

Based on the results of the RI field activities, the following conclusions were determined for the Siege Battery MRS:

- A total of 5.88 acres were investigated at the MRS during the RI, exceeding the required spatial coverage needed to achieve a high statistical confidence to determine MEC density.
- MD was found in surface and subsurface soil to 12 inches bgs in the 66.3-acre northwestern portion of the MRS delineated within the impact area associated with the former targets at the Crows Nest area, and within the 52 acres of the MRS located on Constitution Island. Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for these portions of the MRS.
- Because no MEC and only one MD item was found and the DQOs for the project were met, an explosive safety hazard is not anticipated to exist in the remaining 48.8 acres of the Siege Battery MRS located on the Main Post and not included in the Crows Nest impact area. Incomplete MEC pathways were identified for surface and subsurface soils for all receptors having access to this portion of the MRS.
- MC pathways to potential receptors were determined to be incomplete for the southeastern Main Post portion, the northwestern Main Post portion, and Constitution Island.

The recommendations for the Siege Battery MRS are as follows:

- Revise the Siege Battery MRS to 48.8 acres within the Main Post. No further action under the MMRP is recommended for the adjusted Siege Battery MRS (WSTPT-015-R-01). Future actions for the Siege Battery MRS may include the preparation of a No Further Action Proposed Plan for public review followed by issuance of a Decision Document.
- Transfer the northwestern 66.3-acre portion of the Siege Battery MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02). This newly defined MRS consolidates the impact area acreage identified in several MRSs associated with former targets at the Crows Nest.
- Delineate the 52 acres of the Siege Battery MRS located east of the Hudson River on Constitution Island as a separate MRS. Based on the MD found on Constitution Island during the RI and the UXO found previously during the SI, an FS is recommended to further evaluate future action at the Siege Battery Constitution Island MRS (WSTPT-015-R-02).

7.1.3 Lusk Reservoir MRS

Based on the results of the RI field activities, the following conclusions were determined for the Lusk Reservoir MRS:

- A total of 6.06 acres were investigated at the MRS during the RI, exceeding the required spatial coverage needed to achieve a high statistical confidence to determine MEC density.
- No MEC was identified during the RI field activities; however, one UXO item was reported in construction fill within the MRS.
- Based on the investigation coverage and statistical assessment, the anticipated MEC density is low and an explosive safety hazard is not anticipated to exist at the southern 74.4-acre portion of the MRS. In the northern 8.8-acre portion of the MRS, the anticipated MEC density is low, but an explosive safety hazard is anticipated to exist.
- MEC exposure pathways in the southern 74.4-acre portion of the MRS were determined to be incomplete because there is no MEC source.
- MEC exposure pathways within the northern 8.8-acre portion of the MRS were determined to be complete because of the one UXO item identified in the MRS and the MEC and MD delineated within the Crows Nest impact area.
- MC pathways to potential receptors in both portions of the MRS were determined to be incomplete.

The recommendations for the Lusk Reservoir MRS are as follows:

- Revise the Lusk Reservoir MRS to 74.4 acres. No further action under the MMRP is recommended for the adjusted Lusk Reservoir MRS (WSTPT-019-R-01). Future actions for the Lusk Reservoir MRS may include the preparation of a No Further Action Proposed Plan for public review followed by issuance of a Decision Document.
- Transfer the 8.8-acre portion of the Lusk Reservoir MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02). This newly defined MRS consolidates the impact area acreage identified in several MRSs associated with firing at former targets on Crows Nest.

7.1.4 Artillery Firing Range MRS

Based on the results of the RI field activities, the following conclusions were determined for the Artillery Firing Range MRS:

- A total of 6.4 acres were investigated at the MRS during the RI, exceeding the required spatial coverage needed to achieve a high statistical confidence to determine MEC density.

- MD was found in surface and subsurface soil to 10 inches bgs in the northern 42-acre portion of the MRS and in the southern 123.4-acre portion of the MRS. Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for these portions of the MRS.

- No MEC or MD was found during the RI and the DQOs for the project were met. An explosive safety hazard is not anticipated to exist in the remaining 7-acre portion of the Artillery Firing Range MRS. Incomplete MEC pathways were identified for surface and subsurface soils for all receptors having access to this portion of the MRS.

- MC pathways to potential receptors were determined to be incomplete.

The recommendations for the Artillery Firing Range MRS are as follows:

- Revise the Artillery Firing Range MRS to 7 acres. No further action under the MMRP is recommended for the Artillery Firing Range MRS (WSTPT-001-R-01). Future actions for the Artillery Firing Range MRS may include the preparation of a No Further Action Proposed Plan for public review followed by issuance of a Decision Document.

- Transfer the northern 42-acre portion of the Artillery Firing Range MRS associated with the Crows Nest impact area to the Artillery Firing Range North MRS (WSTPT-001-R-02). It is recommended that the Artillery Firing Range North MRS be further evaluated for potential action in an FS to address hazards related to the presence of MEC.

- Delineate as a separate MRS the remaining southern 123.4-acre portion of the Artillery Firing Range MRS where a complete MEC exposure pathway to potential receptors is present, but which is not within the Crows Nest impact area. An FS is recommended to further evaluate future response actions at the Artillery Firing Range South MRS (WSTPT-001-R-03**)**.

7.1.5 Artillery Firing Range North MRS

Based on the results of the RI field activities, the following conclusions were determined for the Artillery Firing Range North MRS:

- MEC, in the form of UXO, and MD were found in surface and subsurface soil to 15 inches bgs within the MRS, which represents the delineated Crows Nest impact area situated in the northern extent of West Point. MEC and MD in construction fill are also potentially present based on the available records reviewed to date.
- Complete MEC pathways in surface and subsurface soil and an explosive safety hazard for all receptors were identified for the MRS.
- MC pathways to potential receptors were determined to be incomplete.

It is recommended that the Crows Nest impact area, comprised primarily of acreage formerly associated with the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, and the Artillery Firing Range MRS, be consolidated into the newly assigned Artillery Firing Range North MRS for West Point under tracking number WSTPT-001-R-02. It is recommended that the Artillery Firing Range North MRS be further evaluated for potential action in an FS to address hazards related to the presence of MEC.

A summary of the area in the Artillery Firing Range North MRS (Crows Nest impact area) is presented in **Table 7-1.**

Table 7-1 Artillery Firing Range North MRS Delineation

Original MRS Identifier	Area (acres) Recommended for Inclusion in Artillery Firing Range North MRS
Fort Clinton West (WSTPT-008-R-01)	12.7
Siege Battery (WSTPT-015-R-01)	66.3
Lusk Reservoir (WSTPT-019-R-01)	8.8
Artillery Firing Range (WSTPT-001-R-01)	42
Area previously not included within an MRS boundary at West Point	13.5
Artillery Firing Range North MRS Total Area:	143.3

7.2 SUMMARY OF RECOMMENDATIONS

West Point has an existing installation-wide land use controls (LUCs) requirement involving dig permitting whenever ground is broken. The Department of Public Works reviews all dig permits and requires construction support for areas known to contain or having the potential to contain MEC. West Point uses a Probability Assessment (U.S. Army Garrison [USAG] West Point, 2010) to determine which areas on the installation require construction support for ground disturbing activities. The areas considered in the Probability Assessment are divided into Group A and Group B. Group A areas have a low probability of encountering MEC, and workers in these areas are provided a safety brochure with instructions in the event a munitions item is encountered. Group B areas require construction support for ground disturbing activities. The Department of Public Works reviews dig permit requests and compares them to the map in the Probability Assessment and provides guidance to the dig permit requestor. The existing installation-wide LUCs were taken into consideration in determining the conclusions and recommendations for each MRS and are not considered a remedial action.

Table 7-2 presents a summary of the conclusions and recommendations for each MRS, including the area delineated in the Crow Nest impact area, the exposure pathway analyses findings, and the future recommendations. **Figure 7-1** depicts the proposed boundary revisions and the recommendations for the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and the newly delineated Artillery Firing Range North MRS.

Table 7-2 West Point MMRP RI Recommendations Summary

<table>
<tr><th colspan="2">Original Configuration</th><th colspan="2">Configuration Following RI Delineation</th><th rowspan="2">RI MEC Exposure Pathway</th><th rowspan="2">RI MC Exposure Pathway</th><th rowspan="2">Recommendations</th></tr>
<tr><th>MRS Identifier</th><th>Area (acres)</th><th>MRS Identifier</th><th>Area (acres)</th></tr>
<tr><td>Fort Clinton West (WSTPT-008-R-01)</td><td>14.4</td><td>Fort Clinton West (WSTPT-008-R-01)</td><td>1.7</td><td>Incomplete</td><td>Incomplete</td><td>No Further Action</td></tr>
<tr><td rowspan="2">Siege Battery (WSTPT-015-R-01)</td><td rowspan="2">167.1[1]</td><td>Siege Battery (WSTPT-015-R-01)</td><td>48.8</td><td>Incomplete</td><td>Incomplete</td><td>No Further Action</td></tr>
<tr><td>Siege Battery Constitution Island (WSTPT-015-R-02)</td><td>52</td><td>Complete</td><td>Incomplete</td><td>Feasibility Study for MEC hazard</td></tr>
<tr><td>Lusk Reservoir (WSTPT-019-R-01)</td><td>83.2</td><td>Lusk Reservoir (WSTPT-019-R-01)</td><td>74.4</td><td>Incomplete</td><td>Incomplete</td><td>No Further Action</td></tr>
<tr><td rowspan="3">Artillery Firing Range (WSTPT-001-R-01)</td><td rowspan="3">172.4</td><td>Artillery Firing Range (WSTPT-001-R-01)</td><td>7</td><td>Incomplete</td><td>Incomplete</td><td>No Further Action</td></tr>
<tr><td>Artillery Firing Range South (WSTPT-001-R-03)</td><td>123.4</td><td>Complete</td><td>Incomplete</td><td>Feasibility Study for MEC hazard</td></tr>
<tr><td>Artillery Firing Range North (WSTPT-001-R-02)</td><td>143.3[2]</td><td>Complete</td><td>Incomplete</td><td>Feasibility Study for MEC hazard</td></tr>
<tr><td>Total area:</td><td>437.1</td><td>Total area:</td><td>450.6</td><td></td><td></td><td></td></tr>
</table>

Notes: [1] The SI reported area for the Siege Battery MRS (WSTPT-015-R-01) was 179.3 acres (TLI, 2007), which was subsequently used in the Final Work Plan (WESTON, 2011a). During the RI, this area was determined to be inclusive of portions of the Hudson River and was adjusted to 167.1 acres to align with the current land boundary. The 12.2 acres removed is assumed to be associated with the Siege Battery – TD – River MRS (WSTPT-016-R-01).

[2] Artillery Firing Range North MRS acreage represents portions of the Fort Clinton West MRS, the Siege Battery MRS, the Lusk Reservoir MRS, the Artillery Firing Range MRS, and 13.5 additional acres characterized as being within the Crows Nest impact area.

SECTION 7
FIGURE

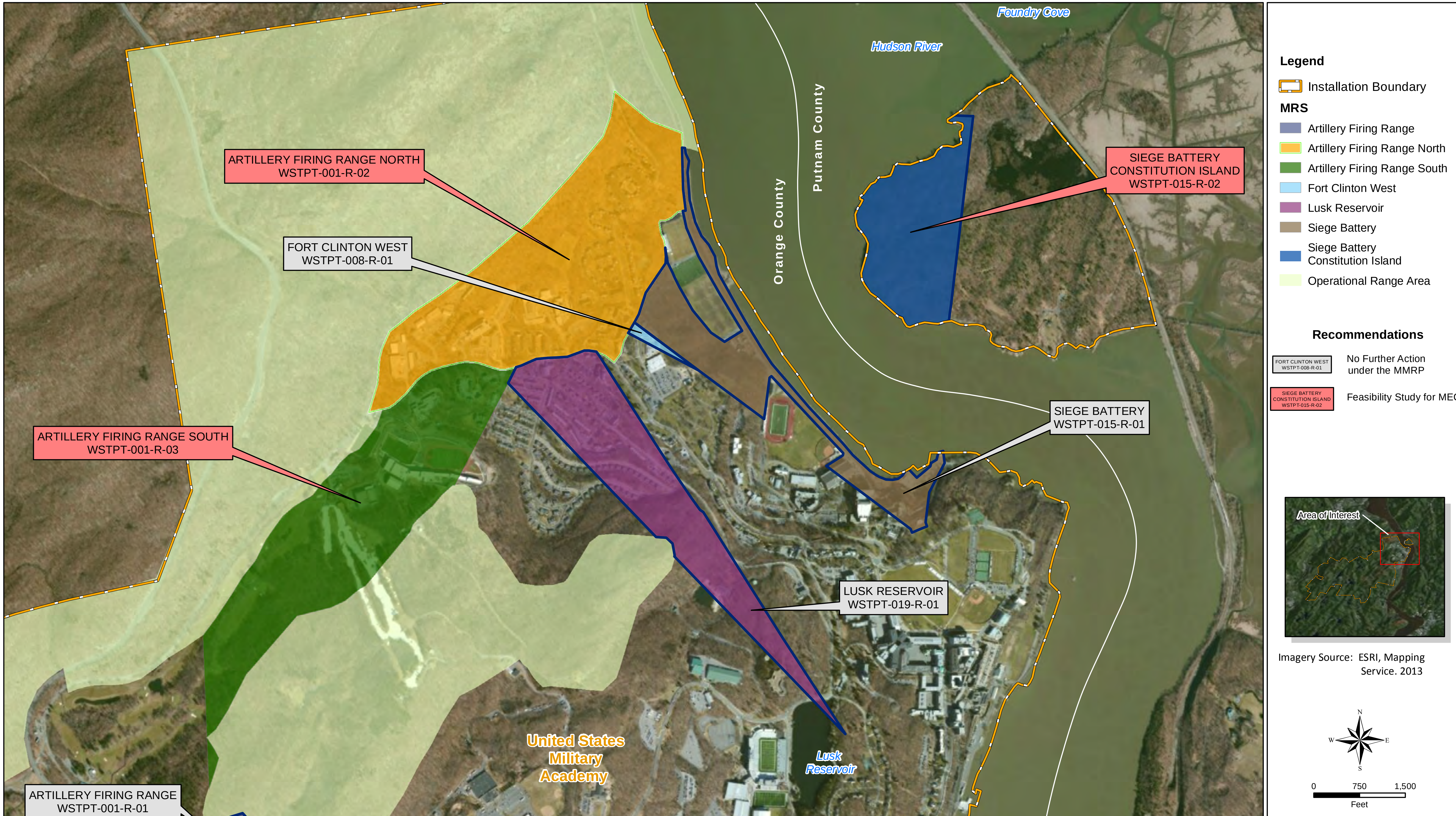


Figure 7-1
Post-RI MRS Recommendations
U.S. Army Garrison West Point

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